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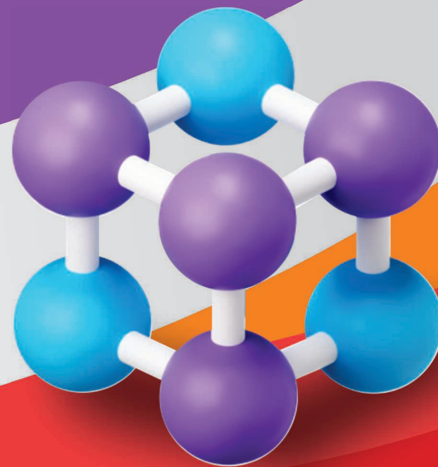

Sample Question Papers

Physics

CBSE **Class 12** *(Term I)*

- One Day Revision
- The Qualifiers *Chapterwise MCQs*
- Latest CBSE Sample Paper

10 Sample Question Papers *with OMR Sheet*

As per CBSE Sample Paper
Issued On 02 Sep, 2021...

Sample Question Papers

Physics

CBSE **Class 12** *(Term I)*

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Syllabus

Physics CBSE Class 12 (Term I)

Time: 90 Minutes | Max Marks: 35

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UNIT-I Electrostatics

23 Periods

Chapter-1 Electric Charges and Fields

Electric Charges; Conservation of charge, Coulomb's law-force between two-point charges, forces between multiple charges; superposition principle and continuous charge distribution. Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field. Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet.

Chapter-2 Electrostatic Potential and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field.

Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarisation, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor.

UNIT-II Current Electricity *15 Periods*

Chapter-3 Current Electricity

Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, electrical resistance, V-I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity; temperature dependence of resistance. Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff's laws and simple applications, Wheatstone bridge, metre bridge **(qualitative ideas only).** Potentiometer - principle and its applications to measure potential difference and for comparing EMF of two cells; measurement of internal resistance of a cell **(qualitative ideas only)**.

UNIT-III Magnetic Effects of Current and Magnetism *16 Periods*

Chapter-4 Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment. Biot - Savart law and its application to current carrying circular loop. Ampere's law and its applications to infinitely long straight wire. Straight and toroidal solenoids (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields. Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Chapter-5 Magnetism and Matter

Current loop as a magnetic dipole and its magnetic dipole moment, magnetic dipole moment of a revolving electron, bar magnet as an equivalent solenoid, magnetic field lines; earth's magnetic field and magnetic elements.

UNIT-IV Electromagnetic Induction and Alternating Currents *19 Periods*

Chapter-6 Electromagnetic Induction

Electromagnetic induction; Faraday's laws, induced EMF and current; Lenz's Law, Eddy currents. Self and mutual induction.

Chapter-7 Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only), LCR series circuit, resonance; power in AC circuits. AC generator and transformer.

MCQs Preparation Tips

Focus on Theory
MCQs can be formed from any part or line of the chapter. So, strong command on theory will increase your chances to solve objective questions correctly and quickly.

Practice of Solving MCQs
Cracking an MCQ-based examination requires you to be familiar with the question format, so continuous practice will make you more efficient in solving MCQs.

Speed & Accuracy
In MCQ-based examination, you need both speed and accuracy, if your accuracy is good but speed is slow then you might attempt less questions resulting in low score.

Learn to Identify Wrong Answers
The simplest trick is, observe the options first and take out the least possible one and repeat the process until you reach the correct option.

Analyze your Performance
During the practice of MCQs, you can identify your weak & strong topics/chapter by analyzing of incorrect answers, in this way you will get an awareness about your weaker topics.

Practice through Sample Papers
Solving more & more papers will make you more efficient and smarter for exams. Solve lots of Sample Papers given in a good Sample Papers book.

Attempting MCQs in Exams

1. Read the paper from beginning to end & attempt those questions first in which you are confident. Now move on to those questions which requires thinking and in last attempt those questions for which you need more attention.

2. Read instructions of objective questions carefully and find out what is being asked,
a bit carelessness can lead you to incorrect answer.

3. Tick/Write down the correct option only while filling the OMR sheet.
Step by step solution is not required in MCQ type questions, it is a waste of time, you will not get extra marks for this.

4. Most of the time, you need not to solve the MCQ completely to get the correct option. You can start thinking in reverse order and choose the best fit option.

5. As there is no negative marking for incorrect answers, so don't leave any question unanswered. Use your guess if you have not exact idea about the correct answer.

ONE DAY REVISION

Revise All the Concepts in a Day
Just Before the Examination...

Electric Charges and Fields

1. **Charge** is the property associated with matter due to which it produces/experiences electric and magnetic effects. There are two types of charges namely **positive charge** and **negative charge .**
2. **Conservation of Electric Charge** During any process, the net electric charge of an isolated system remains constant, i.e. conserved. In simple words, charge can neither be created nor be destroyed.
3. **Quantisation of Charge** Charge on an object can only be integer multiple of a smallest charge (e), i.e. charge on an object, $q = \pm ne$, where n is an integer and e is the electronic charge.

   where, $e = -1.6 \times 10^{-19}$ C.
4. **Coulomb's Law** It states that, the electrostatic force of attraction or repulsion acting between two stationary point charges q_1 and q_2 separated in vacuum by a distance r is given by

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

Also, $$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N-m}^2/\text{C}^2$$

where, $\varepsilon_0 =$ permittivity of free space

$= 8.85419 \times 10^{-12}$ $\text{C}^2/\text{N-m}^2$

In vector form, $$\mathbf{F} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{|\mathbf{r}|^3}\mathbf{r}$$

or $$\mathbf{F} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}\hat{\mathbf{r}}$$

5. **Relative Permittivity** It is given by the ratio

$$\varepsilon_r = \frac{\varepsilon \text{ (absolute permittivity of the medium)}}{\varepsilon_0}$$

It is also denoted by K, which is called **dielectric constant** of the medium. It has no units.

$$\therefore \quad K \text{ or } \varepsilon_r = \frac{\varepsilon}{\varepsilon_0} = \frac{F_{\text{vacuum}}}{F_{\text{medium}}}$$

6. **Principle of Superposition of Electrostatic Forces** It states that, the net force experienced by a given charge particle q_0 due to a system of charged particles is equal to the vector sum of the forces exerted on it due to all the other charged particles of the system.

i.e. $$\mathbf{F}_0 = \mathbf{F}_{01} + \mathbf{F}_{02} + \mathbf{F}_{03} + \dots + \mathbf{F}_{0n}$$

or $$\mathbf{F}_0 = \frac{q_0}{4\pi\varepsilon_0}\left[\sum_{i=1}^{n} \frac{q_i}{|\mathbf{r}_{i0}|^3}\mathbf{r}_{i0}\right]$$

7. **Electrostatic Force due to Continuous Charge Distribution** The region in which charges are closely spaced is said to have **continuous charge distribution**.
   - Electrostatic force at a point due to a **linear charge distribution** is given by
   $$\mathbf{F} = \frac{q_0}{4\pi\varepsilon_0}\int_L \frac{\lambda dl}{r_0^2}\hat{\mathbf{r}}_0$$
   - Electrostatic force at a point due to a **surface charge distribution** is given by
   $$\mathbf{F} = \frac{q_0}{4\pi\varepsilon_0}\int_S \frac{\sigma dS}{r_0^2}\hat{\mathbf{r}}_0$$
   - Electrostatic force at a point due to **volume charge distribution** is given by
   $$\mathbf{F} = \frac{q_0}{4\pi\varepsilon_0}\int_V \frac{\rho dV}{r_0^2}\hat{\mathbf{r}}_0$$
8. **Electric field** is the region surrounding an electric charge or a group of charges, in which another charge experiences a force.

9. **Electric field intensity** at any point is given by

$$E = \lim_{q_0 \to 0} \frac{F}{q_0}$$

where, q_0 is a small positive test charge which experiences a force F at given point.

10. **Electric field intensity due to a point charge** q at a distance r is given as

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}$$

11. **Electric field due to system of charges** is given as

$$E = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \frac{q_i}{r_i^2} \hat{r}_i$$

12. **Electric lines of force** are the imaginary curves drawn in electric field along which an unit positive test charge tends to move.

The tangent to a electric line of force at any point gives the direction of electric field at that point.

13. **Electric Dipole Moment** Magnitude of electric dipole moment is equal to product of magnitude of any charge q and separation between two charges $(2l)$.

$$p = q(2l)$$

Direction of electric dipole moment is taken from negative charge $(-q)$ to positive charge $(+q)$.

14. **Electric field at any point on the axial line of electric dipole** is given by

$$E_{\text{axial}} = \frac{1}{4\pi\varepsilon_0} \frac{2pr}{(r^2 - l^2)^{3/2}}$$

When $l << r$, $E_{\text{axial}} = \frac{1}{4\pi\varepsilon_0} \frac{2p}{r^3}$

15. **Electric field at any point on equatorial line of electric dipole** is given by

$$E_{\text{equatorial}} = \frac{1}{4\pi\varepsilon_0} \frac{p}{(r^2 + l^2)^{3/2}}$$

If $l << r$, $E_{\text{equatorial}} = \frac{1}{4\pi\varepsilon_0} \frac{p}{r^3}$

16. When $l << r$, $\frac{E_{\text{axial}}}{E_{\text{equatorial}}} = 2$

17. **Torque on an electric dipole placed in uniform electric field** is given by

$$\tau = p \times E \text{ or } \tau = pE \sin\theta$$

Torque experienced by the dipole is

(i) minimum, when $\theta = 0°$ or π; $\tau = \tau_{\min} = 0$

(ii) maximum, when $\theta = \pi/2$; $\tau = \tau_{\max} = pE$

18. **Work done in rotating the electric dipole from** θ_1 **to** θ_2, $W = pE(\cos\theta_1 - \cos\theta_2)$

19. **Potential energy of electric dipole**, when it makes an angle θ with the direction of electric field,

$$U = -pE\cos\theta = -p \cdot E$$

20. **Electric flux** over an area is equal to the total number of electric field lines crossing this area. It is given as

$$\phi_E = E \cdot dS$$

21. **Gauss's Law** The total electric flux linked with closed surface S,

$$\phi_E = \oint E \cdot dS = \frac{q}{\varepsilon_0}$$

where, q is the total charge enclosed by the closed gaussian (imaginary) surface.

22. **Electric field intensity due to an infinitely long thin straight charged wire at a distance** r, is given as $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

where, λ is the uniform linear charge density.

23. **Electric field due to a thin infinite plane sheet of charge with uniform surface charge density** σ **at any nearby point** is

$$E = \frac{\sigma}{2\varepsilon_0} \text{ (for thin non-conducting plate)}$$

and $E = \frac{\sigma}{\varepsilon_0}$ (for conducting plates)

24. **Electric field due to two equally and oppositely charged parallel plane sheets of charge at any point,** is given as

$$E = \frac{\sigma}{\varepsilon_0} \text{ (between the two plates)}$$

and $E = 0$ (outside the plates)

Electrostatic Potential and Capacitance

1. **Electric potential** or **electrostatic potential** at any point in the region of electric field is equal to the amount of work done in bringing the unit positive test charge from infinity to that point, against electrostatic forces without acceleration.

   $$\text{Electric potential } (V) = \frac{\text{Work done } (W)}{\text{Charge } (q)}$$

   Its SI unit is volt (V) and $1\text{V} = 1$ J/C.
2. **Electric Potential Difference** The difference of potential between two points A and B in an electric field is defined as, the amount of work done in moving an unit positive test charge from point B to the A against electrostatic force without any acceleration, i.e. the difference of electric potentials of two points (i.e. V_A and V_B) in the electric field.
3. **Electric potential due to a point charge** q at any point lying at a distance r from it, is given by

   $$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$
4. The potential at a point due to a positive charge is **positive**, while due to **negative** charge is negative.
5. Electric potential at any point due to a **system of n-point charges** $q_1, q_2, \ldots, q_n$, whose position vectors are $\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_n$, respectively is given by

   $$V = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{|\mathbf{r} - \mathbf{r}_i|}$$

   where, $\mathbf{r}$ is the position vector of point P w.r.t. the origin.
6. The electric potential on the perpendicular bisector, i.e. in equatorial plane due to an electric dipole is zero.
7. **Electric potential due to an electric dipole at any point** P, whose position vector is $\mathbf{r}$ with respect to mid-point of dipole is given by

   $$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} \quad \text{or} \quad V = \frac{1}{4\pi\varepsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{|\mathbf{r}|^2}$$

   where, θ is the angle between $\mathbf{r}$ and $\mathbf{p}$.
8. **Electric potential due to a thin charged spherical shell carrying charge** q **and radius** R, respectively at any point lying
   - inside the shell is $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$, for $r < R$
   - on the surface of shell is $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$, for $r = R$
   - outside the shell is $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$, for $r > R$

   where, r is the distance of the point from the centre of the shell.
9. **Equipotential surface** is a surface which has same electrostatic potential at every point on it.
10. **Relationship between electric field and potential gradient,**

    $$E = -\frac{dV}{dr}$$
11. **Electrostatic potential energy of a system of two point charges,**

    $$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

    Electrostatic potential energy of a system of n **point charges,**

    $$U = \frac{1}{4\pi\varepsilon_0}\sum_{j=1}^{n}\sum_{i=1}^{n}\frac{q_j q_i}{r_{ji}}$$

    Here, $j \neq i$ and $ij = ji$.
12. **Potential energy of a single charge in external field** is $q \cdot V(\mathbf{r})$, where $V(\mathbf{r})$ is the potential at the point due to external electric field $\mathbf{E}$.
13. **Potential energy of a system of two charges in an external field,**

    $$U = q_1 \cdot V(\mathbf{r}_1) + q_2 \cdot V(\mathbf{r}_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$$

    where, $q_1, q_2 =$ two point charges at position vectors $\mathbf{r}_1$ and $\mathbf{r}_2$ respectively,

    $V(\mathbf{r}_1) =$ potential at r_1 due to the external field

    and $V(\mathbf{r}_2) =$ potential at r_2 due to the external field.
14. **Potential energy of the dipole placed in external field** $\mathbf{E}$, so that it rotates from angle θ_1 to θ_2 with respect to $\mathbf{E}$,

    $$U(\theta) = pE(\cos\theta_1 - \cos\theta_2)$$
15. **Capacitance of a conductor** is given as $C = q/V$.
16. The **capacitance of air filled parallel plate capacitor** is given by

    $$C_0 = \frac{\varepsilon_0 A}{d}$$

    When a dielectric medium of dielectric constant K is filled fully between the plates of the capacitor, then capacitance, $C = \frac{KA\varepsilon_0}{d}$
17. The capacitance of a parallel plate capacitor partially filled with a dielectric medium of dielectric constant K is given by

    $$C = \frac{\varepsilon_0 A}{(d - t + t/K)}$$

    where, $t =$ thickness of dielectric medium.
18. **Series Combination of Capacitors**
    - The equivalent capacitance is given by

    $$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

- If n-identical capacitors are connected in series combination, then equivalent capacitance,

$$C_s = \frac{C_{eq}}{n}$$

19. **Parallel Combination of Capacitors**
- The equivalent capacitance is given by

$$C_{eq} = C_1 + C_2 + C_3$$

- The equivalent capacitance of n-identical capacitors connected in parallel combination,

$$C_p = nC_{eq}$$

20. **Electrostatic energy stored in a capacitor** (parallel plate) is given by

$$U = \frac{1}{2}CV^2 = \frac{1}{2}qV = \frac{q^2}{2C}$$

21. **Energy Density** The energy stored per unit volume of space in a capacitor is known as energy density. It is given by $U_E = \frac{1}{2}\varepsilon_0 E^2$, where E is the electric field intensity between two plates of capacitor.

Current Electricity

1. **Electric current** is the rate of flow of charge. If ΔQ charge flows in time Δt, then current at any time t,

$$I = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$$

2. **Electric current in terms of drift velocity,** $I = neA v_d$.
3. **Current density** at any point of conductor,

$$J = I/A = ne\, v_d$$

It is a vector quantity.

4. **Mobility of a charge carrier** is given as

$$\mu = \frac{\text{Drift velocity}}{\text{Electric field}} = \frac{v_d}{E} = \frac{e\tau}{m}$$

where, m is mass of electron and τ is relaxation time.

5. **Ohm's Law** At constant temperature and other physical conditions, the potential difference V across the ends of a given metallic wire (conductor) in a circuit is directly proportional to the current flowing through it.

i.e. $V = IR$

where, R = resistance of conductor.

6. **Resistance** The opposition offered by the conductor in the flow of current, is called resistance, it is given as $R = \rho \frac{l}{A}$

where, ρ is the resistivity.

7. **Resistivity** of a material is equal to resistance per unit length per unit area.

Resistivity of material is given as $\rho = \frac{m}{ne^2\tau}$.

8. **Relationship between current density** (J)**, electric field** (E) **and conductivity** (σ),

$$J = \sigma E$$

9. Temperature coefficient of resistance is given by

$$\alpha = \frac{R_2 - R_1}{R_1 (T_2 - T_1)}$$

10. **Electrical energy** is defined as the total work done by the source of emf (E) in maintaining the electric current (I) in the given circuit for a specified time t.

$$E = VIt = I^2Rt = \frac{V^2t}{R}$$

Its SI unit is joule (J).

11. **Electrical power** is defined as, the rate of electrical energy supplied per unit time to maintain flow of electric current through a conductor.

$$P = VI = I^2R = \frac{V^2}{R}$$

Its SI unit is watt (W).

12. **Electromotive Force (EMF) of Cell**
The maximum potential difference between the two poles or terminals of the cell in an open circuit is called the electromotive force (emf) of the cell. It is denoted by E and its SI unit is volt (V).

13. **Internal resistance** is the resistance offered by the electrolyte of the cell due to the motion of charge through it and is denoted by r.

14. **The relationship between r, R, E and V,** is

$$r = R\left(\frac{E}{V} - 1\right)$$

15. **Combination of Cells**
- **Series Combination** The equivalent emf of series combination is given by

$$E = E_1 + E_2$$

Equivalent resistance, $r = r_1 + r_2$.

- **Parallel Combination** The equivalent emf of parallel combination is given by

$$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$$

and internal resistance of combination,

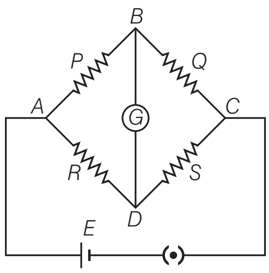
$$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

16. **Kirchhoff's First Law or Junction Law** The algebraic sum of electric currents at any junction of electric circuit is equal to zero,

i.e. $\Sigma I = 0$

Junction law supports the law of conservation of charge.

17. **Kirchhoff's Second Law or Loop Law** In any closed mesh of electrical circuit, the algebraic sum of emfs of cells and the product of currents and resistances is always equal to zero.
    i.e. $\Sigma E + \Sigma I R = 0$
    Kirchhoff's second law supports the law of conservation of energy.
18. **Wheatstone bridge** is an arrangement of four resistances connected to form the arms of quadrilateral *ABCD* as shown below



    Wheatstone bridge is said to be balanced, when
    $$\frac{P}{Q} = \frac{R}{S}$$
19. **Meter bridge** is an electrical device used to determine the resistance and hence, specific resistance of material of given wire/conductor. It is based on the principle of balanced Wheatstone bridge.
    At balanced situation of bridge,
    $$\frac{R}{S} = \frac{l}{(100 - l)} \quad \Rightarrow S = \left(\frac{100 - l}{l}\right) \times R$$
    where, l is the balancing length.
20. The **potentiometer** works on the principle that, potential difference across any two points of uniform current carrying conductor is directly proportional to the length between the two points. i.e. $V \propto l$.
21. • The emfs of two primary cells can be compared using potentiometer as $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
    where, l_1 and l_2 are the balancing lengths corresponding to cells of emfs E_1 and E_2, respectively.
    • Internal resistance of primary cell of emfs is given by
    $$r = R\left(\frac{l_1}{l_2} - 1\right)$$
    where, R = external resistance.

Moving Charges and Magnetism

1. **Biot-Savart's Law** According to this law, the magnetic field due to small current carrying element at any nearby point is given by
   $$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{I d\mathbf{l} \times \mathbf{r}}{r^3} \text{ or } dB = \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2}$$
   Here, $\frac{\mu_0}{4\pi} = 10^{-7}$ T-m /A (or Wb/A-m)
   where, μ_0 = permeability of free space.
   The SI unit of magnetic field is tesla (T).
   Its direction is given by Ampere's swimming rule or right hand thumb rule.
2. **Magnetic field due to infinitely straight current carrying conductor** at any point which lies near the middle of conductor at a distance r from the wire is given by $B = \frac{\mu_0 I}{2\pi r}$.
3. **Magnetic field at the centre of a circular current carrying conductor/coil,** $B = \frac{\mu_0 I}{2r}$
   For N-turns of coil, $B = \frac{\mu_0 N I}{2r}$
4. **Ampere's Circuital Law** The line integral of the magnetic field **B** around any closed loop in vacuum is equal to μ_0 times the total current threading through the loop or enclosed by the curve.
   i.e. $$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$$
5. **Magnetic field due to straight current carrying solenoid,**
   - at any point inside it is $B = \mu_0 n I$,
     where n = number of turns per unit length.
   - at the ends is $B = \frac{1}{2}\mu_0 n I$.
6. **Magnetic Field due to Toroidal Solenoid**
   If a toroid has core of relative permeability μ_r, then magnetic field
   - inside the toroidal solenoid, $B = \mu_0 n I$.
   - in the open space, interior or exterior of toroidal solenoid, $B = 0$.
7. **Magnetic force** experienced by a single charge particle q moving with speed v in uniform magnetic field at an angle θ with it, is given by
   $$\mathbf{F} = q(\mathbf{v} \times \mathbf{B}) \quad \text{or} \quad F = qvB \sin\theta$$
8. The trajectory/path traversed by the charged particle in magnetic field is
   - **straight line**, when angle between **v** and **B** is 0° or 180°.
   - **circle,** when angle between **v** and **B** is 90°.
   - **helical,** when angle between v and B is an acute angle.
9. When charged particle enters in magnetic field perpendicularly, then
   - **Radius**, $r = \frac{mv}{qB}$

- **Time period**, $T = \frac{2\pi m}{qB}$
- **Kinetic energy** $= \frac{q^2B^2r^2}{2m}$

10. When angle between **v** and **B**, $\theta < 90^\circ$, then
radius of helical path, $r = \frac{mv \sin\theta}{qB}$
Pitch $= \frac{2\pi m v \cos\theta}{qB} = v_{||} \times T$
11. **Lorentz force** is the total force experienced by a moving charge inside the electric and magnetic fields. It is given by
$$\mathbf{F} = q\,(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$
12. The magnetic force experienced by a current carrying conductor placed in a uniform magnetic field is given by
$$\mathbf{F} = I\,(\mathbf{l} \times \mathbf{B}) \text{ or } F = IBl\sin\theta$$
where, θ is the angle between current and magnetic field.
13. Magnetic force per unit length between two straight parallel current carrying conductors is given by
$$\frac{F}{L} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}$$
14. **Torque** experienced by a current carrying loop placed in uniform magnetic field B is given by
$$\tau = NIAB\sin\theta \text{ or } \tau = \mathbf{M} \times \mathbf{B}$$
where, $\mathbf{M} = NI\mathbf{A}$.
15. **Moving coil galvanometer** is a device used to detect the small electrical current in the circuit. Its working is based on the principle that, a current carrying loop placed in uniform magnetic field experiences a torque.
16. - **Current sensitivity**, $I_S = \frac{\theta}{I} = \frac{NBA}{k}$
where, θ = twist produced due to rotation of the coil.
- **Voltage sensitivity**, $V_S = \frac{\theta}{V}\frac{NBA}{kR}$
17. In equilibrium position,
deflecting torque = restoring torque
$\Rightarrow \quad I = \frac{k}{NBA}\theta$
18. A **galvanometer can be converted into an ammeter** by connecting a very low resistance (shunt S) in parallel with galvanometer, which is given by
$$S = \frac{I_g G}{I - I_g}$$
19. A **galvanometer can be converted into voltmeter** by connecting a very high resistance R in series with galvanometer, which is given by
$$R = \frac{V}{I_g} - G$$

Magnetism and Matter

1. **Magnetic lines of forces** are used to represent magnetic field in a region.
   - They are closed continuous curves.
   - Tangent drawn at any point gives the direction of magnetic field.
   - They cannot intersect each other.
   - Outside a magnet, they are directed from north-pole to south-pole and inside a magnet, they are directed from south-pole to north-pole.
2. **Magnetic dipole moment of a magnetic dipole** is given by $\mathbf{M} = m(2\mathbf{l})$
where, m is pole strength and $2l$ is dipole length (magnetic length).
The SI unit of magnetic dipole moment is A-m^2 or J/T.
It is a vector quantity and its direction is from south-pole towards north-pole.
3. **Current Loop as a Magnetic Dipole** Current loop behaves like a magnetic dipole, whose dipole moment is given by
$$\mathbf{M} = I\mathbf{A}$$
The direction of dipole moment can be obtained by right hand thumb rule.
4. **Magnetic dipole moment of a revolving electron,**
$$M = \frac{evr}{2}$$
where, v = speed of electron on a circular path of radius r.
or $\quad M = \frac{e}{2m_e}L$
where, L = angular momentum and given as $L = m_e vr$ and m_e = mass of electron.
5. **Earth's Magnetic Field** Earth behaves like a magnet, whose magnetic north-pole is somewhere close to the geographical south-pole and the magnetic south-pole is closed to the geographical north-pole.
6. There are three **elements of earth's magnetic field** namely
   - Angle of declination (α),
   - Angle of dip (δ)

- and horizontal component of earth's magnetic field (H_e).

7. The angle between geographical meridian and magnetic meridian is known as **angle of declination** (α).
8. In magnetic meridian, the angle made by resultant earth's magnetic field (B_e) with the horizontal is known as **angle of dip** (δ).
9. Relationship between **horizontal & vertical components of the earth's magnetic field and angle of dip** is given by

$$H_e = B_e \cos\delta \quad \text{and} \quad V_e = B_e \sin\delta$$

So, $$\frac{V_e}{H_e} = \tan\delta$$

and $$B_e = \sqrt{V_e^2 + H_e^2}$$

Electromagnetic Induction

1. **Magnetic flux** linked with any surface is equal to the total number of magnetic lines of force passing through it. It is a scalar quantity.

   It is given as, $\phi = \mathbf{B} \cdot d\mathbf{S}$
2. **Faraday's Law of Electromagnetic Induction** Whenever magnetic flux linked with the closed loop or circuit changes, an emf is induced in the loop or circuit.
   Mathematically, the induced emf is given as
   $$e = -N\frac{d\phi}{dt}$$
   where, N = number of turns in loop.

   Induced current in the loop, $I = \frac{|e|}{R} = \frac{N}{R} \cdot \frac{d\phi_B}{dt}$

   where, R is the resistance of the loop.
3. **Lenz's Law** The direction of induced emf or induced current is such that it always opposes the cause that produced it, i.e. change in magnetic flux linked with the circuit.

   Lenz's law is a consequence of the law of conservation of energy.
4. **Motional EMF** The emf ε induced in a conductor of length l moving with velocity v in a direction perpendicular to magnetic field B is given by $\varepsilon = vBl$
5. The induced emf developed between two ends of conductor of length l rotating with angular velocity ω about one end in a direction perpendicular to magnetic field B, is given by
   $$\varepsilon = \frac{B\omega l^2}{2}$$
6. **Eddy Currents** These are loops of electric current induced within bulk pieces of conductors by a changing magnetic field in the conductor, according to Faraday's law of electromagnetic induction. It causes the heating of conductor.
7. **Self-induction** is the phenomenon of production of induced emf in a coil itself, when a current passing through it changes continuously.

   In this case, induced emf, $e = -L\frac{dI}{dt}$

   where, L is the coefficient of self-induction.

   The SI unit of inductance is henry (H).
8. Equivalent inductance of two **inductors in parallel combination** is $\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$
9. Equivalent inductance of two **inductors in series combination** is $L = L_1 + L_2$
10. **Self-inductance of a long solenoid**,
    $$L = \frac{\mu N^2 A}{l}$$
11. **Mutual induction** is the phenomenon of generation of induced emf in secondary coil, when current linked with primary coil changes.

    Here, $$e = -M\frac{dI}{dt}$$

    where, M is coefficient of mutual inductance.
12. **Mutual inductance of closely wound solenoids**,
    $$M = \frac{\mu_0 N_1 N_2 A}{l}$$
13. The capacity of an inductor to store energy in a magnetic field is the **magnetic energy stored in an inductor**.
    $$U = \frac{1}{2}LI^2$$
14. The energy stored per unit volume (V) in a magnetic field (B) is known as **energy density**.

    $\therefore$ Energy density $= \frac{U}{V} = \frac{1}{2}\frac{B^2}{\mu_0}$

Alternating Current

1. **Alternating Current** (AC) is the current whose magnitude changes continuously with time between zero & a maximum value and whose direction reverses periodically.

   The instantaneous alternating current is given by
   $$I = I_0 \sin\omega t$$
   rms value of current, $I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 I_0$

   Average value of AC, $I_{av} = \frac{2I_0}{\pi} = 0.637 I_0$

2. **Alternating EMF or Voltage** The instantaneous alternating emf is given by

$$V = V_0 \sin \omega t$$

Hence, $V_{rms} = \frac{V_0}{\sqrt{2}} = 0.707\ V_0$

$$V_{av} = \frac{2V_0}{\pi} = 0.637\ V_0$$

3. **Power in an AC Circuit,** $P_{av} = V_{rms}\ I_{rms} \cos \phi$
4. In an **AC circuit containing resistance** only,
   - Voltage and current are in same phase.
   - Maximum current, $I_0 = \frac{V_0}{R}$
   - rms current, $I_{rms} = \frac{V_{rms}}{R}$
   - If $V = V_0 \sin \omega t$, then $I = I_0 \sin \omega t$.
   - Average power in R is maximum, so $P_{av} = V_{rms}\ I_{rms}$.
5. In an **AC circuit containing capacitor** only,
   - Capacitive reactance, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$
   - Capacitor offers infinite reactance in DC circuit, as $f = 0$ or acts as open circuit.
   - $I_0 = \frac{V_0}{X_C} = \frac{V_0}{(1/\omega C)} = V_0\ \omega C$
   - Voltage lags behind the current by phase $\pi/2$.
   - If $V = V_0 \sin \omega t$, then $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$.
   - Average power consumption (during a complete cycle),

   $$P_{av} = V_{rms}\ I_{rms} \cos \phi = 0 \qquad \left(\because\ \phi = \frac{\pi}{2}\right)$$
6. In an A**C circuit containing inductor** only,
   - Inductive reactance, $X_L = \omega L = 2\pi f L$
   - Peak current, $I_0 = \frac{V_0}{X_L} = \frac{V_0}{\omega L}$
   - rms current, $I_{rms} = \frac{V_{rms}}{X_L} = \frac{V_{rms}}{\omega L}$
   - Voltage leads the current by phase $\frac{\pi}{2}$.
   - If $V = V_0 \sin \omega t$, then $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$.
   - Average power consumption,

   $$P_{av} = V_{rms}\ I_{rms} \cos \phi = 0 \qquad \left(\because\ \phi = \frac{\pi}{2}\right)$$
7. In an L- C- R **series AC circuit,**
   - Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2} = \frac{V_{rms}}{I_{rms}}$
   - If $X_L > X_C$, then V leads the current by phase angle ϕ and if $X_L < X_C$, then V lags behind I by phase angle ϕ, where

   $$\tan \phi = \frac{X_L - X_C}{R}$$
8. In **a resonant** L- C- R **series AC circuit,**
   - $X_L = X_C$
   - Impedance, $Z = Z_{min} = R$
   - The phase difference between V and I is 0°.
   - Resonant angular frequency, $\omega_0 = \frac{1}{\sqrt{LC}}$
   - Average power consumption P_{av} becomes maximum.
   - Current becomes maximum and $I_{max} = \frac{V_{rms}}{R}$.
9. **Quality Factor** It indicates the sharpness of resonance in L-C-R series AC circuit.

   $$Q\text{-factor} = \frac{\text{Voltage across } L \text{ or } C}{\text{Voltage across } R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$
10. **AC Generator** It is an electrical machine which produces electrical energy from mechanical work.

    Principle It is based on the phenomenon of electromagnetic induction.

    A magnetic flux linked with a coil of the generator,

    $$\phi = BA \cos \omega t$$

    EMF induced in the coil will be

    $$e = -N \frac{d}{dt} BA \cos \omega t = NBA\omega \sin \omega t$$
11. **Transformer** It is an electrical device which converts low alternating voltage to high alternating voltage and *vice-versa* without changing frequency of AC and power. Its working is based on the principle of mutual induction.
12. **Types of Transformer** There are two types of transformers
    - **Step-up Transformer** It converts low alternating voltage into high alternating voltage.
    - **Step-down Transformer** It converts high alternating voltage into low alternating voltage.
13. **For an ideal transformer,**

    Input power = Output power

    or $\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2}$

    where, N_1 = number of turns in primary coil of the transformer

    and N_2 = number of turns in secondary coil of the transformer.

THE QUALIFIERS

Chapterwise Set of MCQs to Check Preparation
Level of Each Chapter

1. Electric Charges and Fields

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. Five balls named A to E are suspended using separate threads. Pairs (A, B), (B, D) and (D, A) show electrostatic attraction, while pairs (B, C) and (D, E) show repulsion. Therefore, ball A must be

(a) positively charged
(b) negatively charged
(c) neutral
(d) made of metal

2. Two charges $+Q$ and $+2Q$ are situated at the ends of a straight line. Another charge $+q$ is placed at the mid-point of the line, then choose the correct statement regarding the charge $+q$.

(a) It will remains at rest.
(b) It will move towards the bigger charge $+2Q$.
(c) It will move towards the smaller charge $+Q$ and then come to rest.
(d) It will move towards the bigger charge $+2Q$ and then come to rest.

3. An arrangement of three fixed electric charges is as shown below. In each arrangement, at point P, a test charge $+q$ have been placed. The charges and point P all lie on a straight line. The distances between adjacent items, either between two charges or between a charge and point P, all are the same.

Correct order of magnitude of force on P in a decreasing order is

(a) II > I > III > IV
(b) I > II > III > IV
(c) I > IV > II > III
(d) III > IV > I > II

4. A positron and an electron are located in a uniform electric field, they will experience

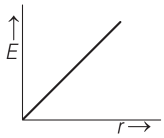
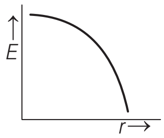
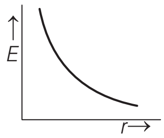
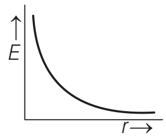
(a) forces equal in same direction
(b) forces equal in magnitude only
(c) equal acceleration in opposite directions
(d) accelerations equal in magnitude only

5. Electric force at a point is given by $F = \frac{1}{4\pi\varepsilon_0} q_0 \int \frac{\sigma dS}{r_0^2}\hat{\mathbf{r}}_0$.

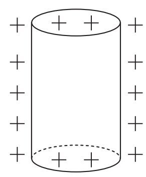
The nature of charges are

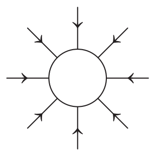
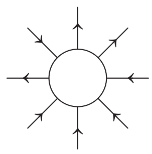
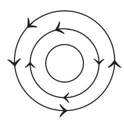
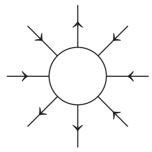
(a) concentrated at a point
(b) spread over a thin rod
(c) uniformly distributed over a surface
(d) uniformly distributed by a closed surface

6. A uniformly charged solid cube has its dimensions $(a \times a \times a)\,\text{cm}^3$. The variation of electric field at $r >> a$ can be represented by

(a) 
(b) 
(c) 
(d) 

7. For a uniformly charged cylinder, which of the following figure represents the top view sketch of electric field lines?



(a) 
(b) 
(c) 
(d) 

8. The electric field acting at a certain region is given by the expression $E = Ar^2$. A charge contained in a sphere of radius a centred at the origin of the field will be given by

(a) $A\varepsilon_0 a^2$
(b) $4\pi\varepsilon_0 Aa^4$
(c) $\varepsilon_0 Aa^3$
(d) $4\pi\varepsilon_0 Aa^2$

9. An electric dipole has a pair of equal and opposite point charges q and $-q$ are separated by a distance $2x$. The axis of the dipole is defined as

(a) direction from positive charge to negative charge
(b) direction from negative charge to positive charge
(c) perpendicular to the line joining the two charges drawn at the centre and pointing upward direction
(d) perpendicular to the line joining the two charges drawn at the centre and pointing downward direction

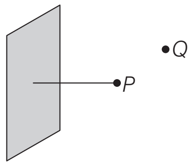
10. An electric dipole is situated along the X-axis at the origin O. A point P making an angle $\frac{\pi}{3}$ with the X-axis is located 20 cm away from the origin. If the electric field at P makes an angle θ with X-axis, the value of θ will be

(a) $\frac{\pi}{3}$
(b) $\frac{\pi}{3} + \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$
(c) $\frac{2\pi}{3}$
(d) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

11. An electric dipole of dipole length 2 cm is placed in a uniform electric field intensity 2×10^5 N/C, making an angle 30° with the field. If it experiences a torque equal to 4 N-m, the charge on the dipole is

(a) 8 mC
(b) 2 mC
(c) 5 mC
(d) 7 mC

12. A thin infinite uniformly charged plane sheet, is given in the figure below



Study the following statements.

I. Electric field at P is equal to electric field at Q.

II. Conducting thin sheet produces double electric field strength at P as compared to non-conducting thin sheet.

III. Gauss's law is not applicable to a charged thin conducting sheet.

Now, choose the correct statement(s).

(a) Only I
(b) Only II
(c) Both I and II
(d) All of these

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** A metal ball is suspended in a uniform electric field with the help of an insulating thread. When a high energy X-ray beam falls on the ball, the ball gets deflected in the direction of electric field.

Reason The ball will oscillate in the electric field.

14. **Assertion** If the bob of a simple pendulum is kept in a horizontal electric field, its period of oscillation will remain same.

Reason If bob is charged and kept in horizontal electric field, then the time period will be decreased.

15. **Assertion** On going away from a point charge or a small electric dipole, electric field decreases at the same rate in both the cases.

Reason Electric field at a point is inversely proportional to the square of distance from the charge and also due to an electric dipole.

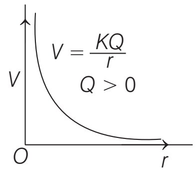
Answers

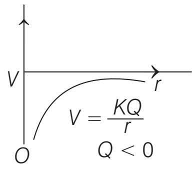
1. *(c)*	**2.** *(c)*	**3.** *(c)*	**4.** *(b)*	**5.** *(d)*
6. *(d)*	**7.** *(b)*	**8.** *(b)*	**9.** *(b)*	**10.** *(b)*
11. *(b)*	**12.** *(c)*	**13.** *(c)*	**14.** *(b)*	**15.** *(d)*

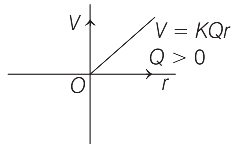
2. Electrostatic Potential and Capacitance

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. Which of the following V *versus* r graph, for a point charge is incorrect?

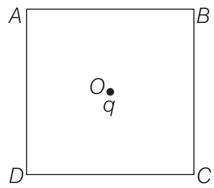
(a) 

(b) 

(c) 

(d) None of these

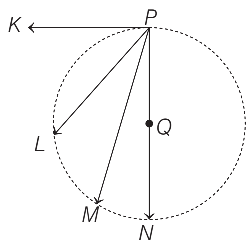
2. 1 nC charge is situated at the centre of square having side $a = 2$ cm.



The work done in moving a charge of 1 C from the corner A to B is

(a) 450 J (b) zero (c) 450 erg (d) 225 J

3. A charge Q is located at the centre of a circle. Work done will be maximum, when another charge is taken from point P to



(a) K (b) L (c) M (d) N

4. A conducting sphere is given a positive charge Q, then which of the following statement(s) is/are correct regarding the given system?

(a) Electric potential at the surface of the sphere is zero.
(b) Electric potential within the sphere is zero.
(c) Electric field is normal to the surface of the sphere.
(d) Electric field varies within the sphere.

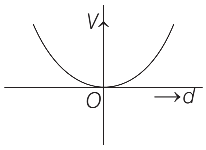
5. The displacement of a charge Q in the electric field $\mathbf{E} = A_1\hat{\mathbf{i}} + A_2\hat{\mathbf{j}} + A_3\hat{\mathbf{k}}$ is $\mathbf{r} = a\hat{\mathbf{i}} + b\hat{\mathbf{j}}$. The work done is

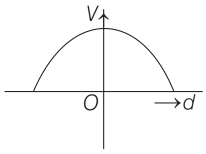
(a) $Q(A_1a + A_2b)$ (b) $(A_1b + A_2a)$ (c) $-(A_1b + A_2a)$ (d) $-Q(A_1a + A_2b)$

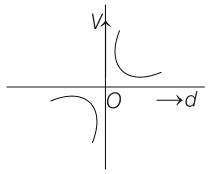
6. Two equal and opposite charges are placed at some distance apart in vacuum. At the middle point of the axis of line joining, these two charges

(a) electric field is zero and potential is finite
(b) electric field is finite and potential is zero
(c) Both electric field and potential are zero
(d) Both electric field and potential are maximum

7. An electric dipole is placed in vacuum. By considering the mid-point of the dipole as the origin, graph of potential *versus* distance from the origin will be

(a) 

(b) 

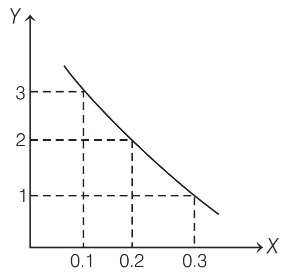
(c) 

(d) None of these

8. What is incorrect for equipotential surface for uniform electric field?

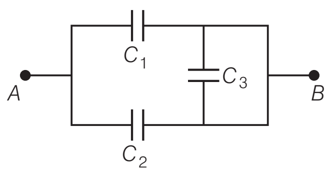
(a) Equipotential surface is flat
(b) Two equipotential surfaces can cross each other
(c) Electric lines are perpendicular to equipotential surface
(d) Work done is zero

9. The variation of potential V with distance x from a fixed point charge is as shown in figure. The electric field strength between $x = 0.1$ m and 0.3 m is



(a) 0.4 Vm^{-1} (b) – 0.4 Vm^{-1} (c) 10 Vm^{-1} (d) – 10 Vm^{-1}

10. The equivalent capacitance of the combination of three capacitors, each of capacitance C as shown in figure between points A and B is

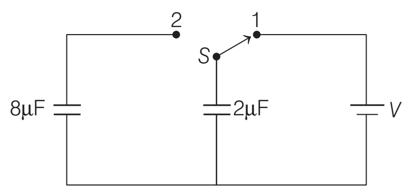


(a) $\frac{C}{2}$ (b) $\frac{3C}{2}$ (c) $\frac{1}{3C}$ (d) 2C

11. A condenser of capacity 30 μF is charged to 12 V. It acquires electric energy equal to

(a) 2.16 mJ (b) 2.16 μJ (c) 5.02 mJ (d) 5.02 μJ

12. In the given figure, 2μF capacitor is charged. When switch S is turned to position 2, the percentage of stored energy loss is



(a) 0% (b) 20% (c) 75% (d) 80%

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** A and B are two conducting spheres of same radii. A being solid and B being hollow. Both are charged to the same potential, then charge on A is equal to charge on B.

Reason Potentials on both are same.

14. **Assertion** The capacity of a given conductor remains constant even, if charge is varied on it.

Reason Capacitance depends on the medium as well as the shape and size of the conductor only.

15. **Assertion** A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times.

Reason The surface density of charge on the plate remains constant or unchanged.

Answers

1. (c)	**2.** (b)	**3.** (a)	**4.** (c)	**5.** (d)
6. (c)	**7.** (a)	**8.** (b)	**9.** (c)	**10.** (d)
11. (a)	**12.** (d)	**13.** (a)	**14.** (a)	**15.** (c)

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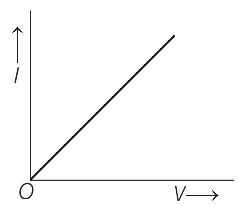
3. Current Electricity

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. An ammeter and a voltmeter of resistance R are connected in series and their reading are A and V, respectively. If another resistance R is connected in parallel with voltmeter, then

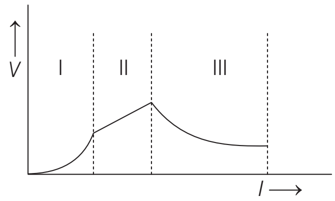
(a) both A and V will increase
(b) both A and V will decrease
(c) A will decrease and V will increase
(d) A will increase and V will decrease

2. A copper wire has length l and cross-sectional area A. In an experiment to verify Ohm's law, the I -V characteristic of the wire is drawn as follows



The slope of the graph becomes
(a) more, if experiment is performed at higher temperature
(b) more, if steel wire is used
(c) more, if the length of the wire is increased
(d) less, if the length of the wire is increased

3. A graph of voltage *versus* current for an electric element is as shown below



In which of the following region is the element ohmic in nature?
(a) Only I (b) Only II (c) Only III (d) None of these

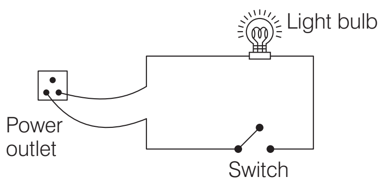
4. As the temperature increases, the resistance of the metallic conductors increases because
(a) collisions of the conducting electrons with the metal ions decreases
(b) collisions of conducting electrons with the lattice consisting of the ions of the metal increases
(c) the number of collisions between free electrons decreases
(d) the number of collisions between free electrons increases

5. A wire of length l is stretched by 10%, the percentage increase in resistance will be
(a) 1% (b) 1.1% (c) 11% (d) 21%

6. Two wires are joined together in series. The temperature coefficient of resistance wires are R_1 and R_2 is α_1 and α_2, respectively. The effective temperature coefficient of resistance is
(a) $\alpha_1 + \alpha_2$ (b) $\dfrac{\alpha_1 R_1 + \alpha_2 R_2}{R_2 + R_1}$ (c) $\sqrt{\alpha_1 \alpha_2}$ (d) $\alpha_1 \alpha_2$

7. For two incandescent bulbs of rated power P_1 and P_2, if $P_1 > P_2$. Then, choose the correct statement.
(a) Filament of bulb 1 is more thicker than filament of bulb 2.
(b) Filament of bulb 1 is thinner than the filament of bulb 2.
(c) Filament of both bulbs is of same thickness.
(d) Rated power of a bulb is independent of filament thickness.

8. A bulb of rating 60W, 220V is being used as a light source daily. Its circuit is as shown in the figure below

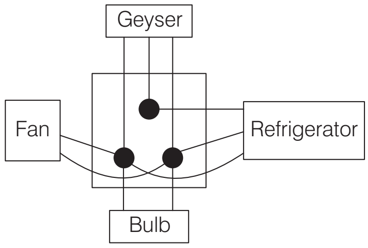


I. Resistance of the bulb must be lower than 1 kΩ.
II. Current through the bulb is less than 1 A.
III. Energy consumed by the bulb is 60 J/h.

Choose the correct statement(s).

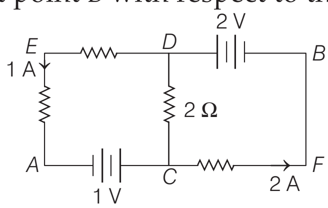
(a) Only I (b) Only II
(c) Both I and II (d) Both II and III

9. In a household connection, four electrical appliances are used from a single socket. If geyser, refrigerator, bulb and fan uses 4A, 2A, 1A and 1A current respectively, then current received from the main supply by the socket will be



(a) 2 A (b) 4A (c) 8A (d) 10A

10. In the given circuit, currents in different branches and value of one resistor are shown in figure. Then, potential at point *B* with respect to the point *A via C* and *D* is



(a) 2 V (b) –2 V (c) –1 V (d) 1 V

11. Which of the following statement(s) is/are incorrect?

(a) A galvanometer is placed at the centre of a Wheatstone bridge.
(b) In a balanced Wheatstone bridge, cell and galvanometer can be interchanged without disturbing null point.
(c) A rheostat is used as a potential divider.
(d) Accuracy of a meter bridge decrease upon increasing the length of the resistance wire.

12. For which of the following pairs of resistors, the balancing length will be 0.25 m in a meter bridge?

(a) 7 Ω, 3Ω (b) (7/3) Ω, 7Ω (c) 25Ω, 7Ω (d) 2Ω, 3Ω

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** The electron drift velocity is small and the charge on the electron is also small but still, we obtain large current in a conductor.

Reason This is due to the conducting property of the conductor.

14. **Assertion** During charging, the current flows in opposite directions in a cell.

Reason Terminal voltage of the cell is higher than the emf of the cell.

15. **Assertion** A potentiometer is preferred over that of a voltmeter for measurement of emf of a cell.

Reason Potentiometer does not draw any current from the cell.

Answers

1. (d)	2. (d)	3. (b)	4. (d)	5. (d)
6. (b)	7. (a)	8. (c)	9. (c)	10. (d)
11. (d)	12. (b)	13. (c)	14. (a)	15. (a)

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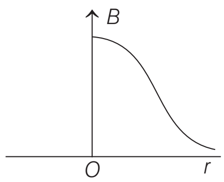
4. Moving Charges and Magnetism

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. Which of the following statement(s) is/are correct for the magnetic field strength at a point due to a long straight conductor?
(a) It obeys the inverse square law.
(b) It varies inversely as the distance from the conductor.
(c) It varies inversely as the cube of the distance from the conductor.
(d) It varies directly as the distance from the conductor.

2. A graph of a magnetic field *versus* distance, for a current carrying loop of radius R is given below.



Which of the following expression is true for the graph?
(a) For $r = 0$, magnetic field (B) is maximum and for $r >> R$, $B \propto \frac{1}{r^3}$.
(b) For $r = 0$, magnetic field (B) is maximum and for $r >> R$, $B \propto \frac{1}{r^2}$.
(c) For $r = 0$, magnetic field (B) is minimum and for $r >> R$, $B \propto r$.
(d) For $r = 0$, magnetic field (B) is minimum and for $r >> R$, $B \propto \frac{1}{r}$.

3. In a long straight wire placed along Z-axis , a current i flows in the negative z-direction. At a point (x, y) in a plane $z = 0$, the magnetic field B is

(a) $\frac{\mu_0 i}{2\pi}\left(\frac{y\hat{\mathbf{i}} - x\hat{\mathbf{j}}}{x^2 + y^2}\right)$ (b) $\frac{\mu_0 i}{2\pi}\left(\frac{x\hat{\mathbf{j}} - y\hat{\mathbf{i}}}{x^2 + y^2}\right)$ (c) $\frac{\mu_0 i}{2\pi}\left(\frac{x\hat{\mathbf{i}} - y\hat{\mathbf{j}}}{x^2 + y^2}\right)$ (d) $\frac{\mu_0 i}{2\pi}\left(\frac{x\hat{\mathbf{i}} + y\hat{\mathbf{j}}}{x^2 + y^2}\right)$

4. An observer moves past an electron at rest. His instrument can measure
(a) an electric field only (b) a magnetic field only
(c) both electric and magnetic fields
(d) any of the two fields, depending upon his speed

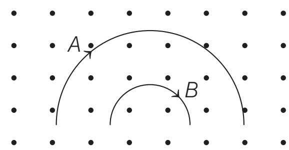
5. An electron is moving with a uniform velocity u along positive X-axis. It enters a region of magnetic field at $y>0$, where

$B=0$; for $x, y \le 0$ and $B=B_0$; for $x, y>0$.

The electron exits from the region after some time with velocity v at coordinate y, then

(a) $v>u, y<0$
(b) $v=u, y>0$
(c) $v>u, y>0$
(d) $v=u, y<0$

6. Two particles A and B of masses m_A and m_B, respectively having same charge are moving in a plane. Both particles enter in a uniform magnetic field perpendicular to the plane. If speed of the particles are v_A and v_B respectively, then

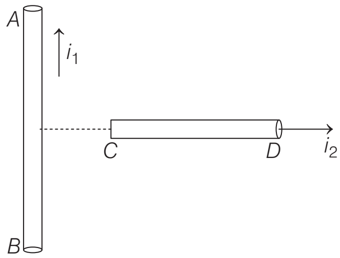


(a) $m_A v_A < m_B v_B$
(b) $m_A v_A > m_B v_B$
(c) $m_A < m_B$ and $v_A < v_B$
(d) $m_A = m_B$ and $v_A = v_B$

7. An electron is moving in a circular path under the influence of a transverse magnetic field 3.57×10^{-2} T. If the value of $\frac{e}{m}$ is 1.76×10^{11} C/kg, then the frequency of revolution of the electron is

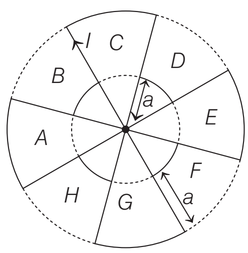
(a) 6.82 MHz
(b) 1 GHz
(c) 100 MHz
(d) 62.8 MHz

8. For the set-up given in the figure, rod AB is fixed and rod CD is movable. Which of the following statement(s) is/are correct, when current i_1 is passed through AB?



(a) The field at C is upward and the rod CD will move upwards parallel to itself.
(b) The field at C is upward and the rod CD will move downwards parallel to itself.
(c) The field at C is downward and the rod CD will move upward and turn clockwise at the same time.
(d) The field at C is downward and the rod CD will move upward and turn anti-clockwise at the same time.

9. A circle is segmented into 8 equal parts. If current I flows through the circle, then magnetic moment due to given figure is



(a) $\frac{7}{2} I\pi a^2$
(b) $\frac{5}{2} I\pi a^2$
(c) $4 I\pi a^2$
(d) $\frac{5}{3} I\pi a^2$

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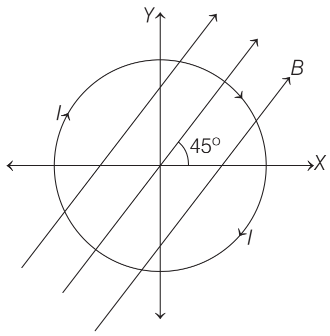
10. A constant current I is flowing through a circular coil placed in a uniform magnetic field B as shown in figure, then the



(a) loop is in stable equilibrium
(b) loop is in unstable equilibrium
(c) torque acting on the loop is maximum
(d) torque acting on the loop is $\frac{1}{\sqrt{2}}$ times the maximum torque

11. The full scale deflection current of a galvanometer of resistance 1Ω is 5 mA. The value of shunt to be added in series to convert it into a voltmeter of range 5 V is

(a) 1.5 kΩ
(b) 1 kΩ
(c) 0.5 kΩ
(d) 100 Ω

12. Which of the following statement(s) is/are correct about galvanometer?

I. Galvanometer constant is dimensionless.
II. Current sensitivity is expressed as the exact reverse of the galvanometer constant.

(a) Only I
(b) Only II
(c) Both I and II
(d) None of these

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** When two long straight wires are connected to a battery, they may come closer to each other.

Reason Force of attraction acts between two wires carrying current.

14. **Assertion** The net force on a closed current loop placed in a uniform magnetic field is zero.

Reason The torque produced in a conducting loop is zero, when it is placed in a uniform magnetic field such that magnetic field is perpendicular to the plane of the loop.

15. **Assertion** Magnetic field at any point except inside due to a toroid is zero, which means no magnetic force is experienced around a toroid.

Reason Magnetic field due to a coil is maximum at centre and decreases rapidly, as the distance from the wire increases.

Answers

1. (b)	**2.** (a)	**3.** (c)	**4.** (c)	**5.** (d)
6. (b)	**7.** (b)	**8.** (c)	**9.** (b)	**10.** (c)
11. (b)	**12.** (b)	**13.** (c)	**14.** (b)	**15.** (a)

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5. Magnetism and Matter

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. Magnets found in nature are called natural magnets. Which of the following is the property of natural magnets?

I. Strong field   II. Weak field strength
III. Regular shape   IV. Irregular shape

(a) Both I and II   (b) Both II and IV   (c) Both II and III   (d) Both I and IV

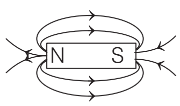
2. If L_e is the effective length and L_g is the geometric length of a bar magnet, then $\frac{L_e}{L_g}$ is equal to

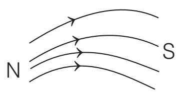
(a) $\frac{1}{2}$ (b) $\frac{3}{4}$ (c) $\frac{5}{6}$ (d) $\frac{8}{9}$

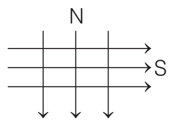
3. The direction of magnetic moment in a bar magnet is given by which of the following directions?

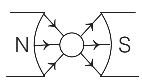
(a) $N \rightarrow S$ (b) $S \rightarrow N$ (c) Both (a) and (b)   (b) None of these

4. Which of the following figure does not represent magnetic lines of force?

(a) 

(b) 

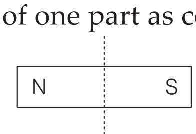
(c) 

(d) 

5. Which of the following statement(s) is/are correct?

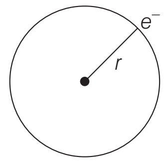
(a) Magnitude of dipole moment due to a current loop is given by $I^2 A$.
(b) The direction of the dipole moment due to a current loop is given by right hand thumb rule.
(c) The direction of the dipole moment due to a current loop is given by Fleming's left hand rule.
(d) None of the above

6. A thin bar magnet is cut into two equal parts as shown below. The ratio of moment of inertia to the magnetic moment of one part as compared to original magnet will be



(a) $\frac{1}{2}$ (b) $\frac{1}{4}$ (c) $\frac{1}{3}$ (d) $\frac{1}{6}$

7. An electron moves along a circle of radius r, with constant speed v. Its magnetic moment will be



(a) evr (b) $\frac{1}{2}evr$ (c) $\pi r^2 ev$ (d) $2\pi rev$

8. Earth has a huge magnetic field around it. It is also called magnetosphere.

I. Magnetic field of earth is similar to that of a bar magnet.
II. Magnetic South-pole of earth is close to geographical North-pole.
III. Strength of earth's magnetic field is very large.

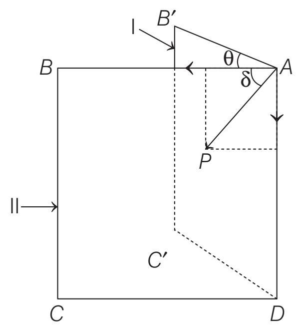
Which of the following statement(s) is/are correct?

(a) Only I (b) Only II (c) Both I and II (d) Both II and III

9. Which of the following is not an element of earth's magnetic field?

(a) Angle of declination
(b) Angle of repose
(c) Angle of dip
(d) Horizontal component of earth's magnetic field

10. A figure of magnetic elements of earth is given below



Which of the following statement(s) is/are correct about the figure?

(a) Labelled parts I and II represent respectively magnetic meridian and geographic meridian.
(b) Labelled parts I and II represent respectively geographic meridian and magnetic meridian.
(c) Labelled parts I and II represent respectively horizontal component of earth's magnetic field and magnetic equator.
(d) Labelled parts I and II represent respectively magnetic meridian and horizontal component of earth's magnetic field.

11. The plane of a dip circle in geographic meridian is set-up, such that apparent dip is δ_1. It is again set-up in vertical plane perpendicular to geographic meridian, such that apparent dip is δ_2. Then, the declination angle α at the place is given by

(a) $\alpha = \tan^{-1}(\tan\delta_1 + \tan\delta_2)$ (b) $\alpha = \tan^{-1}(\tan\delta_1 \tan\delta_2)$

(c) $\alpha = \tan^{-1}\left(\frac{\tan\delta_1}{\tan\delta_2}\right)$ (d) $\alpha = \tan^{-1}(\tan\delta_1 - \tan\delta_2)$

12. Consider a plane S formed by the dipole axis and the axis of the earth's rotational plane. Let *P* be the point on the magnetic equator in plane *S*. Let *Q* be the point of intersection of the geographical and magnetic meridian. Declination and dip angle at *P* and *Q* respectively, are

(a) at *P*; 0, 0 and at *Q* ; 0,0
(b) at *P*; 11.3°, 0 and at *Q* ; 0,0
(c) at *P*; 0, 11.3° and at *Q* ; 0,0
(d) at *P*; 0, 0 and at *Q* ; 0,11.3°

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** The poles of magnet cannot be separated by breaking into two pieces.
Reason The magnetic moment will be reduced to half, when a magnet is broken into two equal pieces.

14. **Assertion** When radius of the circular loop carrying current is doubled, its magnetic moment becomes four times.
Reason Magnetic moment depends on area of the loop.

15. **Assertion** Magnetism is relativistic in nature, i.e. stationary charges do not produce magnetic field.
Reason When we move along with the charge, i.e. there is no relative motion, then we find no magnetic field associated with the charge.

Answers

1. (b)	**2.** (c)	**3.** (b)	**4.** (c)	**5.** (b)
6. (b)	**7.** (b)	**8.** (c)	**9.** (b)	**10.** (b)
11. (c)	**12.** (d)	**13.** (b)	**14.** (a)	**15.** (a)

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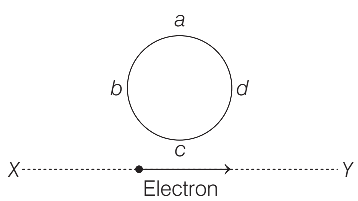
6. Electromagnetic Induction

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. Magnetic field of 3×10^6 T is passing through a surface normally. If the area of the surface is 10^2cm^2, then the flux through the surface is

(a) 3×10^4T (b) 3×10^4 Wb (c) 3×10^5 T (d) 3×10^5Wb

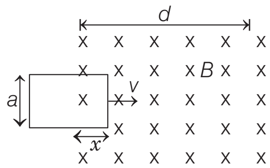
2. An electron moving in a straight line is as shown below. A circular coil *abcd* is placed adjacent to the path of electron, the direction of induced current is

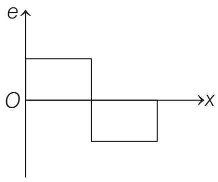


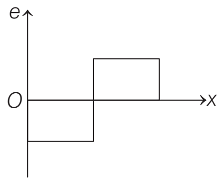
(a) *adcb*
(b) in opposite direction, as the electron goes past the coil
(c) No current induced
(d) *abcd*

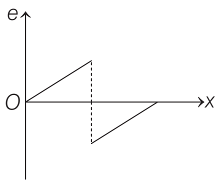
3. A metal rod moves in a uniform magnetic field. The velocity of the rod is perpendicular to the direction of magnetic field across the length of rod. Select the correct statement from the following.
(a) The entire rod is at the same electric potential.
(b) There is an electric field in the rod.
(c) The electric potential is highest at the centre of the rod and decreases towards its ends.
(d) The electric potential is lowest at the centre of the rod and increases towards its ends.

4. A rectangular loop having constant speed v is traversing along a magnetic field B ofcertain thickness d. The graph between position x of the right hand edge of the loop and the induced emf e will be



(a)


(b)


(c)


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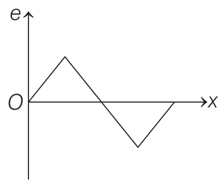
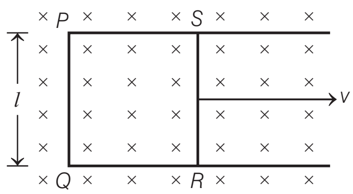


5. Figure shows a rectangular conducting loop $PQRS$ in which arm RS of length l is movable. The loop is kept in a uniform magnetic field B directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed v.

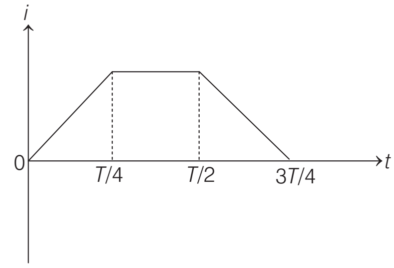


The power dissipated by heat is

(a) $\frac{v^2 B^2 l^2}{R}$ (b) $\frac{v^2 B^2 l^2}{R^2}$ (c) $\frac{vB^2 l^2}{R^2}$ (d) $\frac{vB^2 l^2}{R}$

6. When the current in a coil changes from 8A to 2 A in 3×10^{-2} s, the emf induced in the coil is 2V. The self-inductance of the coil (in mH) is
(a) 1 (b) 5 (c) 20 (d) 10

7. The current i in a coil varies with time as shown in the figure. The variation of induced emf with time would be represented by



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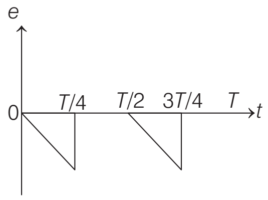

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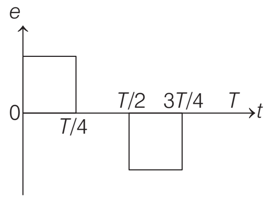

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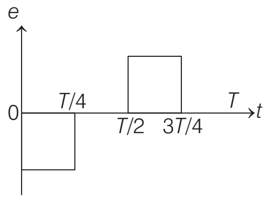

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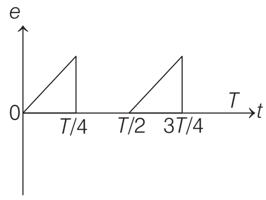

8. An incandescent light bulb takes some time to heat up and produce light, whereas a fluorescent tubelight instantly lightens up. Which of the following device is used to achieve fast action of tubelight?

(a) Capacitor bank (b) Choke coil
(c) Rheostat (d) Thermostat

9. A inductor of length l is cut into three equal pieces and joined in parallel in the circuit. The ratio of $\frac{L}{L'}$ is

(a) $\frac{1}{3}$ (b) $\frac{1}{9}$ (c) 9 (d) 3

10. In which of the following cases (for, $t >> 0$), an inductor will work properly?

(a) $I = 0$ (b) $I =$ constant (c) $I = I_0 \sin \omega t$ (d) $I = \frac{I_0}{\sqrt{2}}$

11. Mutual inductance between two magnetically coupled coils, depend on

(a) nature of material
(b) number of turns of the coils
(c) cross-sectional area of their common core
(d) All of the above

12. The energy density in the magnetic field is given by $\frac{1}{2\mu_0} B^2$.

The energy stored by solenoid is given by

(a) $\frac{1}{2} \frac{N^2 B^2 L}{\mu_0 N^2}$ (b) $\frac{1}{2} \frac{AB^2 L}{\mu_0}$ (c) $\frac{1}{2} \frac{B^2}{\mu_0} \frac{A^2}{L^2}$ (d) None of these

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** Lenz's law violates the principle of conservation of energy.
Reason Induced emf do not oppose the change in magnetic flux responsible for its production .

14. **Assertion** Eddy currents are produced in any metallic conductor, when magnetic flux is changed around it.
Reason Electric potential determines the flow of charge.

15. **Assertion** Acceleration of a magnet falling through a solenoid decreases.
Reason The induced current produced in a circuit always flow in such a direction that it opposes the change that produced it.

Answers

1. (b)	**2.** (b)	**3.** (b)	**4.** (b)	**5.** (a)
6. (d)	**7.** (c)	**8.** (b)	**9.** (c)	**10.** (c)
11. (d)	**12.** (b)	**13.** (d)	**14.** (b)	**15.** (a)

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7. Alternating Current

Direction (Q. Nos. 1-12) *Each of the question has four options out of which only one is correct. Select the correct option as your answer.*

1. For which value of angular frequency ω, the current is not alternating in nature?
(a) $\omega = \frac{\pi}{2}$ (b) $\omega = 2\pi$ (c) $\omega = 0$ (d) $\omega = \frac{4\pi}{3}$

2. The ratio of average value of AC to the peak value of AC is
(a) $\frac{2}{\pi}$ (b) $\frac{\pi}{2}$ (c) $\frac{1}{\pi}$ (d) π

3. Consider an electric circuit containing a capacitor of capacitance C and electric bulb of resistance R. An AC of variable frequency is supplied to the circuit.
Then, which of the following statement(s) is/are correct?
(a) When ω is increased, the bulb glows dimmer.
(b) When ω is increased, the bulb glows brighter.
(c) When ω is increased, total impedance of the circuit remains unchanged.
(d) When ω is increased, total impedance of the circuit increases.

4. In an AC circuit, an alternating voltage $V = 200\sqrt{2} \sin 100\, t$ volt is connected to a capacitor of capacity 1μF. The rms value of current in the circuit is

(a) 20mA (b) 10mA (c) 100mA (d) 200mA

5. An inductance and a resistance are connected in series with an AC source. Choose the correct statement from the following.

(a) The current across the resistance leads the current across the inductance by $\frac{\pi}{2}$.

(b) The current and the potential difference across the resistance lag behind the potential difference across the inductance by an angle $\pi/2$.

(c) The current and the potential difference across the resistance lag behind the potential difference across the inductance by an angle π.

(d) The potential difference across the resistance lags behind the potential difference across the inductance by an angle $\pi/2$ but the current in the resistance leads the potential difference across the inductance by $\pi/2$.

6. A resistance draws power P, when connected to an AC. If an inductance is connected in series with resistance, the new impedance becomes Z. The power drawn will be

(a) $P\sqrt{\frac{R}{Z}}$ (b) $P\left(\frac{R}{Z}\right)$ (c) P (d) $P\left(\frac{R}{Z}\right)^2$

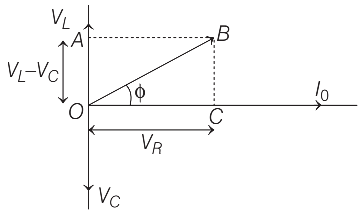
7. Circuit A contains condenser and circuit B contains inductor only. Same current I flows in the circuit. If frequency of the applied voltage is increased, then which of the following relation holds true?

(a) $I_A < I_B$ (b) $I_A = I_B$ (c) $I_A > I_B$ (d) $I_A = I_B = 0$

8. In an L-C-R series resonating circuit, the average power loss is given by

(a) VI (b) $\frac{VI}{2}$ (c) $\frac{VI}{\sqrt{2}}$ (d) $\frac{VI}{\sqrt{3}}$

9. A phasor diagram of a circuit is given below



Identify the circuit and formula of impedance.

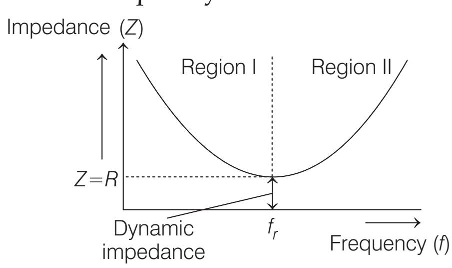
(a) Series L-C-R, impedance = R

(b) Parallel L-C-R, impedance = 0

(c) Series L-C-R, impedance = $\sqrt{R^2 + (X_L - X_C)^2}$

(d) Parallel L-C-R, impedance = $\sqrt{R^2 + (X_C - X_L)^2}$

10. A graph of impedance *versus* frequency for series resonance circuit is given below



Which of the following option is correct?

(a) For region I, $X_C > X_L$
(b) For region II, $X_C > X_L$
(c) For region I, $X_L > X_C$
(d) For region II, $X_L = X_C$

11. A student finds out voltage and current measurements from an unknown combination of *R*, *L* and *C*.

The measurements are $e = 75\sin(\omega t)$ V and $I = 1.5\sin\left(\omega t + \frac{\pi}{4}\right)$A.

Which of the following statement(s) is/are correct?

I. There must be a capacitor in the circuit.
II. There must be an inductor in the circuit.
III. There must be a resistance in the circuit.

(a) Only I
(b) Only II
(c) Both I and III
(d) Both II and III

12. An AC generator can be converted into DC generator by

(a) removing commutator
(b) connecting commutator
(c) reducing turns of coil
(d) reversing the magnetic field

ASSERTION-REASONING MCQs

Direction (Q. Nos. 13-15) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

13. **Assertion** In a pure inductive circuit, current decreases, when frequency increases.

Reason The current is inversely proportional to the frequency of alternating current.

14. **Assertion** When capacitive reactance (X_C) is smaller than the inductive reactance (X_L) in *L-C-R* circuit, emf leads the current.

Reason The phase angle between the alternating emf and alternating current of the circuit is positive.

15. **Assertion** A transformer can never be 100% efficient. There is always some energy loss in transformer.

Reason Flux leakage, resistance of windings and eddy currents are very common causes which results in energy loss.

Answers

1. (c)	**2.** (a)	**3.** (b)	**4.** (a)	**5.** (a)
6. (d)	**7.** (a)	**8.** (b)	**9.** (c)	**10.** (a)
11. (c)	**12.** (b)	**13.** (a)	**14.** (a)	**15.** (a)

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Latest CBSE
SAMPLE PAPER

Latest Sample Question Paper for Class XII (Term I)
Issued by CBSE on 2 Sept, 2021

Physics Class 12 (Term I)

Instructions

1. This question paper is divided into three sections.
   (a) Section A contains 25 questions. Attempt any 20 questions.
   (b) Section B contains 24 questions. Attempt any 20 questions.
   (c) Section C contains 6 questions. Attempt any 5 questions.
2. Each question carries 0.77 mark.
3. There is **no** negative marking.

Maximum Marks : 35 **Time : 90 Minutes**

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. Which of the following is not the property of equipotential surface?
(a) They do not cross each other.
(b) The rate of change of potential with distance on them is zero.
(c) For a uniform electric field, they are concentric spheres.
(d) They can be imaginary spheres.

2. Two point charges $+8q$ and $-2q$ are located at $x = 0$ and $x = L$, respectively. The point on X-axis at which net electric field is zero due to these charges, is
(a) $8L$ (b) $4L$ (c) $2L$ (d) L

3. An electric dipole of moment p is placed parallel to the uniform electric field. The amount of work done in rotating the dipole by 90° is
(a) $2pE$ (b) pE (c) $pE/2$ (d) zero

4. Three capacitors $2\,\mu F$, $3\,\mu F$ and $6\,\mu F$ are joined in series with each other. The equivalent capacitance is
(a) $1/2\,\mu F$ (b) $1\,\mu F$ (c) $2\,\mu F$ (d) $11\,\mu F$

5. Two point charges placed in a medium of dielectric constant 5 are at a distance r between them, experience an electrostatic force F. The electrostatic force between them in vacuum at the same distance r will be
(a) $5F$ (b) F (c) $F/2$ (d) $F/5$

6. Which statement is true for Gauss's law?
(a) All the charges whether inside or outside the gaussian surface contribute to the electric flux.
(b) Electric flux depends upon the geometry of the gaussian surface.
(c) Gauss's theorem can be applied to non-uniform electric field.
(d) The electric field over the gaussian surface remains continuous and uniform at every point.

7. A capacitor plates are charged by a battery with V volts. After charging battery is disconnected and a dielectric slab with dielectric constant K is inserted between its plates, the potential across the plates of a capacitor will become
(a) zero (b) $V/2$ (c) V/K (d) KV

8. The best instrument for accurate measurement of emf of a cell is
(a) potentiometer (b) meter bridge
(c) voltmeter (d) ammeter and voltmeter

9. An electric current is passed through a circuit containing two wires of same material, connected in parallel. If the lengths and radii of the wires are in the ratio of 3 : 2 and 2 : 3, then the ratio of the current passing through the wire will be
(a) 2 : 3 (b) 3 : 2 (c) 8 : 27 (d) 27 : 8

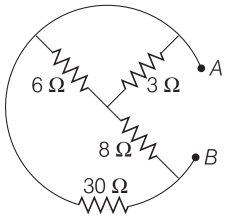
10. By increasing the temperature, the specific resistance of a conductor and a semiconductor
(a) increases for both
(b) decreases for both
(c) increases for a conductor and decreases for a semiconductor
(d) decreases for a conductor and increases for a semiconductor

11. We use alloys for making standard resistors because they have
(a) low temperature coefficient of resistivity and high specific resistance
(b) high temperature coefficient of resistivity and low specific resistance
(c) low temperature coefficient of resistivity and low specific resistance
(d) high temperature coefficient of resistivity and high specific resistance

12. A constant voltage is applied between the two ends of a uniform metallic wire, heat H is developed in it. If another wire of the same material, double the radius and twice the length as compared to original wire is used, then the heat developed in it will be
(a) $H/2$ (b) H (c) $2H$ (d) $4H$

13. If the potential difference V applied across a conductor is increased to $2V$ with its temperature kept constant, then the drift velocity of the free electrons in a conductor will
(a) remain the same (b) become half of its previous value
(c) be double of its initial value (d) become zero

14. The equivalent resistance between A and B is



(a) 3 Ω (b) 5.5 Ω (c) 7.5 Ω (d) 9.5 Ω

15. The SI unit of magnetic field intensity is

(a) $A\text{-}mN^{-1}$
(b) $NA^{-1}\ m^{-1}$
(c) $NA^{-2}m^{-2}$
(d) $NA^{-1}m^{-2}$

16. The coil of a moving coil galvanometer is wound over a metal frame in order to

(a) reduce hysteresis
(b) increase sensitivity
(c) increase moment of inertia
(d) provide electromagnetic damping

17. Two wires of the same length are shaped into a square of side *a* and a circle with radius *r*. If they carry same current, the ratio of their magnetic moment is

(a) $2:\pi$
(b) $\pi:2$
(c) $\pi:4$
(d) $4:\pi$

18. The horizontal component of earth's magnetic field at a place is $\sqrt{3}$ times the vertical component. The angle of dip (in rad) at that place is

(a) $\pi/6$
(b) $\pi/3$
(c) $\pi/4$
(d) $0°$

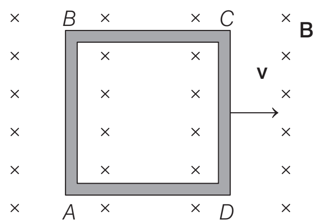
19. The small angle between magnetic axis and geographic axis at a place is

(a) magnetic meridian
(b) geographic meridian
(c) magnetic inclination
(d) magnetic declination

20. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon the

(a) rate at which current change in the two coils
(b) relative position and orientation of the two coils
(c) rate at which voltage induced across two coils
(d) currents in the two coils

21. A conducting square loop of side *L* and resistance *R* moves in its plane with the uniform velocity *v* perpendicular to one of its sides. A magnetic induction *B* constant in time and space pointing perpendicular and into the plane of the loop exists everywhere as shown in the figure. The current induced in the loop is

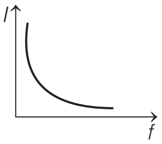


(a) BLv/R, clockwise
(b) BLv/R, anti-clockwise
(c) $2\,BLv/R$, anti-clockwise
(d) zero

22. The magnetic flux linked with the coil (in Wb) is given by the equation $\phi = 5t^2 + 3t + 16$. The induced emf in the coil at time $t = 4$ s will be

(a) – 27 V
(b) – 43 V
(c) – 108 V
(d) 210 V

23. Which of the following graphs represent the variation of current I with frequency f in an AC circuit containing a pure capacitor?

(a)


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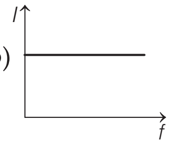

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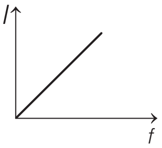

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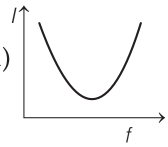


24. A 20 V AC is applied to a circuit consisting of a resistance and a coil with negligible resistance. If the voltage across the resistance is 12 V, then the voltage across the coil is

(a) 16 V (b) 10 V (c) 8 V (d) 6 V

25. The instantaneous values of emf and the current in a series AC circuit are $E = E_0 \sin \omega t$ and $I = I_0 \sin(\omega t + \pi / 3)$ respectively, then it is

(a) necessarily a R-L circuit
(b) necessarily a R-C circuit
(c) necessarily a L-C-R circuit
(d) can be R-C or L-C-R circuit

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. A cylinder of radius r and length l is placed in an uniform electric field parallel to the axis of the cylinder. The total flux for the surface of the cylinder is given by

(a) zero (b) πr^2 (c) $E \pi r^2$ (d) $2 E\pi r^2$

27. Two parallel large thin metal sheets have equal surface densities 26.4×10^{-12} C/m^2 of opposite signs. The electric field between these sheets is

(a) 1.5 N/C
(b) 1.5×10^{-16} N/C
(c) 3×10^{-10} N/C
(d) 3 N/C

28. Consider an uncharged conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is

(a) negative and uniformly distributed over the surface of sphere
(b) positive and uniformly distributed over the surface of sphere
(c) negative and appears at a point the surface of sphere closest to point charge
(d) zero

29. Three charges $2q$, $-q$ and $-q$ lie at vertices of a triangle. The value of E and V at centroid of triangle will be

(a) $E \neq 0$ and $V \neq 0$
(b) $E = 0$ and $V = 0$
(c) $E \neq 0$ and $V = 0$
(d) $E = 0$ and $V \neq 0$

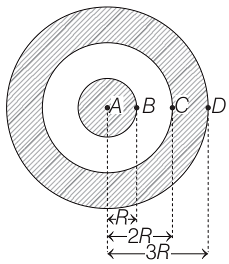
30. Two parallel plate capacitors X and Y, have the same area of plates and same separation between plates. X has air and Y with dielectric of constant 2, between its plates. They are connected in series to a battery of 12 V. The ratio of electrostatic energy stored in X and Y is

(a) 4 : 1 (b) 1 : 4 (c) 2 : 1 (d) 1 : 2

31. Which among the following, is not a cause for power loss in a transformer?
(a) Eddy currents are produced in the soft iron core of a transformer.
(b) Electric flux sharing is not properly done in primary and secondary coils.
(c) Humming sound produced in the tranformers due to magnetostriction.
(d) Primary coil is made up of a very thick copper wire.

32. An alternating voltage source of variable angular frequency ω and fixed amplitude V is connected in series with a capacitance C and electric bulb of resistance R (inductance zero). When ω is increased,
(a) the bulb glows dimmer
(b) the bulb glows brighter
(c) net impedance of the circuit remains unchanged
(d) total impedance of the circuit increases

33. A solid spherical conductor has charge $+Q$ and radius R. It is surrounded by a solid spherical shell with charge $-Q$, inner radius $2R$ and outer radius $3R$. Which one of the following statement is true?

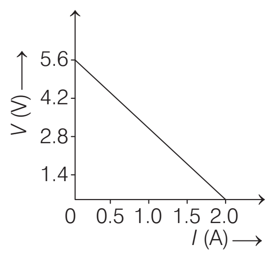


(a) The electric potential has a maximum magnitude at point C and the electric field has a maximum magnitude at point A.
(b) The electric potential has a maximum magnitude at point D and the electric field has a maximum magnitude at point B.
(c) The electric potential at point A is zero and the electric field has a maximum magnitude at point D.
(d) Both the electric potential and electric field achieve a maximum magnitude at point B.

34. A battery is connected to the conductor of non-uniform cross-section area. The quantity which remains constant is
(a) electric field only
(b) drift speed and electric field
(c) electric field and current
(d) current only

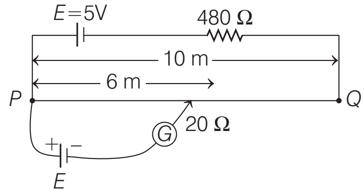
35. Three resistors having values R_1, R_2 and R_3 are connected in series to a battery. Suppose R_1 carries a current of 2.0 A, R_2 has a resistance of 3.0 Ω and R_3 dissipates 6.0 W of power. Then, the voltage across R_3 is
(a) 1 V
(b) 2 V
(c) 3 V
(d) 4 V

36. A straight line plot showing the terminal potential difference (V) of a cell as a function of current (I) drawn from it, is shown in the figure. The internal resistance of the cell would be



(a) 2.8 Ω
(b) 1.4 Ω
(c) 1.2 Ω
(d) zero

37. A 10 m long wire of uniform cross-section and $20\,\Omega$ resistance is used in a potentiometer. The wire is connected in series with a battery of 5 V along with an external resistance of $480\,\Omega$. If an unknown emf E is balanced at 6.0 m length of the wire, then the value of unknown emf is

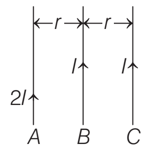


(a) 1.2 V (b) 1.02 V (c) 0.2 V (d) 0.12 V

38. The current sensitivity of a galvanometer increases by 20%. If its resistance also increases by 25%, then the voltage sensitivity will

(a) decreased by 1% (b) increased by 5%
(c) increased by 10% (d) decreased by 4%

39. Three infinitely long parallel straight current carrying wires A, B and C are kept at equal distance from each other as shown in the figure . The wire C experiences net force F .The net force on wire C, when the current in wire A is reversed will be



(a) zero (b) $F/2$ (c) F (d) $2F$

40. In a hydrogen atom, the electron moves in an orbit of radius 0.5 Å making 10 rps, the magnetic moment associated with the orbital motion of the electron will be

(a) 2.512×10^{-38} A-m^2 (b) 1.256×10^{-38} A-m^2
(c) 0.628×10^{-38} A-m^2 (d) zero

41. An air-cored solenoid with length 30 cm, area of cross-section 25 cm^2 and number of turns 800, carries a current of 2.5 A.

The current is suddenly switched OFF in a brief time of 10^{-3} s. Ignoring the variation in magnetic field near the ends of the solenoid, the average back emf induced across the ends of the open switch in the circuit would be

(a) zero (b) 3.125 V (c) 6.54 V (d) 16.74 V

42. A sinusoidal voltage of peak value 283 V and frequency 50 Hz is applied to a series L-C-R circuit in which $R = 3\Omega$, $L = 25.8$ mH and $C = 796\,\mu$F, then the power dissipated at the resonant condition will be

(a) 39.70 kW (b) 26.70 kW (c) 13.35 kW (d) zero

43. A circular loop of radius 0.3 cm lies parallel to much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with the bigger loop is

(a) 3.3×10^{-11} Wb (b) 6×10^{-11} Wb
(c) 6.6×10^{-9} Wb (d) 9.1×10^{-11} Wb

44. If both the number of turns and core length of an inductor is doubled keeping other factors constant, then its self-inductance will be
(a) unaffected (b) doubled (c) halved (d) quadrupled

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion (A)** To increase the range of an ammeter, we must connect a suitable high resistance in series to it.

Reason (R) The ammeter with increased range should have high resistance.

46. **Assertion (A)** An electron has a high potential energy when it is at a location associated with a more negative value of potential and a low potential energy when at a location associated with a more positive potential.

Reason (R) Electrons move from a higher potential region to lower potential region.

47. **Assertion (A)** A magnetic needle free to rotate in a vertical plane, orients itself (with its axis) vertical at the poles of the earth.

Reason (R) At the poles of the earth, the horizontal component of earth's magnetic field will be zero.

48. **Assertion (A)** A proton and an electron, with same momenta, enter in a magnetic field in a direction at right angles to the lines of the force. The radius of the paths followed by them will be same.

Reason (R) Electron has less mass than the proton.

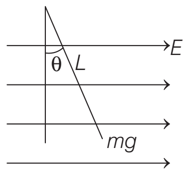
49. **Assertion (A)** On increasing the current sensitivity of a galvanometer by increasing the number of turns, may not necessarily increase its voltage sensitivity.

Reason (R) The resistance of the coil of the galvanometer increases on increasing the number of turns.

Section C

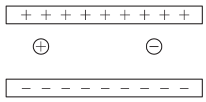
This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. A small object with charge q and weight mg is attached to one end of a string of length L attached to a stationary support. The system is placed in a uniform horizontal electric field E, as shown in the given figure. In the presence of the field, the string makes a constant angle θ with the vertical. The sign and magnitude of q



(a) positive with magnitude mg/E
(b) positive with magnitude $mg/E\tan\theta$
(c) negative with magnitude $mg/E\tan\theta$
(d) positive with magnitude $E\tan\theta/mg$

51. A free electron and a free proton are placed between two oppositely charged parallel plates. Both are closer to the positive plate than the negative plate.



Which of the following statement is true?

I. The force on the proton is greater than the force on the electron.

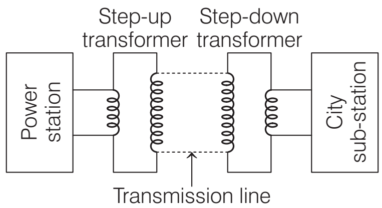
II. The potential energy of the proton is greater than that of the electron.

III. The potential energy of the proton and the electron is the same.

(a) I only (b) II only (c) III and I (d) II and I

CASE STUDY

Read the following paragraph and answers the questions.



Long distance power transmissions

The large-scale transmission and distribution of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up. It is then transmitted over long distances to an area sub-station near the consumers. There the voltage is stepped-down. It is further stepped-down at distributing sub-stations and utility poles before a power supply of 240 V reaches our homes.

52. Which of the following statement is true?

(a) Energy is created when a transformer step-up the voltage.

(b) A transformer is designed to convert an AC voltage to DC voltage.

(c) Step-up transformer increases the power for transmission.

(d) Step-down transformer decreases the AC voltage.

53. If the secondary coil has a greater number of turns than the primary, then

(a) the voltage is stepped-up ($V_s > V_p$) and this arrangement is called a step-up transformer

(b) the voltage is stepped-down ($V_s < V_p$) and this arrangement is called a step-down transformer

(c) the current is stepped-up ($I_s > I_p$) and this arrangement is called a step-up transformer

(d) the current is stepped-down ($I_s < I_p$) and this arrangement is called a step-down transformer

54. We need to step-up the voltage for power transmission, so that

(a) the current is reduced and consequently, the $I^2 R$ loss is cut down

(b) the voltage is increased, the power losses are also increased

(c) the power is increased before transmission is done

(d) the voltage is decreased so V^2/R losses are reduced

55. A power transmission line feeds input power at 2300 V to a step-down transformer with its primary windings having 4000 turns. The number of turns in the secondary in order to get output power at 230 V are

(a) 4 (b) 40 (c) 400 (d) 4000

ANSWERS

1. (c)	**2.** (c)	**3.** (b)	**4.** (b)	**5.** (a)	**6.** (d)	**7.** (c)	**8.** (a)	**9.** (c)	**10.** (c)
11. (a)	**12.** (c)	**13.** (c)	**14.** (c)	**15.** (b)	**16.** (d)	**17.** (c)	**18.** (a)	**19.** (d)	**20.** (b)
21. (d)	**22.** (b)	**23.** (c)	**24.** (a)	**25.** (d)	**26.** (a)	**27.** (d)	**28.** (d)	**29.** (c)	**30.** (c)
31. (d)	**32.** (b)	**33.** (d)	**34.** (d)	**35.** (c)	**36.** (a)	**37.** (d)	**38.** (d)	**39.** (a)	**40.** (b)
41. (d)	**42.** (c)	**43.** (d)	**44.** (b)	**45.** (d)	**46.** (c)	**47.** (a)	**48.** (b)	**49.** (a)	**50.** (b)
51. (b)	**52.** (d)	**53.** (a)	**54.** (a)	**55.** (c)					

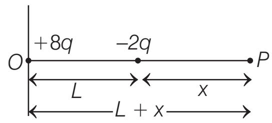
SOLUTIONS

1. Potential is same at an equipotential surface. So, there is no potential gradient along any direction parallel to the surface and so no electric field parallel to surface $\left(E = -\frac{dV}{dr} = 0\right)$.

This means that, the electric field E and line of force are always at right angles to the equipotential surface.

Hence, they are no concentric sphere for uniform electric field.

2. Let P be the point at a distance of x from $-2q$ charge and $(L+x)$ from $+8q$ charge at which the net electric field is zero.



E_1 = electric field intensity due to $+8q$ charge at P

and E_2 = electric field intensity due to $-2q$ charge at P.

According to question, $\mathbf{E}_1 + \mathbf{E}_2 = 0$

or $|\mathbf{E}_1| = |\mathbf{E}_2|$

$$\Rightarrow \quad \frac{k(8q)}{(L+x)^2} = \frac{k(2q)}{(x)^2}$$

$$\Rightarrow \quad \frac{4}{(L+x)^2} = \frac{1}{x^2}$$

$$\Rightarrow \quad 4x^2 = (L+x)^2$$

$$\Rightarrow \quad 2x = L+x$$

$$\Rightarrow \quad x = L$$

$\therefore$ Distance of point P from origin

$$= L + x = L + L = 2L$$

3. The work done in rotating a dipole in a uniform electric field is given by

$$W = pE(\cos\theta_1 - \cos\theta_2)$$

Here, $\theta_1 = 0°$ (for parallel position)

and $\theta_2 = 90°$ (given)

$$\therefore \quad W = pE(\cos 0° - \cos 90°)$$

$$= pE(1-0) = pE$$

4. Given, $C_1 = 2\ \mu\text{F}$, $C_2 = 3\ \mu\text{F}$ and $C_3 = 6\ \mu\text{F}$

The equivalent capacitance for series combination,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{6}{6} = 1$$

$$\Rightarrow \quad C_{eq} = 1\ \mu\text{F}$$

5. The electrostatic force between two point charges placed in a medium is given by

$$F = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{r^2} \quad \text{... (i)}$$

where, K = dielectric constant of medium = 5 (given).

Similarly, the electrostatic force between two charges placed in vacuum at same distance.

$$\therefore \quad F_0 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} \quad \text{... (ii)}$$

Dividing Eq. (ii) by Eq. (i), we get

$$\frac{F_0}{F} = \frac{K}{1}$$

$$\Rightarrow \quad F_0 = KF = 5F$$

6. Statement (d) is true for Gauss's law. The correct form of other are as

(a) The charges inside the gaussian surface contributes to the electric flux.

(b) Gauss's law is true for any closed surface, no matter what is its shape or size be.

(c) Gauss's theorem can be applied to uniform electric field only.

7. The capacitance of a capacitor is given by

$$C = \frac{\varepsilon_0 A}{d} \quad \text{... (i)}$$

When a dielectric slab of dielectric constant K is inserted between its plates.

Its capacitance becomes, $C' = \frac{\varepsilon_0 KA}{d}$ ... (ii)

As, the charge on capacitor remains same in given case, so $Q' = Q$

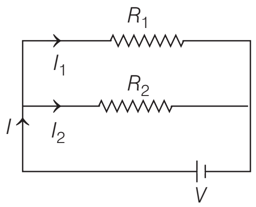
$\Rightarrow \quad C'V' = CV \quad (\because Q = CV)$

$\Rightarrow \quad V' = \frac{CV}{C'} = \frac{1}{K}V$

[using Eqs. (i) and (ii)]

8. Potentiometer and voltmeter are used to measure emf in a cell. But potentiometer is preferred over voltmeter because it does not draw any current from the cell and thus no potential drop occurs across it. Hence, the measurement of emf is more accurate.

9. The situation can be shown as below



where, R_1 = resistance of first wire

and R_2 = resistance of second wire.

Let I_1, I_2 be the respective currents passing through them and V be the potential applied across them.

Given, ratio of length, $l_1 : l_2 = 3 : 2$

and ratio of radii, $r_1 : r_2 = 2 : 3$

The resistance of a wire is given by

$$R = \rho\frac{l}{A} = \rho\frac{l}{\pi r^2}$$

$$\therefore \quad \frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{r_2^2}{r_1^2} = \frac{3}{2} \times \left(\frac{3}{2}\right)^2 = \frac{27}{8}$$

From Ohm's law, $V = IR$

$$\Rightarrow \quad I = \frac{V}{R}$$

$$\therefore \quad \frac{I_1}{I_2} = \frac{R_2}{R_1} = \frac{8}{27} \text{ or } 8 : 27$$

10. A conductor has positive temperature coefficient of resistivity, while a semiconductor has negative temperature coefficient of resistivity. So, when temperature increases, the specific resistance of a conductor increases, while that of semiconductor decreases.

11. Alloys have low temperature coefficient of resistivity and high specific resistance. So, alloys are used to make wires for standard resistances, resistance boxes, etc.

12. The resistance of first wire,

$$R_1 = \rho\frac{l_1}{A_1} = \rho\frac{l_1}{\pi r_1^2} \quad \ldots \text{(i)}$$

Similarly, for second wire,

$$R_2 = \rho\frac{l_2}{A_2} = \rho\frac{l_2}{\pi r_2^2}$$

Given, $l_2 = 2l_1$ and $r_2 = 2r_1$

$$\Rightarrow \quad R_2 = \rho\frac{(2l_1)}{\pi(2r_1)^2}$$

$$R_2 = \rho\frac{l_1}{2\pi r_1^2} = \frac{1}{2}R_1 \quad \text{[using Eq. (i)]}$$

Heat produced in a wire is given by

$$H = \frac{V^2}{R} \times t \quad (\because \text{voltage is constant})$$

$$\therefore \quad \frac{H_1}{H_2} = \frac{R_2}{R_1} = \frac{1}{2}$$

$$\Rightarrow \quad H_2 = 2H_1 = 2H \quad (\text{given, } H_1 = H)$$

13. The drift velocity of electron is given by

$$v_d = \frac{eE}{ml}\tau = \frac{eV}{ml}\tau$$

where, e = charge on electron,

m = mass of electron,

l = length of conductor

and τ = relaxation time.

Here, e, m and l are constants.

Also, if temperature is kept constant, then τ remains constant.

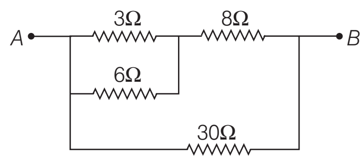
$$\Rightarrow \quad v_d \propto V$$

$$\therefore \quad \frac{v_d}{v_d'} = \frac{V}{2V}$$

$$\Rightarrow \quad v_d' = 2v_d$$

i.e. The drift velocity of free electrons in a conductor will be double of its initial value.

14. The circuit can be redrawn as



Here, 6 Ω and 3 Ω resistors are in parallel, so their equivalent resistance,

$$R_1 = \frac{6 \times 3}{6 + 3} = \frac{18}{9} = 2\,\Omega$$

Now, R_1 and 8 Ω are in series connection, so

$$R_2 = R_1 + 8 = 2 + 8 = 10\,\Omega$$

Now, R_2 and 30 Ω are in parallel connection, so

$$R_{eq} = \frac{R_2 \times 30}{R_2 + 30} = \frac{10 \times 30}{10 + 30} = \frac{300}{40} = 7.5\,\Omega$$

15. The force on a charge placed in a magnetic field,

$$F = qvB\sin\theta$$

$$\Rightarrow \quad B = \frac{F}{qv\sin\theta}$$

$$\text{Unit of } B = \frac{\text{N}}{(\text{A-s}) \times (\text{ms}^{-1})} = \text{NA}^{-1}\text{m}^{-1}$$

16. The coil of a moving coil galvanometer is wound over a metal frame in order to provide electromagnetic damping. So, by producing eddy currents in conducting frame, it helps in stopping the coil so on and becomes a dead beat galvanometer.

17. For a square

Perimeter of square = Length of wire

$\Rightarrow \quad 4a = l \Rightarrow a = l/4$

For a circle

Circumference of circle = Length of wire

$\Rightarrow \quad 2\pi r = l \Rightarrow r = \dfrac{l}{2\pi}$

The magnetic moment is given as,

$$M = IA$$

$$\therefore \frac{M_1(\text{square})}{M_2(\text{circle})} = \frac{IA_1}{IA_2} = \frac{a^2}{\pi r^2} = \frac{(l/4)^2}{\pi(l/2\pi)^2}$$

$$= \frac{l^2}{16} \times \frac{4\pi^2}{\pi l^2} = \frac{\pi}{4} \text{ or } \pi : 4$$

18. According to tangent law, $B_V = B_H \tan\delta$

where, δ = angle of dip.

$\Rightarrow \quad \tan\delta = \dfrac{B_V}{B_H}$

Here, $B_H = \sqrt{3}\, B_V$

$\Rightarrow \quad \tan\delta = \dfrac{B_V}{\sqrt{3}B_V} = \dfrac{1}{\sqrt{3}}$

$\Rightarrow \quad \delta = \tan^{-1}\left(\dfrac{1}{\sqrt{3}}\right) = 30° \text{ or } \dfrac{\pi}{6} \text{ rad}$

19. Magnetic declination or angle of declination is the small angle between magnetic axis and geographic axis at a place.

20. The mutual inductance between a pair of coils depends on their geometry, distance between them, relative position and orientation of the two coils.

21. The current induced in a coil is given by

$$I = \frac{|e|}{R} = \frac{N}{R}\frac{d\phi}{dt}$$

The conducting square loop is moving with a uniform speed in the uniform magnetic field. Hence, rate of change of magnetic flux is zero.

i.e. $\dfrac{d\phi}{dt} = 0$

$\therefore$ The induced current in the loop is zero.

22. Given, $\phi = 5t^2 + 3t + 16$ Wb

The emf induced in the coil,

$$e = -\frac{d\phi}{dt} = -\frac{d}{dt}(5t^2 + 3t + 16)$$

$$= -(5 \times 2t + 3)$$

At $t = 4$ s,

$$e = -[10(4) + 3] = -43 \text{ V}$$

23. When a capacitor of reactance X_C is connected across a supply voltage of V volt, then the current in it is given by

$$I = \frac{V}{X_C}$$

Also, $X_C = \dfrac{1}{2\pi f C}$

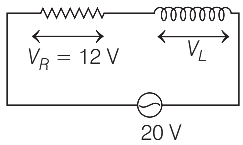
where, f = frequency of source

and C = capacitance of capacitor.

$\Rightarrow \quad I = V \times 2\pi f C \text{ or } I \propto f$

Hence, the graph between current and frequency is a straight line inclined to frequency axis as shown in option (c).

24. The given situation can be shown as



From circuit diagram, the effective voltage of circuit,

$$V = \sqrt{V_R^2 + V_L^2}$$

$\Rightarrow \quad V^2 = V_R^2 + V_L^2$

$\Rightarrow \quad (20)^2 = (12)^2 + V_L^2$

$\Rightarrow \quad 400 = 144 + V_L^2$

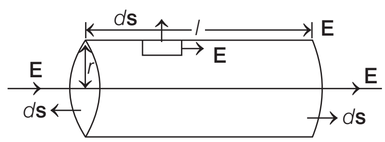
$\Rightarrow \quad V_L = \sqrt{256} = 16$ V

25. Given, $E = E_0 \sin\omega t$

and $\quad I = I_0 \sin\left(\omega t + \dfrac{\pi}{3}\right)$

Since, the voltage is lagging behind the current by $\pi/3$, which is possible in the circuit containing capacitance. So, the given series circuit can be *R-C* or *L-C-R* circuit.

26. The situation can be shown as



Total flux through the cylinder,

$$\phi = \int \mathbf{E}\cdot d\mathbf{s} + \int \mathbf{E}\cdot d\mathbf{s} + \int \mathbf{E}\cdot d\mathbf{s}$$

$$= \int E\cdot ds \cos 180° + \int E\cdot ds \cos 0° + \int E\cdot ds \cos 90°$$

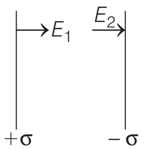
$$= -E\int ds + E\int ds + 0$$

$$= -E\pi r^2 + E\pi r^2 = 0$$

Total electric flux over the closed cylindrical surface containing no charge, is zero.

27. Given, $\sigma = 26.4 \times 10^{-12} \text{C/m}^2$

The field between two plates is as shown below

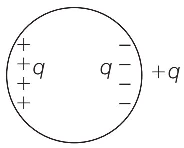


$\therefore$ Net electric field, $E_R = E_1 + E_2$

$$= \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

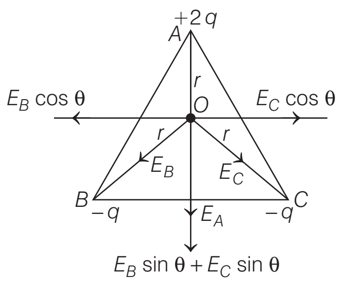
$$= \frac{26.4 \times 10^{-12}}{8.85 \times 10^{-12}} \simeq 3 \text{ N/C}$$

28. When a positive point charge is placed outside an uncharged conducting sphere, equal negative charge is induced on the closest side where point charge is placed and an equal positive charge is induced on the opposite side as shown below



But the net charge on the conducting sphere is still zero as per conservation of charge.

29. The electric field intensity due to each charge can be shown as



The electric field at O due to B will be

$$E_B = \frac{k(-q)}{r^2}$$

The electric field at O due to C will be

$$E_C = \frac{k(-q)}{r^2}$$

So, $E_B = E_C$

From the figure, $E_B \cos\theta$ and $E_C \cos\theta$ are equal and opposite. Hence, they get cancelled.

Therefore, $E_R = E_A + E_B \sin\theta + E_C \sin\theta$.

Hence, electric field at the centre O of the triangle is non-zero.

Now, potential at O is due to all charges,

$$V_R = V_{-q} + V_{-q} + V_{2q}$$

$$= \frac{-kq}{r} - \frac{kq}{r} + \frac{k \times 2q}{r} = 0$$

30. The capacitance of X is given by $C_X = \frac{\varepsilon_0 A}{d}$

The capacitance of Y is given by

$$C_Y = \frac{\varepsilon_0 KA}{d} = \frac{2\varepsilon_0 A}{d}$$

($\because$ dielectric constant, $K = 2$)

The electrostatic energy stored in a capacitor,

$$U = \frac{Q^2}{2C}$$

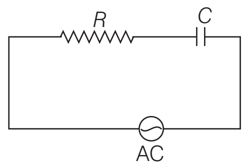
As, given capacitors are connected in series, so charge on them will be same.

$$\therefore \quad \frac{U_X}{U_Y} = \frac{C_Y}{C_X} = 2 \text{ or } 2:1$$

31. Since, the primary coil is made up of a very thick copper wire, so the power loss is very negligible.

Hence, it is not a cause of power loss in a transformer.

32. The situation can be shown as



As we know, $X_C = \frac{1}{2\pi fC} = \frac{1}{\omega C}$

So, as ω increases, the capacitive reactance decreases, due to this the impedance of circuit decreases.

Therefore, the brightness of bulb will increase or the bulb will glow brighter.

33. According to the given situation, the electric field exists only between B and C or R and $2R$.

As, electric field, $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

$$\Rightarrow \quad E \propto \frac{1}{r^2}$$

and electric potential, $V = \frac{Q}{4\pi\varepsilon_0 r}$

$$\Rightarrow \quad V \propto \frac{1}{r}$$

So, both the electric field and electric potential achieve a maximum magnitude at B.

34. When a battery is connected across the two ends of a conductor, the net charge flowing per unit time remains constant regardless of the geometry of the conductor.

But electric field and drift speed vary in accordance with geometry (cross-section area).

Hence, the quantity which remains constant is current.

35. Given, $I_1 = 2\text{ A}$, $R_2 = 3\Omega$ and $P_3 = 6\text{ W}$

As we know,

Power, $P_3 = I_3^2 R_3$

$$\Rightarrow \quad R_3 = \frac{P_3}{I_3^2} = \frac{6}{(2)^2}$$

($\because$ current is same in series circuit)

$$= \frac{6}{4} = 1.5\ \Omega$$

$\therefore$ Voltage across R_3,

$$V_3 = I_3 R_3 = 2 \times 1.5 = 3\text{ V}$$

36. From graph, the potential, $V = 5.6$ V

and current, $I = 2$ A

$\therefore$ Internal resistance,

$$r = \frac{\text{Potential }(V)}{\text{Current }(I)} = \frac{5.6}{2}$$

$$= 2.8\ \Omega$$

37. Given, $E = 5$ V, $R_1 = 20\ \Omega$, $R_2 = 480\ \Omega$,

$l_1 = 10$ m and $l_2 = 6$ m

The current through the potentiometer wire,

$$I = \frac{E}{R_1 + R_2} = \frac{5}{20 + 480}$$

$$= \frac{5}{500} = 0.01\text{ A}$$

$\therefore$ Potential across potentiometer wire,

$$V_1 = IR_1 = 0.01 \times 20 = 0.2\text{ V}$$

In balanced condition,

$$\frac{V_1}{V_2} = \frac{l_1}{l_2}$$

$$\Rightarrow \quad V_2 = \frac{l_2}{l_1} \times V_1$$

$$= \frac{6}{10} \times 0.2 = 0.12\text{ V}$$

38. If I_s be the initial current sensitivity of a galvanometer and R be its initial resistance, then

$$I_s' = I_s + \frac{20}{100} I_s = 1.2\ I_s$$

and $$R' = R + \frac{25}{100} R = 1.25\ R$$

$\therefore$ The voltage sensitivity of the galvanometer becomes,

$$V_s' = I_s'/R'$$

$$= 1.2\ I_s/1.25R$$

$$= \frac{120}{125}\left(\frac{I_s}{R}\right) = \frac{24}{25} V_s$$

$\therefore$ Percentage decrease in voltage sensitivity

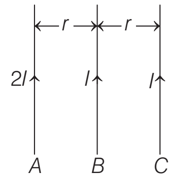
$$= \frac{V_s - V_s'}{V_s} \times 100$$

$$= \frac{V_s - \frac{24}{25}V_s}{V_s} \times 100$$

$$= \frac{1}{25} \times 100 = 4\%$$

39. In first case, the force between A and C is given as

$$F_1 = \frac{\mu_0}{4\pi} \times \frac{2I \times I}{2r} = \frac{\mu_0}{4\pi} \times \frac{I^2}{r} \qquad \text{(attractive)}$$



and that between B and C is

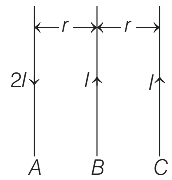
$$F_2 = \frac{\mu_0}{4\pi} \times \frac{I \times I}{r} = \frac{\mu_0}{4\pi} \times \frac{I^2}{r} = F_1 \qquad \text{(attractive)}$$

$\therefore$ Net force on C,

$$F_{\text{net}} = F_1 + F_2 = 2F_1 = F \qquad \text{(given)}$$

In second case, the force between A and C,

$$F_1' = \frac{\mu_0}{4\pi}\frac{2I^2}{2r} = \frac{\mu_0}{4\pi}\frac{I^2}{r} \qquad \text{(repulsive)}$$



and that between B and C is

$$F_2' = \frac{\mu_0}{4\pi} \times \frac{I^2}{r} = F_1' \qquad \text{(attractive)}$$

$\therefore$ Net force on C,

$$F_{\text{net}} = -F_1' + F_2'$$

$$= -F_1' + F_1' = 0$$

40. Given, $r = 0.5\text{Å} = 0.5 \times 10^{-10}$ m

and $\omega = 10$ rps $= 10 \times 2\pi$ rad/s

$$\therefore \quad f = \frac{\omega}{2\pi} = \frac{10 \times 2\pi}{2\pi} = 10\text{ Hz}$$

The magnetic moment associated with the orbital motion of electron,

$$M = IA = \frac{evr}{2} = \frac{er}{2}(r\omega) \qquad (\because v = r\omega)$$

$$= \frac{e \cdot r^2}{2} \times 2\pi f = er^2\pi f$$

$$= 1.6 \times 10^{-19} \times (0.5 \times 10^{-10})^2 \times 3.14 \times 10$$

$$= 1.256 \times 10^{-38}\text{ A-m}^2$$

41. Given, $l = 30$ cm $= 0.3$ m, $A = 25\text{ cm}^2$

$= 25 \times 10^{-4}\text{ m}^2$

$N = 800$ and $I = 2.5$ A

The magnetic field inside a solenoid,

$$B = \mu_0 nI = \mu_0 \frac{N}{l} I$$

So, the magnetic flux,

$$\phi_1 = NBA = N\mu_0 \frac{N}{l} IA$$

$$= \mu_0 \frac{N^2}{l} IA$$

$$= \frac{4\pi \times 10^{-7} \times (800)^2 \times 2.5 \times 25 \times 10^{-4}}{0.3}$$

$$= 16.74 \times 10^{-3} \text{ Wb}$$

When the current is switched OFF, then the flux becomes zero, i.e. $\phi_2 = 0$.

$\therefore$ Back emf induced, $|e| = \frac{d\phi}{dt} = \frac{\phi_1 - \phi_2}{\Delta t}$

$$= \frac{16.74 \times 10^{-3} - 0}{10^{-3}}$$

$$= 16.74 \text{ V}$$

42. Given, $V_0 = 283$ V, $f = 50$ Hz,

$R = 3\ \Omega$, $L = 25.8$ mH and $C = 796\ \mu$F

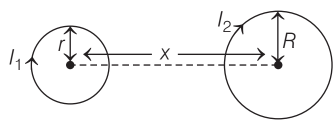
At resonance, the capacitive reactance is equal to the inductive reactance. So, power dissipated,

$$P = I^2 R = \left(\frac{I_0}{\sqrt{2}}\right)^2 R = \left(\frac{V_0}{R\sqrt{2}}\right)^2 R$$

$$= \frac{V_0^2}{2R} = \frac{(283)^2}{2 \times 3}$$

$$= 13.35 \times 10^3 \text{ W} = 13.35 \text{ kW}$$

43. The given situation can be shown as



Given, $I_1 = 2$ A, $r = 0.3$ cm $= 0.003$ m

$R = 20$ cm $= 0.2$ m

and $x = 15$ cm $= 0.15$ m

Let the flux linked with smaller loop be ϕ_1 and that with the bigger loop be ϕ_2, then

$$\phi_1 = B_2 A_1 = \frac{\mu_0}{4\pi} \frac{2\pi R^2 I_2}{(R^2 + x^2)^{3/2}} \times \pi r^2$$

Mutual inductance between them,

$$M = \frac{\phi_1}{I_2} = \frac{\mu_0}{4\pi} \frac{2\pi^2 R^2 r^2}{(R^2 + x^2)^{3/2}}$$

$\therefore$ Flux linked with bigger loop,

$$\phi_2 = MI_1 = \frac{\mu_0}{4\pi} \frac{2\pi^2 R^2 r^2}{(R^2 + x^2)^{3/2}} \times I_1$$

$$= \frac{\mu_0}{2} \frac{\pi R^2 r^2}{(R^2 + x^2)^{3/2}} \times I_1$$

$$= \frac{4\pi \times 10^{-7} \times 3.14 \times (0.2)^2 \times (0.003)^2}{2 \times [(0.2)^2 + (0.15)^2]^{3/2}} \times 2$$

$$= 9.1 \times 10^{-11} \text{ Wb}$$

44. The self-inductance of an inductor is given by

$$L = \frac{\mu_0 N^2 A}{l}$$

If $l' = 2l$ and $N' = 2N$, then

$$L' = \frac{\mu_0 (2N)^2 A}{(2l)}$$

$$= \frac{2\mu_0 N^2 A}{l} = 2L$$

45. To increase the range of an ammeter, a suitable low resistance should be connected in parallel to it. So, the ammeter with increased range has low resistance.

Therefore, A is false and R is also false.

46. Assertion is true. But electrons move from a lower potential region to higher potential region.

Therefore, A is true, but R is false.

47. At poles, the magnetic needle orients itself vertically as horizontal component of Earth's magnetic field is zero there.

Therefore, both A and R are true and R is the correct explanation of A.

48. When a charged particle moves in a magnetic field, then the magnetic force acts on it and it provides the necessary centripetal force.

i.e. $\frac{mv^2}{r} = qBv$ (at right angle)

$\Rightarrow r = \frac{mv}{qB} = \frac{p}{qB}$ $(\because p = mv)$

As, charge on electron and proton is same, but the mass of electron is less than the mass of proton.

But it is given that, the momentum of both particles is same. So, radius of their circular path will also be same.

Therefore, both A and R are true but R is not the correct explanation of A.

49. When the number of turns in the coil of galvanometer increases, its resistance increases and the current sensitivity also increases.

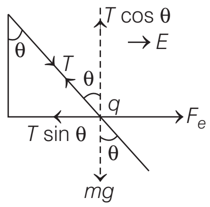
The voltage sensitivity given by

$$V_s = \frac{I_s}{R}$$

It may not necessarily increases as the value of I_s and R may increase by different amounts.

Therefore, both A and R are true and R is the correct explanation of A.

50.



Since, the electrostatic force pushes the charge q to the right, it is a positive charge.

In equilibrium,

$$\Sigma F_y = 0$$

$\Rightarrow \quad T\cos\theta = mg \qquad \ldots\text{(i)}$

and $\quad \Sigma F_x = 0$

$\Rightarrow \quad T\sin\theta = qE \qquad \ldots\text{(ii)}(\because F_e = qE)$

Dividing Eq. (ii) by Eq. (i), we get

$$\tan\theta = \frac{qE}{mg}$$

$$\Rightarrow \quad q = \frac{mg}{E}\tan\theta$$

51. The force of a charged particle in an electric field,

$$F = qE$$

Since, charge on electron and proton is same in magnitude and E is also same. So, force on both will be same.

The potential energy of a system of charges,

$$\text{PE} = qV'(r)$$

Since, potential of proton is (positive) more than that of electron (negative). So, potential energy of proton is greater than that of an electron.

52. A step-down transformer decreases the AC voltage or it converts a high voltage AC to a low voltage AC output.

53. If the number of turns in the secondary coil is greater than that of primary coil, then the voltage in the output or secondary coil increases, i.e. $V_s > V_p$ and this arrangement is called a step-up transformer.

54. In power transmission, we need to step-up the voltage, so the current is reduced and consequently the power (I^2R) loss is cut down.

55. Given, $V_i = 2300$ V, $N_p = 4000$ turns

and $\quad V_o = 230$ V

Using transformation ratio,

$$\frac{V_o}{V_i} = \frac{N_s}{N_p}$$

$$\Rightarrow \quad N_s = \frac{V_o}{V_i} \times N_p = \frac{230}{2300} \times 4000$$

$$= 400 \text{ turns}$$

SAMPLE PAPER 1

PHYSICS

*A Highly Simulated Practice Questions Paper for CBSE **Class XII** (Term I) Examination*

Instructions

1. *This question paper is divided into three sections.*
2. ***Section - A** contains 25 questions. Attempt **any 20** questions.*
3. ***Section - B** contains 24 questions. Attempt **any 20** questions.*
4. ***Section - C** contains 6 questions. Attempt **any 5** questions.*
5. *Each question carries 0.77 mark.*
6. *There is **no** negative marking.*

Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

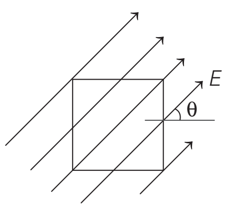
Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. When a glass rod rubbed with silk is brought near the gold leaf electroscope, the leaves diverge. What is the nature of charge on the leaves?

(a) Negative (b) Zero
(c) Positive (d) Either positive or negative

2. A square surface of side L metre in the plane of the paper is placed in a uniform electric field E (in V/m) acting along the same place at an angle θ with the horizontal side of the square as shown in figure. The electric flux linked to the surface in unit of V-m, is

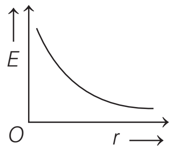


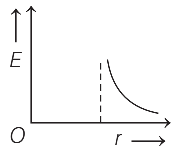
(a) EL^2 (b) $EL^2 \cos\theta$ (c) $EL^2 \sin\theta$ (d) zero

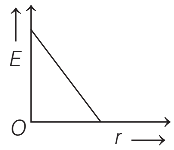
3. If $\mathbf{F}_1$ is the electrostatic force on q_1 due to q_2 and $\mathbf{F}_2$ is the electrostatic force on q_2 due to q_1, then

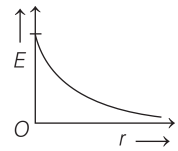
(a) $\mathbf{F}_1 = \mathbf{F}_2$ (b) $\mathbf{F}_1 = \mathbf{F}_2 = 0$ (c) $\mathbf{F}_1 \neq \mathbf{F}_2$ (d) $\mathbf{F}_1 = -\mathbf{F}_2$

4. Which one of the following is the correct depiction of variation of electric field E with distance r for a line of charge?

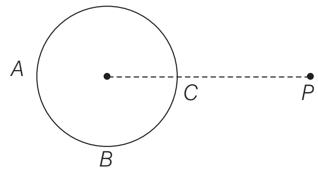
(a) 

(b) 

(c) 

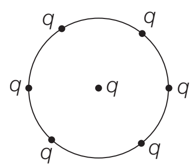
(d) 

5. A hollow conducting sphere is placed in an electric field produced by a point charge placed at P as shown in figure. Let V_A, V_B and V_C be the potentials at points A, B and C, respectively. Then,



(a) $V_C > V_B$ (b) $V_B > V_C$ (c) $V_A > V_B$ (d) $V_A = V_B = V_C$

6. A point charge q is surrounded by six identical charges at distance r shown in the figure. How much work is done by the force of electrostatic repulsion, when the point charge at the centre is removed to infinity?



(a) $6q/4\pi\varepsilon_0 r$ (b) $6q^2/4\pi\varepsilon_0 r$ (c) $36q^2/4\pi\varepsilon_0 r$ (d) Zero

7. Two charges placed in air repel each other by a force of 10^{-4} N. When oil is introduced between the charges, then the force becomes 2.5×10^{-5} N. The dielectric constant of oil is

(a) 2.5 (b) 0.25 (c) 2.0 (d) 4.0

8. Which of the following statement is correct for equipotential surfaces for uniform electric field?

(a) Two equipotential surfaces intersect each other at acute angles.
(b) Electric lines of force are perpendicular to equipotential surface.
(c) Work done in moving a charge on equipotential surface is always negative.
(d) Equipotential surface is always spherical in shape.

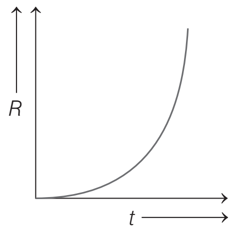
9. When current I flows through a copper wire at room temperature, the conductivity is σ_1. If the temperature is increased, the conductivity becomes σ_2. So, the correct relation between σ_1 and σ_2 is

(a) $\sigma_1 < \sigma_2$ (b) $\sigma_1 > \sigma_2$ (c) $\sigma_1 = \sigma_2$ (d) $\sigma_1 = \sigma_2 = 0$

10. A cell of emf 1.5 V having a finite internal resistance is connected to a load resistance of $2\,\Omega$. For maximum power transfer, the internal resistance of the cell should be

(a) $4\ \Omega$ (b) $0.5\ \Omega$ (c) $2\ \Omega$ (d) None of these

11. The resistance R_t of a conductor varies with temperature t as shown in figure. If the variation is represented by $R_t = R_0(1 + \alpha t + \beta t^2)$, then

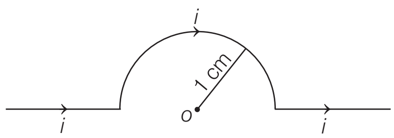


(a) α and β both are negative
(b) α is positive and β is negative
(c) α and β both are positive
(d) α is negative and β is negative

12. A potentiometer is an accurate and versatile device to make electrical measurement of emf because the method involves
(a) cells
(b) potential gradients
(c) a condition of no current flow through the galvanometer
(d) a combination of cells, galvanometer and resistances

13. An electron and α-particle with equal momentum enters perpendicularly into uniform magnetic field, then
(a) path of α-particle will be more curved than that of electron
(b) path of electron will be more curved than that of α-particle
(c) path of both particles will be equally curved
(d) path of both particles will be a straight line

14. A straight wire carrying a current is bent into a semi-circular loop of radius 1cm as shown below



The magnetic field at the centre of arc is 2.5×10^{-4} T. The value of current is
(a) 0.8 A (b) 80 A (c) 0.08 A (d) 8 A

15. A rectangular coil having 100 turns of length 40 cm and breadth 20 cm carrying a current of 10 A is placed in a magnetic field of 5 T. If it makes an angle of 60° with B, then the torque produced in the coil is
(a) 298.26 N-m (b) 524.26 N-m
(c) 346.41 N-m (d) 892.26 N-m

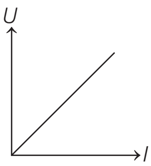
16. A galvanometer of resistance $15\,\Omega$ gives full scale deflection for a current of 2mA. The shunt resistance needed to convert it into an ammeter of range 0 to 5A is
(a) $0.006\,\Omega$ (b) $0.6\,\Omega$ (c) $0.00006\,\Omega$ (d) $6\,\Omega$

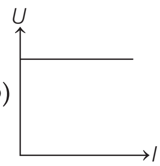
17. When the horizontal component of earth's magnetic field is equal to its vertical component, then angle of dip is
(a) zero (b) 60° (c) 45° (d) 90°

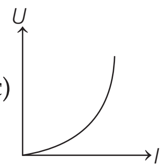
18. Which of the following statement(s) is/are correct ?
(a) The horizontal plane containing the longitude circle and the axis of rotation of the earth is called magnetic meridian.
(b) The angle between the true geographic north and the south shown by a compass needle is called the magnetic declination or simple declination.
(c) The declination is smaller at higher latitudes and greater near the equator.
(d) Dip is the angle that the total magnetic field $\mathbf{B}_E$ of the earth makes with the surface of the earth.

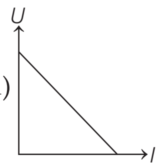
19. A long magnet of pole strength q_m is cut into two parts such that the ratio of their lengths is 1 : 3. The ratio of pole strength of these pieces is
(a) 1 : 3 (b) 3 : 1 (c) 1 : 6 (d) 1 : 1

20. The current flowing through an inductor of self-inductance L is continuously increasing. The graph depicting the variation of magnetic potential energy stored with the current is

(a) 

(b) 

(c) 

(d) 

21. For a current carrying inductor, the coefficient of mutual inductance is 100 mH. If the current through it, changes from 10 A to 2 A in 5 s, then the emf (in mV) associated with it will be
(a) 0.16 (b) 16 (c) 160 (d) 1.6

22. Which of the following statement(s) is/are correct?
(a) In an inductive circuit, using Kirchhoff's loop rule, we get $V - L\frac{di}{dt} = 0$, where the second term is the mutual induced emf in the inductor.
(b) The quantity ω is analogous to the conductance.
(c) The current phasor **I** is $\frac{\pi}{2}$ ahead of the voltage phasor **V**.
(d) The average power supplied to an inductor over one complete cycle is zero.

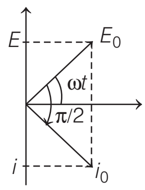
23. An alternating current through a circuit is given as

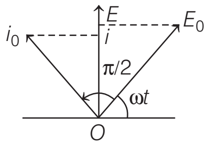
$$I = I_1 \cos \omega t + I_2 \sin \omega t$$

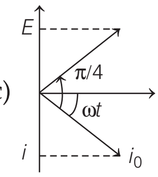
The rms value of the current through the circuit is
(a) $\sqrt{\frac{I_1 + I_2}{2}}$ (b) $\sqrt{I_1 + I_2}$
(c) $\sqrt{\frac{I_1^2 + I_2^2}{2}}$ (d) $\sqrt{I_1 / I_2}$

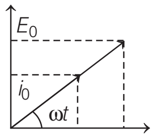
24. The output of a step-down transformer is measured to be 50 V, when connected to a light bulb. If the peak value of current is 2A, then the power of bulb is
(a) $50\sqrt{2}$ W (b) $\frac{50}{\sqrt{2}}$ W
(c) $5\sqrt{2}$ W (d) $2\sqrt{5}$ W

25. The phasor diagram for a pure inductive circuit is correctly depicted in which of the following option?

(a) 

(b) 

(c) 

(d) 

Here, E_0 and i_0 are the peak values of emf and current, respectively.

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. Consider a current carrying wire (current I) in the shape of a circle. Note that as the current progresses along the wire, the direction of **J** (current density) changes in an exact manner, while the current I remains unaffected. The agent that is essentially responsible for it is

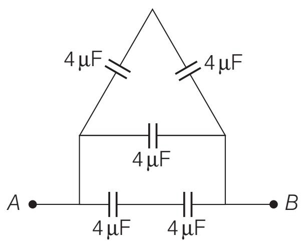
(a) source of emf

(b) electric field produced by charges accumulated on the surface of wire

(c) the charges just behind a given segment of wire which push them just the right way by repulsion

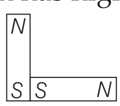
(d) the charges ahead

27. Equivalent capacitance between A and B is

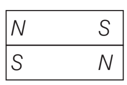


(a) 8 μF (b) 6 μF (c) 26 μF (d) (10/3) μF

28. Following figures show the arrangement of bar magnets in different configurations. Each magnet has magnets in different configurations and has magnetic dipole moment **m**. Which configuration has highest net magnetic dipole moment?



I.



II.

(a) Only I (b) Only II (c) Both I and II (d) None of these

29. F_g and F_e represent gravitational and electrostatic forces respectively between electrons situated at a distance of 10 cm. The ratio of F_g / F_e is of the order of

(Take, $m_e = 9.1 \times 10^{-31}$ kg, $G = 6.67 \times 10^{-11} \text{Nm}^2 \text{kg}^{-2}$ and $e = 1.6 \times 10^{-19}$ C)

(a) 10^{42} (b) 10^{-21} (c) 10^{24} (d) 10^{-43}

30. Consider the following two statements

I. Kirchhoff's junction law follows from the conservation of charge.

II. Kirchhoff's loop law follows from the conservation of energy.

Which of the following is correct?

(a) Only I (b) Only II
(c) Both I and II (d) None of these

31. Amongst the following statements, which option(s) is/are correct, when a 220 V AC is applied to a capacitor C?

(a) The phase of voltage and current is same.
(b) Between the plates of capacitor, maximum voltage is 220 V.
(c) Average power delivered to the capacitor per cycle is zero.
(d) Charge on the plate is not in phase with the applied voltage.

32. A parallel plate capacitor of capacitance 1nF has plate separation d. If the distance between plates is doubled and a dielectric material of dielectric constant ($K = 3$) is inserted completely between the space of plates, then the new capacitance (in nF) will be

(a) $\frac{3}{4}$ (b) $\frac{2}{3}$ (c) $\frac{3}{2}$ (d) $\frac{4}{3}$

33. Masses of three wires of same metal are in the ratio 1 : 2 : 3 and their lengths are in the ratio 3 : 2 : 1. The electrical resistances are in ratio

(a) 1 : 4 : 9 (b) 9 : 4 : 1 (c) 1 : 2 : 3 (d) 27 : 6 : 1

34. A coil of 40 Ω resistance, 100 turns and radius 6 mm is connected to an ammeter of resistance 160 Ω. Coil is placed perpendicular to the magnetic field. When coil is taken out of the field, 32 μC charge flows through it. The intensity of magnetic field will be

(a) 6.55 T (b) 5.66 T (c) 2.55 T (d) 0.566 T

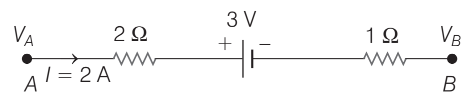
35. A current of 2A flows through a 2 Ω resistor, when connected across a battery. The same battery supplies a current of 0.5 A, when connected across a 9 Ω resistor. The internal resistance of the battery is

(a) $\frac{1}{3}\ \Omega$ (b) $\frac{1}{4}\ \Omega$ (c) 1 Ω (d) 0.5 Ω

36. A system consists of two point charges having charges − 5 nC and Q, respectively. One charge is placed at (1 cm, 0, 0) and other at (10 cm, 0, 0) in a region of space, where there is no external electric field. If the electrostatic potential energy of the system is − 10 μJ, then the value of Q is

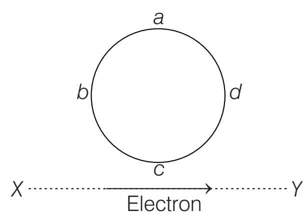
(a) 20 μC (b) 20 nC (c) − 20 nC (d) − 20 μC

37. The potential difference ($V_A - V_B$) between the points A and B in the given figure is



(a) −3 V (b) +3 V (c) +6 V (d) +9 V

38. An electron moves on a straight line path XY as shown. The $abcd$ is a coil adjacent in the path of electron. What will be the direction of current induced in the coil?

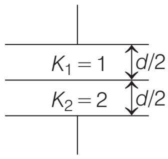


(a) *abcd*
(b) *adcb*
(c) The current will reverse its direction as the electron goes past the coil
(d) No current induced

39. In a circuit, L, C and R are connected in series with an alternating voltage source of frequency f. If the current leads the voltage by 45°, the value of C will be

(a) $\frac{1}{2\pi f\,(2\pi fL + R)}$ (b) $\frac{1}{\pi f\,(2\pi fL + R)}$ (c) $\frac{1}{2\pi f\,(2\pi fL - R)}$ (d) $\frac{1}{\pi f\,(2\pi fL - R)}$

40. Two parallel plates of area A are separated by two different dielectrics as shown in figure. The net capacitance is

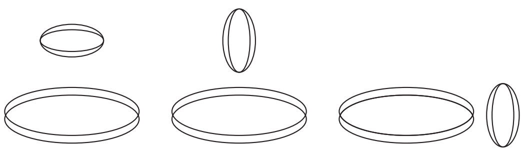


(a) $\frac{4\varepsilon_0 A}{3d}$ (b) $\frac{3\varepsilon_0 A}{R}$ (c) $\frac{2\varepsilon_0 A}{d}$ (d) $\frac{\varepsilon_0 A}{d}$

41. The magnetic field of the earth can be modelled by that of a point sized dipole placed at the centre of the earth. The dipole axis makes an angle of 11.3° with the axis of the earth. At Mumbai, declination is nearly zero. Then,

(a) the declination varies between 11.3° W to 11.3° E
(b) the least declination is 0°
(c) the plane defined by dipole axis and the earth axis passes through Greenwich
(d) declination averaged over the earth must be always negative

42. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be



(a) maximum in situation I (b) maximum in situation II
(c) maximum in situation III (d) the same in all situations

43. A current carrying circular loop of radius R is placed in the XY-plane with centre at the origin. Half of the loop with $x > 0$ is now bent, so that it now lies in the YZ-plane. Which of the following statement is correct about the later situation?

(a) The magnitude of magnetic moment now decreases.
(b) The magnetic moment does not change.
(c) The magnitude of **B** at $(0, 0, z)$, $z >> R$ increases.
(d) The magnitude of **B** at $(0, 0, z)$, $z >> R$ unchanged.

44. In an AC circuit, an alternating voltage $e = 200\sqrt{2} \sin 100\,t$ volt is connected to a capacitor of capacity 1 μF. The rms value of the current in the circuit is

(a) 100 mA (b) 200 mA
(c) 20 mA (d) 10 mA

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** **E** outside vicinity of a conductor depends only on the local charge density σ and it is independent of the other charges present anywhere on the conductor.

Reason **E** outside vicinity of a conductor is given by $\frac{\sigma}{2\varepsilon_0}$.

46. **Assertion** The drift velocity of electrons in a metallic wire decreases, when temperature of the wire increases.

Reason On increasing temperature, conductivity of metallic wire decreases.

47. **Assertion** If we increase the current sensitivity of a galvanometer by increasing number of turns, its voltage sensitivity also increases.

Reason Resistance of a wire does not increases with N.

48. **Assertion** A magnetic needle, which is free to swing horizontally, would lie in the magnetic meridian and the north pole of the needle would point towards the magnetic north pole.

Reason The line joining the magnetic poles is tilted with respect to the geographic axis of the earth. The magnetic meridian at a point makes some angle with the geographic meridian.

49. **Assertion** In a system of co-axial solenoids, it is extremely difficult to calculate the flux linkage with the outer solenoid when current flows in inner solenoid.

Reason The magnetic field due to the inner solenoid would vary across the length as well as cross-section of the outer solenoid (when inner solenoid is smaller in length and radius).

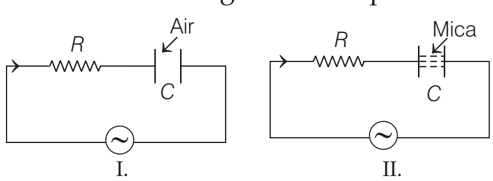
Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. A series R-C circuit is connected to an alternating voltage source. Consider two situations

I. When capacitor is air filled II. When capacitor is mica filled

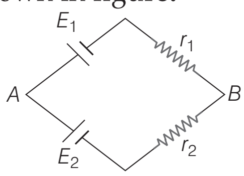
Current through resistor is i and voltage across capacitor is V.



Then, which of the following option is correct regarding two situations of RC-circuit?

(a) $V_1 < V_2$ (b) $V_1 > V_2$ (c) $i_1 > i_2$ (d) $V_1 = V_2$

51. Two batteries of emfs E_1 and $E_2 (E_2 > E_1)$ and internal resistances r_1 and r_2 respectively are connected in parallel as shown in figure.



I. The equivalent emf E_{eq} of the two cells is between E_1 and E_2, i.e. $E_1 < E_{eq} < E_2$.

II. The equivalent emf E_{eq} is smaller than E_1.

III. The equivalent emf E_{eq} is always given by $E_{eq} = E_1 + E_2$.

IV. E_{eq} is independent of internal resistances r_1 and r_2.

Which of the following statement(s) is/are correct?

(a) Only I (b) Only II (c) Both I and III (d) Both II and IV

Case Study

Read the following paragraph and answers the questions.

Ohm's Law

Ohm's law describes that the flow of current through a substance/material, when varying electric potentials are applied across its ends. Also, flow of electrons constitutes electric current. But, as electrons are not visible to our naked eyes, so the water-pipe analogy is used to understand the electrical circuits better.

In a water-pipe system, water flows through a pipe only when there is some difference of pressure between the two ends of the pipe. Similarly, charges will flow through a substance only when there is some difference of potential across its ends.

Ohm thus gave a statement to relate I and V, according to which current I flowing through a conductor is always directly proportional to the potential difference V across the ends of the substance. The property of a substance by virtue of which it opposes the flow of current is known as resistance.

It is given by $R = \rho \frac{L}{A}$, where $\rho =$ resistivity of material.

52. The value of resistivity depends upon the

(a) nature of material (b) temperature of conductor

(c) Both (a) and (b) (d) resistance of material

53. Which of the following characteristics of electron determines the current in a conductor?

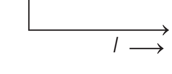
(a) Drift velocity (b) Thermal velocity

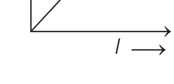
(c) Both drift velocity and thermal velocity (d) Neither drift velocity nor thermal velocity

54. The plot of Ohm's law for a conductor is correctly shown in

(a) 

(b) 

(c) 

(d) 

55. The specific resistance of a cylindrical conductor of length 2m, radius 2mm and having a resistance of 20 Ω is

(a) 40 π Ω-m (b) $20\pi \times 10^{-3}$ Ω-m (c) $4\pi \times 10^{-5}$ Ω-m (d) $4\pi \times 10^{-6}$ Ω-m

OMR SHEET

SP 1

Roll No.

Student Name

Sub Code.

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

Correct | Incorrect | Incorrect | Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	20	a	b	c	d	38	a	b	c	d
2	a	b	c	d	21	a	b	c	d	39	a	b	c	d
3	a	b	c	d	22	a	b	c	d	40	a	b	c	d
4	a	b	c	d	23	a	b	c	d	41	a	b	c	d
5	a	b	c	d	24	a	b	c	d	42	a	b	c	d
6	a	b	c	d	25	a	b	c	d	43	a	b	c	d
7	a	b	c	d	26	a	b	c	d	44	a	b	c	d
8	a	b	c	d	27	a	b	c	d	45	a	b	c	d
9	a	b	c	d	28	a	b	c	d	46	a	b	c	d
10	a	b	c	d	29	a	b	c	d	47	a	b	c	d
11	a	b	c	d	30	a	b	c	d	48	a	b	c	d
12	a	b	c	d	31	a	b	c	d	49	a	b	c	d
13	a	b	c	d	32	a	b	c	d	50	a	b	c	d
14	a	b	c	d	33	a	b	c	d	51	a	b	c	d
15	a	b	c	d	34	a	b	c	d	52	a	b	c	d
16	a	b	c	d	35	a	b	c	d	53	a	b	c	d
17	a	b	c	d	36	a	b	c	d	54	a	b	c	d
18	a	b	c	d	37	a	b	c	d	55	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (c)	**2.** (c)	**3.** (d)	**4.** (a)	**5.** (d)	**6.** (b)	**7.** (d)	**8.** (b)	**9.** (b)	**10.** (c)
11. (c)	**12.** (c)	**13.** (a)	**14.** (d)	**15.** (c)	**16.** (a)	**17.** (c)	**18.** (d)	**19.** (a)	**20.** (c)
21. (c)	**22.** (d)	**23.** (c)	**24.** (a)	**25.** (a)	**26.** (b)	**27.** (a)	**28.** (a)	**29.** (d)	**30.** (c)
31. (c)	**32.** (c)	**33.** (d)	**34.** (d)	**35.** (a)	**36.** (b)	**37.** (d)	**38.** (c)	**39.** (c)	**40.** (a)
41. (a)	**42.** (a)	**43.** (a)	**44.** (c)	**45.** (d)	**46.** (b)	**47.** (d)	**48.** (b)	**49.** (a)	**50.** (b)
51. (a)	**52.** (c)	**53.** (a)	**54.** (d)	**55.** (c)					

SOLUTIONS

1. The glass rod acquires positive charge on rubbing with silk. When the rod is brought near the disc of the electroscope, the near end of disc will acquire negative charge and there will be positive charge on the far end, i.e. on the leaves.

2. Flux due to electric field **E** through any area A is given by $\phi = E\ A\cos\theta$. Now, angle between normal and field lines is $(90°-\theta)$.

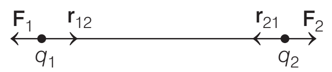
So, $\phi = EA\cos(90° - \theta)$

$= EA\sin\theta$

$= EL^2\sin\theta \qquad (\because A = L^2)$

3. According to Coulomb's law, the magnitude of force on charge q_1 due to q_2 (or on charge q_2 due to q_1) is given by

$$|\mathbf{F}_1| = |\mathbf{F}_2| = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2} \qquad \dots \text{(i)}$$



Let $\mathbf{r}_{12}$ be the unit vector pointing from charge q_1 to q_2 and $\mathbf{r}_{21}$ be the unit vector pointing from charge q_2 to q_1.

$$\therefore \quad \mathbf{F}_1 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2}\hat{\mathbf{r}}_{21} \qquad \dots \text{(ii)}$$

($\because \mathbf{F}_1$ is along the direction of unit vector $\hat{\mathbf{r}}_{21}$)

and $$\mathbf{F}_2 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2}\hat{\mathbf{r}}_{12} \qquad \dots \text{(iii)}$$

($\because \mathbf{F}_2$ is along the direction of unit vector $\hat{\mathbf{r}}_{12}$)

As, $\hat{\mathbf{r}}_{21} = -\hat{\mathbf{r}}_{12}$

So, Eq. (ii) becomes,

$$\mathbf{F}_1 = \frac{-1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2}\hat{\mathbf{r}}_{12} \qquad \dots \text{(iv)}$$

On comparing Eqs. (iii) and (iv), we get

$$\mathbf{F}_1 = -\mathbf{F}_2$$

4. For a line charge distribution, electric field at a distance r is given as

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

where, λ is linear charge density.

i.e. $\qquad E \propto \frac{1}{r}$

Hence, the correct graph is depicted in option (a).

5. Conducting surface behaves as equipotential surface, so here potential on the surface of the conducting sphere will be same.

$\Rightarrow \qquad V_A = V_B = V_C$

6. Work done, $W = U_i - U_f = 6\left(\frac{1}{4\pi\varepsilon_0}\cdot\frac{q\cdot q}{r}\right) - 0$

$$= \frac{6q^2}{4\pi\varepsilon_0 r}$$

7. Given, force in air, $F_a = 10^{-4}$ N

Force in oil, $F_o = 2.5\times10^{-5}$ N

We know that, dielectric constant,

$$K = \frac{F_a}{F_o} = \frac{10^{-4}}{2.5\times10^{-5}} = 4$$

8. The statement given in option (b) is correct, but rest are incorrect and these can be corrected as,

Two equipotential surfaces can never intersect each other.

Work done in moving a charge on equipotential surface is always zero because electric field lines are always perpendicular to the surface.

The shape of equipotential surface depends on the source of electric field. For a point charge, it is spherical in shape. For a line charge, it cylindrical in shape.

9. Copper is a metallic substance, so its conductivity is given as $\sigma = \frac{ne^2\tau}{m}$

where, n, e and m are constants for copper.

$\Rightarrow \qquad \sigma \propto \tau$

where, τ is the relaxation time.

As, the temperature increases, collisions of the electrons with the fixed ion/atom increases, so the relaxation time τ decreases.

As a result, conductivity of the metal decreases with the rise of temperature.

$\therefore \quad \sigma_1 > \sigma_2$

10. The power transferred to output is

$$P = VI = E \times \frac{ER}{R+r}$$

For maximum power,
external resistance (R) = internal resistance (r)

$\Rightarrow \quad r = 2\ \Omega$

11. Graph indicates that resistance increases with increase in temperature, so α and β both are positive.

12. When the emf of a cell is balanced against potential drop across a certain length of potentiometer wire, no current flows through the galvanometer.

$\therefore$ emf of cell = potential drop across balanced length of potentiometer wire

So, potentiometer is an accurate device for measuring emf of a cell.

13. When, the charged particle enters perpendicular to **B**, then its trajectory is a circular path with radius, $r = mv/qB = p/qB$

$$\Rightarrow \quad r \propto \frac{1}{q} \quad (\because p \text{ and } B \text{ are constants})$$

As, $\quad q_e < q_\alpha$

$\Rightarrow \quad r_e > r_\alpha$

As, smaller the radius, greater is the curvature and *vice-versa*.

Hence, the path of α-particle will be more curved than that of electron.

14. Given, $B = 2.5 \times 10^{-4}$ T

and $R = 1\ \text{cm} = 1 \times 10^{-2}$ m

Magnetic field due to a semi-circular loop at the centre is given by

$$B = \frac{\mu_0 i}{4R}$$

Now, substituting the given values, we get

$$\Rightarrow \quad 2.5 \times 10^{-4} = \frac{4\pi \times 10^{-7} \times i}{4 \times 1 \times 10^{-2}}$$

$\Rightarrow \quad i = 7.96$ A

$\Rightarrow \quad i \simeq 8$ A

15. Given, $I = 10$ A, $N = 100$ turns,

$l = 40$ cm, $b = 20$ cm

$B = 5$ T and $\theta = 60°$

$$A = l \times b = 40 \times 20 = 800\ \text{cm}^2 = 8 \times 10^{-2}\ \text{m}^2$$

$$\therefore \quad \tau = NBIA \sin\theta = 100 \times 5 \times 10 \times 8 \times 10^{-2} \times \sin 60° = 346.41\ \text{N-m}$$

16. Given, $G = 15\ \Omega$,

$I_g = 2\ \text{mA} = 2 \times 10^{-3}$ A

and $\quad I = 5$ A

$$\therefore \text{Shunt resistance, } S = \frac{I_g G}{I - I_g} = \frac{2 \times 10^{-3} \times 15}{(5-2) \times 10^{-3}} = 0.006\ \Omega$$

17. Angle of dip, $\delta = \tan^{-1}\left(\frac{B_V}{B_H}\right)$

where, B_V and B_H are the vertical and horizontal components of earth's magnetic field, respectively.

Given, $B_V = B_H$

$\therefore \quad \delta = \tan^{-1}(1) \quad$ or $\quad \delta = 45°$

18. The statement given in option (d) is correct but rest are incorrect and these can be corrected as,

The vertical plane containing the longitude circle and the axis of rotation of the earth is called the geographic meridian. While, magnetic meridian of a place is the vertical plane which passes through the imaginary line joining the magnetic north and the south poles.

The angle between the true geographic north and the north shown by a compass needle is called the magnetic declination or simple declination.

The declination is greater at higher latitudes and smaller near the equator.

19. Pole strength of magnet is independent of its length and it always remains same for a given magnet, i.e. 1 : 3.

20. Magnetic potential energy stored in an inductor is given as

$$U = \frac{1}{2} LI^2$$

$\Rightarrow \quad U \propto I^2$

So, the correct graph is depicted in option (c).

21. Electromotive force (emf) associated in the case of mutual inductance is

$$|\varepsilon| = M \frac{di}{dt}$$

Here, coefficient of mutual inductance,

$M = 100$ mH
$= 100 \times 10^{-3}$ H

Change in current, $di = (10 - 2)\text{ A} = 8\text{ A}$

Time, $dt = 5\text{ s}$

$\Rightarrow \quad \varepsilon = (100 \times 10^{-3}) \times \dfrac{8}{5}$

$\Rightarrow \quad = \dfrac{0.1 \times 8}{5} = 0.16\text{ V or } 160\text{ mV}$

22. In an inductive circuit, using Kirchhoff's loop rule, we get

$$V - L\frac{di}{dt} = 0$$

where, the second term is the self-induced emf in the inductor and L is the self-inductance of the inductor.

The quantity ωL is analogous to the resistance and is called inductive reactance denoted by $X_L (= \omega L)$. The current phasor **I** is $\dfrac{\pi}{2}$ behind the voltage phasor **V**, i.e. $\phi = \dfrac{\pi}{2}$.

When AC flows through an inductor, it generate the voltage and current as given by $V = V_m \sin \omega t$ and $i_m \sin\left(\omega t - \dfrac{\pi}{2}\right)$ respectively.

$\therefore$ Average power supplied to an inductor over one complete cycle,

$$P_{av} = V_{rms} \times I_{rms} \times \cos \phi$$

$$= V_{rms} \times I_{rms} \times \cos \frac{\pi}{2} = 0$$

So, statement given in option (d) is correct and rest are incorrect.

23. As, $(I_{rms})_1 = \dfrac{I_1}{\sqrt{2}}$

and $(I_{rms})_2 = \dfrac{I_2}{\sqrt{2}}$

Hence, the resultant of these two currents,

$$I_{rms} = \sqrt{\left(\frac{I_1}{\sqrt{2}}\right)^2 + \left(\frac{I_2}{\sqrt{2}}\right)^2} = \sqrt{\frac{I_1^2 + I_2^2}{2}}$$

24. Given, $V = 50$ V and $I_P = 2$ A

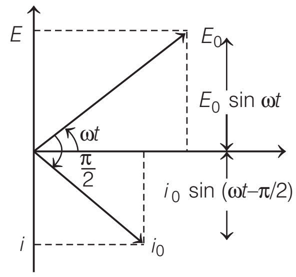
So, $I_{rms} = \dfrac{I_P}{\sqrt{2}} = \dfrac{2}{\sqrt{2}} = \sqrt{2}$ A

Power of bulb,

$$P = VI_{rms} = 50 \times \sqrt{2}$$

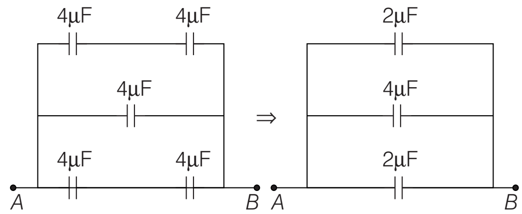
$\Rightarrow \quad P = 50\sqrt{2}$ W

25. For a pure inductive circuit, the phasor representing peak emf E_0 makes an angle ωt in anti-clockwise direction from horizontal axis. As, current lags behind the voltage by 90°, so the phasor representing i_0 is turned 90° clockwise with the direction of E_0.



26. The current density is a vector quantity. Its direction is given by the direction of flow of positive charge in the circuit. The agent that is responsible for it is possible due to electric field produced by charges accumulated on the surface of wire.

27. The figure can be shown as



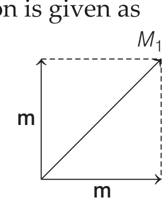
Therefore, capacitors 2μF, 4μF and 2 μF are in parallel.

So, equivalent capacitance between A and B,

$$C_{AB} = 2 + 4 + 2 = 8\mu\text{F}$$

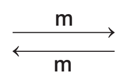
28. Here, magnetic moment for each configuaration is given as

I.



$\Rightarrow \quad |M_1| = \sqrt{m^2 + m^2} = m\sqrt{2}$

II.



$\Rightarrow |M_2| = m - m = 0$

Therefore, configuration I has higher net magnetic dipole moment.

29. Gravitational force, $F_g = \dfrac{G(m_e)(m_e)}{r^2}$

Also, electrostatic force, $F_e = \dfrac{1}{4\pi\varepsilon_0} \dfrac{(e)(e)}{r^2}$

$$\therefore \quad \frac{F_g}{F_e} = \frac{G(m_e)^2}{\left(\dfrac{1}{4\pi\varepsilon_0}\right)e^2}$$

$$= \frac{6.67 \times 10^{-11} \times (9.1 \times 10^{-31})^2}{9 \times 10^9 \times (1.6 \times 10^{-19})^2}$$

$$= 2.39 \times 10^{-43}$$

So, ratio of F_g / F_e is of the order of 10^{-43}.

30. Kirchhoff's junction law follows from the conservation of charge.

Kirchhoff's loop law follows from the conservation of energy.

Therefore, both statements I and II are correct.

31. When AC voltage of 220 V is applied to a capacitor C, the charge on the plates is in phase with the applied voltage. As, the circuit is purely capacitive, so the current leads the voltage by an angle of 90°.

$\therefore$ Power dissipation per cycle in capacitive circuit,

$$P = V_{\text{rms}} I_{\text{rms}} \cos 90° = 0$$

32. Capacitance of parallel plate capacitor with air is given as

$$C = \frac{\varepsilon_0 A}{d} \quad \text{... (i)}$$

where, A is area of cross-section of the plates.

Capacitance of parallel plate capacitor with dielectric is given as

$$C' = \frac{K\varepsilon_0 A}{d'}$$

Given, $K = 3$ and $d' = 2d$

$$\therefore \quad C' = \frac{3\varepsilon_0 A}{2d} \quad \text{...(ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{C}{C'} = \frac{\frac{\varepsilon_0 A}{d}}{\frac{3\varepsilon_0 A}{2d}}$$

$$\Rightarrow \quad \frac{C}{C'} = \frac{2}{3}$$

$$\Rightarrow \quad C' = \frac{3}{2} C = \frac{3}{2}\text{nF} \quad (\text{given, } C = 1\text{nF})$$

Hence, the new capacitance will be $\frac{3}{2}$nF.

33. Resistance of wire in terms of length and area of cross-section is given by

$$R = \rho \frac{l}{A}$$

Since, volume $(V) = \dfrac{\text{mass } (m)}{\text{density } (d)}$

and area $(A) = \dfrac{\text{volume } (V)}{\text{length } (l)}$

$$\Rightarrow \quad A = \frac{m}{dl}$$

Thus, $\quad R = \rho \dfrac{l^2}{m} d$

$$\Rightarrow \quad R_1 : R_2 : R_3 = \frac{l_1^2}{m_1} : \frac{l_2^2}{m_2} : \frac{l_3^2}{m_3}$$

Given, $m_1 : m_2 : m_3 = 1 : 2 : 3$

and $\quad l_1 : l_2 : l_3 = 3 : 2 : 1$

$$\Rightarrow \quad R_1 : R_2 : R_3 = 27 : 6 : 1$$

34. We have, $\Delta q = -\dfrac{N}{R} \Delta\phi$, where $\Delta\phi = \Delta BA \cos\theta$

Given, $\Delta q = 32\ \mu\text{C} = 32 \times 10^{-6}$ C,

$R_1 = 40\ \Omega$, $N = 100$, $r = 6$ mm $= 6 \times 10^{-3}$ m,

$R_2 = 160\,\Omega$ and $\theta = 0°$ (coil is $\perp$ to field B)

$$\therefore \quad 32 \times 10^{-6} = -\frac{100}{(160 + 40)}(0 - B) \times \pi \times (6 \times 10^{-3})^2 \times \cos 0°$$

$\therefore$ Intensity of magnetic field, $B = 0.566$ T

35. Current, $I = \dfrac{E}{R + r}$

$$2 = \frac{E}{2 + r} \quad \text{...(i)}$$

and $\quad 0.5 = \dfrac{E}{9 + r} \quad$ ...(ii)

On dividing Eq. (i) by Eq. (ii), we get

$$\frac{2}{0.5} = \frac{9 + r}{2 + r}$$

$$\Rightarrow \quad 4 = \frac{9 + r}{2 + r} \Rightarrow 3r = 1$$

$$\Rightarrow \quad r = \frac{1}{3}\ \Omega$$

36. Given, $q_1 = -5\text{nC} = -5 \times 10^{-9}$ C, $q_2 = Q$

and $\quad U = -10\ \mu\text{J} = -10 \times 10^{-6}$ J

Distance between the charges,

$$r = x_2 - x_1 = (10 - 1) \text{ cm}$$

$$= 9 \text{ cm} = 9 \times 10^{-2} \text{ m}$$

Potential energy of a system consisting of two point charges is given as $U = \dfrac{1}{4\pi\varepsilon_0} \dfrac{q_1 q_2}{r}$

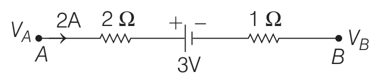
Substituting the given values, we get

$$-10 \times 10^{-6} = \frac{9 \times 10^9 \times (-5 \times 10^{-9}) \times Q}{9 \times 10^{-2}}$$

$$\Rightarrow -10 \times 10^{-6} = -5 \times 10^2 \times Q$$

$$\Rightarrow \quad Q = 2 \times 10^{-8} \text{ C} = 20 \text{ nC}$$

37.



Applying KVL,

$$V_A + (-3) = V_B + 2 \times 2 + 2 \times 1$$

$$\Rightarrow \quad V_A - V_B - 3 = 4 + 2$$

$$\Rightarrow \quad V_A - V_B = 9 \text{ V}$$

38. First current develops in direction of *abcd*, but when electron goes past the coil, then magnetic field inside loop decreases and the current reverses its direction.

39. $\tan\phi = \dfrac{\omega L - \dfrac{1}{\omega C}}{R}$

where, ϕ being the angle by which the current leads the voltage.

Given, $\phi = 45°$

$$\Rightarrow \tan 45° = \frac{\omega L - \frac{1}{\omega C}}{R} \Rightarrow 1 = \frac{\omega L - \frac{1}{\omega C}}{R}$$

$$\Rightarrow R = \omega L - \frac{1}{\omega C} \Rightarrow \omega C = \frac{1}{(\omega L - R)}$$

$$\Rightarrow C = \frac{1}{\omega(\omega L - R)} = \frac{1}{2\pi f(2\pi f L - R)}$$

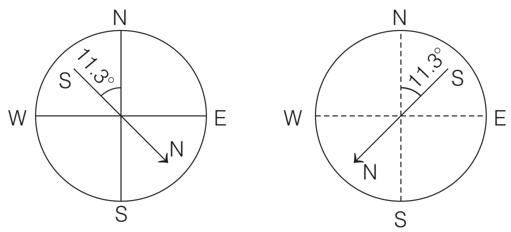
40. Parallel plate capacitor, $C = K\varepsilon_0 A/d$

As given in figure, for series combination,

$$\frac{1}{C'} = \frac{1}{\frac{\varepsilon_0 A}{\frac{d}{2}}} + \frac{1}{\frac{2\varepsilon_0 A}{\frac{d}{2}}} \Rightarrow C' = \frac{4}{3}\frac{\varepsilon_0 A}{d}$$

41. For the earth's magnetism, the magnetic field lines of the earth resemble that of a hypothetical magnetic dipole located at the centre of the earth.

The axis of the dipole does not coincide with the axis of rotation of the earth but is tilted by approximately 11.3° with respect to the later. This results in two situations as given in the figure below



Hence, the declination varies between 11.3° W to 11.3° E.

42. Mutual inductance between two coils depends on their flux linkage, i.e. the fraction of flux linked with one coil which is produced when some current passes through the other coil. In situation (I), two coils have their planes parallel to each other. In this situation, maximum flux passes. Hence, maximum mutual inductance will be in situation (I).

43. The magnetic moment, $M = I \times \pi R^2$. Initially it acts perpendicular to the loop along z-direction. When half of the current loop is bent in YZ-plane, then magnetic moment due to half current loop in XY-plane, $M_1 = I(\pi R^2/2)$ acting along z-direction.

And magnetic moment due to half current loop in YZ-plane, $M_2 = I(\pi R^2/2)$ acting along x-direction.

Effective magnetic moment due to entire bent current loop,

$$M' = \sqrt{M_1^2 + M_2^2}$$
$$= \sqrt{(I\pi R^2/2)^2 + (I\pi R^2/2)^2}$$
$$= \frac{I\pi R^2}{2}\sqrt{2} < M$$

i.e. Magnitude of magnetic moment now decreases.

44. We know that, $e = e_m \sin\omega t$

where, $e_m = \sqrt{2}e_{rms}$.

Given, voltage, $e = 200\sqrt{2}\sin 100\,t$ V

and $C = 1\,\mu F = 1\times10^{-6}$ F

As, $e_{rms} = 200$V and $\omega = 100\ s^{-1}$

$$\therefore \quad X_C = \frac{1}{\omega C} = \frac{1}{100\times10^{-6}} = 10^4\ \Omega$$

$$\therefore \quad I_{rms} = \frac{e_{rms}}{X_C}$$
$$= \frac{200}{10^4} = 2\times10^{-2}\ \textbf{A}$$
$$= \textbf{20 mA}$$

45. **E** outside vicinity of conductor depends on all the charges present in the space and its expression is $\mathbf{E} = \dfrac{\sigma}{\varepsilon_0}$.

Therefore, A is false and R is also false.

46. On increasing the temperature of a conductor, the kinetic energy of free electrons increases. On account of this, they collide more frequently with each other (and with the ions of the conductor) and consequently their drift velocity decreases.

So, on increasing temperature, conductivity of metallic wire decreases.

Therefore, both A and R are true but R is not the correct explanation of A.

47. Current sensitivity, $S_i = \dfrac{NBA}{k}$

$$S_i \propto N$$

and voltage sensitivity, $S_V = \dfrac{NBA}{kR}$

$$S_V \propto \frac{N}{R}$$

So, when S_i is increased by increasing number of turns N, so resistance R increases because length of wire used also increases.

Hence, S_V may remain same or decrease when S_i increases.

Therefore, A is false and R is also false.

48. A magnetic needle, which is free to swing horizontally, would lie in the magnetic meridian and the north pole of the needle would point towards the magnetic north pole.

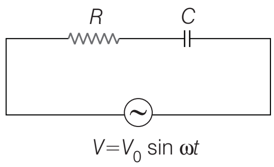
The line joining the magnetic poles is tilted with respect to the geographic axis of the earth. Hence, the magnetic meridian at a point makes some angle with the geographic meridian.

Therefore, both A and R are true but R is not the correct explanation of A.

49. In a system of co-axial solenoids, it is extremely difficult to calculate the flux linkage with the outer solenoid when current flows in inner solenoid.
It is because, the magnetic field due to the inner solenoid would vary across the length as well as cross-section of the outer solenoid (when inner solenoid is smaller in length and radius).

Therefore, both A and R are true and R is the correct explanation of A.

50. Capacitive reactance, $X_C = \frac{1}{2\pi fC}$



$\therefore$ Net impedance, $Z = \sqrt{R^2 + X_C^2}$

So, current in circuit,

$$I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + \left(\frac{1}{2\pi fC}\right)^2}}$$

$$\Rightarrow \quad I = \frac{2\pi fC}{\sqrt{4\pi^2 f^2 C^2 R^2 + 1}} \times V$$

Voltage drop across capacitor,

$$V_C = I \times X_C = \frac{2\pi fC \times V}{\sqrt{4\pi^2 f^2 C^2 R^2 + 1}} \times \frac{1}{2\pi fC}$$

i.e. $$V_C = \frac{V}{\sqrt{4\pi^2 f^2 C^2 R^2 + 1}}$$

When mica is introduced, capacitance will increase. Hence, voltage across capacitor will decrease.

i.e. $V_2 < V_1$

51. Refer figure given in question, the equivalent internal resistance of two cells between A and B is

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{r_1 + r_2}{r_1 r_2}$$

or $$r_{eq} = \frac{r_1 r_2}{r_1 + r_2} \quad \text{...(i)}$$

If E_{eq} is the equivalent emf of the two cells in parallel between A and B, then

$$\frac{E_{eq}}{r_{eq}} = \frac{E_1}{r_1} + \frac{E_2}{r_2} = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2}$$

$$\Rightarrow \quad E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2} \times r_{eq}$$

$$= \frac{(E_1 r_2 + E_2 r_1)}{r_1 r_2} \times \frac{r_1 r_2}{(r_1 + r_2)}$$

$$= \frac{E_1 r_2 + E_2 r_1}{(r_1 + r_2)}$$

This shows that whatever may be the values of r_1 and r_2, the value of E_{eq} is between E_1 and E_2. As $E_2 > E_1$, so $E_1 < E_{eq} < E_2$.

52. Resistivity or specific resistance of material or conductor depends upon the nature of the material and temperature of the conductor.

53. The relationship between current and drift velocity is given by

$$I = neAv_d$$

where, I is the current and v_d is the drift velocity.

So, $I \propto v_d$

Thus, only drift velocity determines the current in a conductor.

54. According to Ohm's law, $V = IR$

Comparing the above equation with the general equation of straight line. i.e. $y = mx + c$, we can say that voltage and current varies linearly with each other, starting from the origin.

Since, conductors obeys Ohm's law, so the correct option is (d).

55. Given, $l = 2$ m, $R = 20\ \Omega$

$$r = 2 \text{ mm} = 2 \times 10^{-3} \text{ m}$$

$$\therefore \quad A = \pi r^2 = \pi \times (2 \times 10^{-3})^2 = 4\pi \times 10^{-6} \text{ m}^2$$

As, we know, $R = \rho \frac{l}{A}$

or $$\rho = \frac{RA}{l}$$

$$\Rightarrow \quad \rho = \frac{20 \times 4\pi \times 10^{-6}}{2} = 4\pi \times 10^{-5}\ \Omega\text{-m}$$

SAMPLE PAPER 2

PHYSICS

A Highly Simulated Practice Questions Paper
*for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

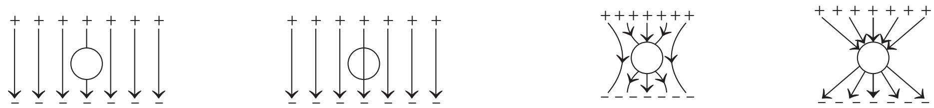
Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. An uncharged sphere of metal is placed in between two charged plates as shown. The lines of force look like



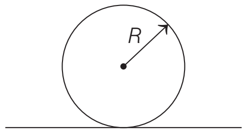
(A) (B) (C) (D)

(a) A (b) B (c) C (d) D

2. Three equal charges are placed on the three corners of a square. If the force between q_1 and q_2 is F_{12} and that between q_1 and q_3 is F_{13}, then the ratio of magnitudes (F_{12}/F_{13}) is

(a) 1 : 2 (b) 2 : 1 (c) $1 : \sqrt{2}$ (d) $\sqrt{2} : 1$

3. If linear charge density of a wire as shown in the figure is λ, then which of the following statement(s) is/are correct?



(a) Electric field at the centre is $\frac{\lambda}{2\varepsilon_0}$.

(b) Electric field at the centre of the loop is $\frac{\lambda}{2\pi\varepsilon_0 R}$.

(c) Electric field at the centre of the loop is $\frac{\lambda}{2\pi\varepsilon_0 R} + \frac{\lambda}{2\varepsilon_0 R}$.

(d) None of the above

4. Number of electrons present on a body, having a charge of $10\,\mu C$ are

(a) 62.5×10^{13} (b) 6.25×10^{14} (c) 6.25×10^{13} (d) 6.25×10^{-14}

5. A capacitor is charged to 500 V and then its plates are joined together through a resistance of 10 Ω. If the heat produced in the resistance is 1.25 J, then the capacitance will be

(a) 1 μF (b) 10 μF (c) 100 μF (d) 0 F

6. The work done in carrying a charge of – 5C from infinity to a particular point in a uniform electric field having potential – 20 V will be

(a) 1 J (b) 10 J (c) 50 J (d) 100 J

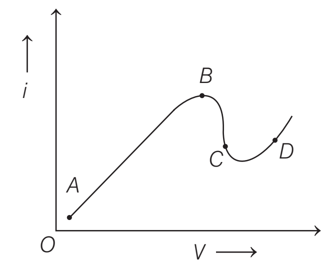
7. Two point charges q and $-2q$ are kept at distance d apart. At a distance of $d/3$

(a) from charge q, potential is zero
(b) from charge $-2q$, potential is zero
(c) from charge q, potential is non-zero
(d) Both (b) and (c)

8. A battery of emf E and internal resistance 2 Ω is connected with a resistor of resistance 10 Ω. If the circuit is closed and current in the circuit is 5A, the value of E is

(a) 10 V (b) 50 V (c) 6 V (d) 60 V

9. The region in which Ohm's law is followed in the given graph is

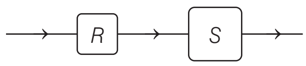


(a) region AB
(b) region BC
(c) region CD
(d) regions AB and CD

10. Mobility of electron is related to relaxation time as

(a) $\mu \propto \frac{1}{\tau}$ (b) $\mu \propto \tau$ (c) $\mu \propto -\frac{1}{\tau}$ (d) $\mu \propto -\tau$

11. Two plates R and S are in the form of a square having the same thickness. The side of S is twice the side of R. The direction of current is shown by an arrow head in figure. Then, which of the following statement(s) is/are correct?



(a) The resistance of R is twice that of S.
(b) Both have the same resistance.
(c) The resistance of S is four times that of R.
(d) The resistance of R is half that of S.

12. Two resistances R and $2R$ are connected in parallel in an electric circuit. The thermal energy developed in R and $2R$ is in the ratio

(a) 1:2 (b) 1:4 (c) 4:1 (d) 2:1

13. A 10 m long straight wire having mass 700 g is suspended in mid-air by a uniform horizontal magnetic field B. If a current of 7A is passing through the wire, then the magnitude of the field is (Take, $g = 10 \text{ m/s}^2$)

(a) 0.9 T (b) 0.05 T (c) 0.1 T (d) 0.01 T

14. Biot-Savart law indicates that the moving electrons with velocity **v**, produce a magnetic field **B** such that

(a) $\mathbf{B} \perp d\mathbf{l} \times \mathbf{r}$ (b) $\mathbf{B} \parallel \mathbf{v}$
(c) it obeys inverse cube law
(d) it is along the line joining the electron and point of observation

15. When a charged particle moves in the region of magnetic field, then

(a) magnitude of its velocity keeps on changing
(b) velocity of particle remains constant
(c) direction of motion keeps on changing
(d) kinetic energy of particle keeps on changing

16. Which of the following statement(s) is/are correct about the magnetic lines of force inside a bar magnet?

(a) They are from north-pole to south-pole of the magnet.
(b) They do not exist.
(c) They depend upon the area of cross-section of the bar magnet.
(d) They are from south-pole to north-pole of the magnet.

17. A particle of charge q and mass m moves in a circular orbit of radius r with angular speed ω. The ratio of the magnitude of its magnetic moment to that of its angular momentum is

(a) $-\dfrac{q}{2m}$ (b) $\dfrac{q\omega r^2}{2}$ (c) $\dfrac{q\omega}{2mr^2}$ (d) $\dfrac{q\omega r^2}{2m}$

18. Which of the following statement(s) is/are incorrect?

(a) The horizontal plane containing the longitude circle and the axis of rotation of the earth is called magnetic meridian.
(b) The angle between the true geographic north and the north by a compass needle is called the magnetic declination or simple declination.
(c) The declination is greater at higher latitudes and smaller near the equator.
(d) Dip is the angle that the total magnetic field $\mathbf{B}_E$ of the earth makes with the surface of the earth.

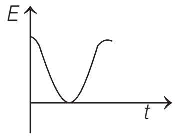
19. Magnetic brakes in train works on the principle of

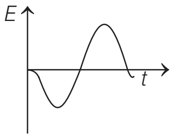
(a) electric flux (b) Gauss's law (c) eddy currents (d) None of these

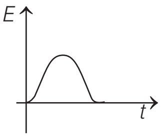
20. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon

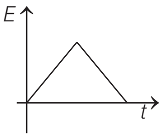
(a) the rates at which currents are changing in the two coils
(b) relative position and orientation of the two coils
(c) the materials of the wires of the coils
(d) the currents in the two coils

21. The variation of induced emf (E) with time (t) in a coil, if a short bar magnet is moved along its axis with a constant velocity is best represented as

(a) 

(b) 

(c) 

(d) 

22. The average power consumed in one cycle is zero, if

(a) $E = E_0 \sin\omega t$ and $I = I_0 \sin\omega t$

(b) $E = E_0 \sin\omega t$ and $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

(c) $E = 1$ and $I = I_0 \sin\omega t$

(d) None of these

23. A battery of 10 V is connected to the primary of a transformer of ratio 20. The output across secondary coil is

(a) 20 V
(b) 10 V
(c) 5 V
(d) zero

24. A lamp consumes only 50% of peak power in an AC circuit. What is the phase difference between the applied voltage and circuit current?

(a) $\frac{\pi}{6}$
(b) $\frac{\pi}{3}$
(c) $\frac{\pi}{4}$
(d) $\frac{\pi}{2}$

25. In an L-C circuit, angular frequency at resonance is ω. What will be the new angular frequency, when inductor's inductance is made two times and capacitor's capacitance is made four times?

(a) $\frac{\omega}{2\sqrt{2}}$
(b) $\frac{\omega}{\sqrt{2}}$
(c) 2ω
(d) $\frac{2\omega}{\sqrt{2}}$

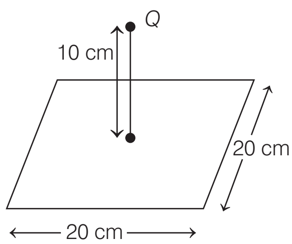
Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. Two charged particles having charge q travel in identical helical path. They are moving in completely opposite directions with the uniform magnetic field $B = B_0\hat{k}$, then which of the following statement(s) is/are correct?

(a) They have equal z-component of momenta.
(b) They must have equal radii.
(c) They represent a particle and anti-particle.
(d) The charge to mass ratio satisfy the equation $\left(\frac{q}{m}\right)_1 + \left(\frac{q}{m}\right)_2 = 0$.

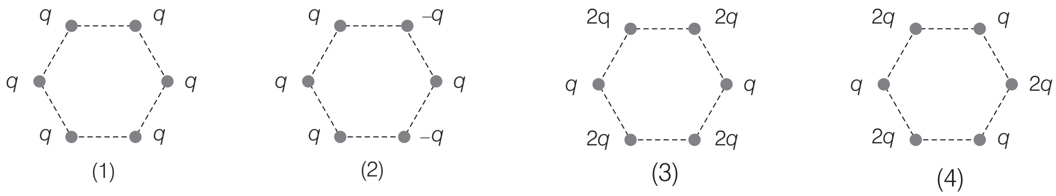
27. A point charge Q is placed at a distance of 10 cm directly above the centre of a square of side 20 cm as shown in figure.



If the magnitude of electric flux through the square is 4×10^5 N m^2C^{-1}, then the value of Q is

(a) 21.2 μC (b) 2.12 μC (c) 21.2 nC (d) 2.12 nC

28. Figures below show regular hexagons, with charges at the vertices. In which of the following cases, the electric field at the centre is non-zero?



(a) 1 (b) 2 (c) 3 (d) 4

29. An *L-C-R* series circuit consists of a resistance of 10 Ω, a capacitor of reactance 60 Ω and an inductor coil. The circuit is found to resonate when put across a 300 V, 100 Hz supply. The inductance of coil is (Take, $\pi = 3$)

(a) 0.1 H (b) 0.01 H (c) 0.2 H (d) 0.02 H

30. Two condensers of capacity 0.3 μF and 0.6 μF respectively are connected in series. The combination is connected across a potential of 6 V. The ratio of energies stored by the condensers will be

(a) 1 : 2 (b) 2 : 1 (c) 1 : 4 (d) 4 : 1

31. If a magnet is suspended at an angle of 30° to the magnetic meridian, the dip needle makes an angle of 45° with the horizontal. The real dip is

(a) $\tan^{-1}(\sqrt{3/2})$ (b) $\tan^{-1}(\sqrt{3})$ (c) $\tan^{-1}(\sqrt{3}/2)$ (d) $\tan^{-1}(2/\sqrt{3})$

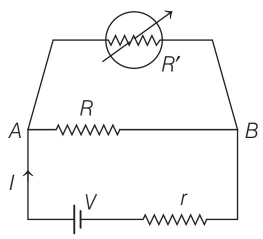
32. An infinite line charge produces a field of 9×10^4 NC^{-1} at a distance of 2 cm. The linear charge density will be

(a) 10^{-5} cm^{-1} (b) 10^{-6} cm^{-1} (c) 10^{-7} cm^{-1} (d) 10^{-8} cm^{-1}

33. A long horizontal metallic rod with length along the east-west direction is falling under gravity. The potential difference between its two ends will

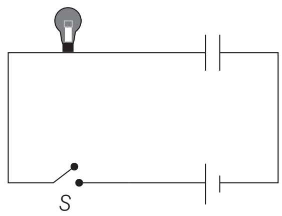
(a) be zero (b) be constant
(c) increase with time (d) decrease with time

34. Consider a simple circuit shown in figure carrying a variable resistance R', which can vary from R to infinity. If r is the internal resistance of the battery ($r << R' << R$), then choose the correct statement.



(a) Potential drop across AB is nearly constant as R' is varied.
(b) Current through R' is nearly a constant as R' is varied.
(c) Current I depends sensitively on R'.
(d) The current drawn from the battery is $I \leq \frac{V}{r+R}$ always.

35. A light bulb, a capacitor and a battery are connected together as shown below, with switch S initially open. When the switch S is closed, then which one of the following statement(s) is/are true?



(a) The bulb will light up for an instant when the capacitor starts charging.
(b) The bulb will light up when the capacitor is fully charged.
(c) The bulb will not light up at all.
(d) The bulb will light up and go off at regular intervals.

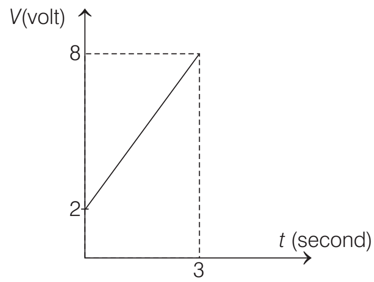
36. A current of 10 A is passing through an aluminium wire of cross-sectional area 4×10^{-6} m^2. The density of the aluminium conductor is 2.7 g/cc. Considering aluminium gives 1 electron per atom for conduction, then find the drift velocity of the electrons, if molecular weight of aluminium is 27 g.

(a) 1.6×10^{-4} m/s (b) 3.6×10^{-4} m/s
(c) 2.6×10^{-4} m/s (d) 1.5×10^{-4} m/s

37. A wire of length L metre carrying a current I ampere is bent in the form of a circle. The magnitude of the magnetic moment is

(a) $\frac{L^2 I^2}{4\pi}$ (b) $\frac{LI}{4\pi}$ (c) $\frac{L^2 I}{4\pi}$ (d) $\frac{LI^2}{4\pi}$

38. A circuit element is placed in a closed box. At time $t = 0$, a constant current generator supplying a current of 1 A is connected across the box. Potential difference across the box varies according to graph shown in the figure. The element in the box is



(a) a resistance of 2 Ω (b) a battery of emf 6 V
(c) an inductance of 2 H (d) a capacitance of 0.5 F

39. A metal conductor of length 1 m rotates vertically about one of its ends at angular velocity 5 rad/s. If the horizontal component of earth's magnetic field is 0.2×10^{-4} T, then the emf developed between the two ends of the conductor is

(a) 5 μV (b) 50 μV (c) 5 mV (d) 50 mV

40. A voltage of peak value 283 V and varying frequency is applied to a series L-C-R combination in which $R = 3\,\Omega$, $L = 25$ mH and $C = 400\,\mu$F. The frequency (in Hz) of the source at which maximum power is dissipated in the given circuit is

(a) 51.5 Hz (b) 50.7 Hz (c) 51.1 Hz (d) 50.3 Hz

41. Two resistances are connected in two gaps of a meter bridge. The balance point is 20 cm from the zero end. When a resistance of 15 Ω is connected in series with the smaller of the two, the null point shifts to 40 cm. The value of the smaller resistance (in ohm) is

(a) 3 (b) 6 (c) 9 (d) 12

42. Two circular coils 1 and 2 are made from the same wire but the radius of the coil-1 is twice that of the coil-2. What is the ratio of current in them, so that the magnetic field at their centres is same?

(a) 3 : 2 (b) 2 : 1 (c) 6 : 7 (d) 2 : 3

43. A 10 μF capacitor is charged to a potential of 25 V. The battery is then disconnected and a pure 100 mH coil is connected across the capacitor, so that *L*-*C* oscillations are set-up. The maximum current in the coil is

(a) 0.25 A (b) 0.01 A (c) 2.5 A (d) 1.6 A

44. When a DC voltage of 200V is applied to a coil of self-inductance $(2\sqrt{3}/\pi)$H, a current of 1A flows through it. But by replacing DC source with AC source of 200V, the current in the coil is reduced to 0.5A. Then, the frequency of AC supply is

(a) 30 Hz (b) 60 Hz (c) 75 Hz (d) 50 Hz

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** The value of resistance connected in series with galvanometer in meter bridge experiment is high.

Reason The current is measured more accurately by galvanometer as the resistance increases.

46. **Assertion** The tyres of aircraft are slightly conducting. So, when an aircraft moves on ground its tyres gets charged.

Reason If a conductor is connected to ground, the extra charge induced on conductor will flow to ground.

47. **Assertion** A bulb is connected in series with a solenoid. If a soft iron core is introduced in the solenoid, the bulb will glow brighter.

Reason On introducing soft iron core in the solenoid, the inductance decreases.

48. **Assertion** Ampere's circuital law states that, the relationship between the current and magnetic field is created by it.

Reason This law is given as $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i$.

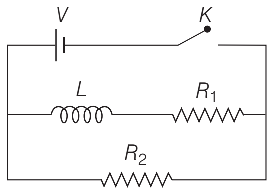
49. **Assertion** When a proton and a deuteron particle are placed in the same uniform electric field, they experiences different accelerations.

Reason Mass of proton and deuteron particle is different from each other.

Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. In the circuit shown below, the key K is closed at $t = 0$. The current through the battery is



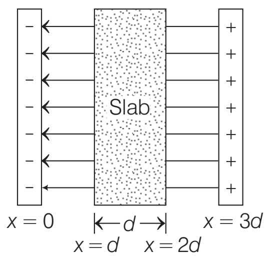
(a) $\dfrac{VR_1 R_2}{\sqrt{R_1^2 + R_2^2}}$ at $t = 0$ and $\dfrac{V}{R_2}$ at $t = \infty$

(b) $\dfrac{V}{R_2}$ at $t = 0$ and $\dfrac{V(R_1 + R_2)}{R_1 R_2}$ at $t = \infty$

(c) $\dfrac{V}{R_2}$ at $t = 0$ and $\dfrac{VR_1 R_2}{\sqrt{R_1^2 + R_2^2}}$ at $t = \infty$

(d) $\dfrac{V(R_1 + R_2)}{R_1 R_2}$ at $t = 0$ and $\dfrac{V}{R_2}$ at $t = \infty$

51. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at $x = 0$ and positive plate is at $x = 3d$. The slab is equidistant from the plates. When the capacitor is given some charge and as one moves from 0 to $3d$, then



I. the magnitude of the electric field remains the same.
II. the direction of the electric field remains the same.
III. the electric potential increases continuously.

Which of the following statement(s) is/are correct?

(a) Only I (b) Only III (c) Both I and III (d) Both II and III

Case Study

Read the following paragraph and answer the questions.

Equipotential Surfaces

Equipotential in terms of Physics is defined as a region in space in which every specified point has same potential. If these points are connected by a line or curve, it is known as an **equipotential line**.

When such points lie on a surface,then it is called an **equipotential surface** and when they lie in space or a volume, then it is called an **equipotential volume**.

For any charge configuration, equipotential surface through a point is normal to the electric field at the point and directed from one equipotential surface at higher potential to the other equipotential surface at lower potential.

52. Work done in moving a test charge from one equipotential surface to another, is

(a) positive (b) negative
(c) infinite (d) zero

53. The equipotential surface will be spherical for a

(a) dipole (b) quadrupole
(c) dielectric molecule (d) point charge

54. Which of the following statement is true in terms of work done along an equipotential surface?

(a) Work done is zero.
(b) Work done can have a non-zero value.
(c) Work done is defined as $-\int_P^Q \mathbf{E}\cdot d\mathbf{l}$ (for points P and Q).
(d) Both (a) and (c)

55. When a charge moves once round a circle, the work done will be

(a) zero (b) π J (c) 2π J (d) $\frac{3\pi}{4}$ J

OMR SHEET

SP 2

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

Correct | Incorrect | Incorrect | Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	20	a	b	c	d	38	a	b	c	d
2	a	b	c	d	21	a	b	c	d	39	a	b	c	d
3	a	b	c	d	22	a	b	c	d	40	a	b	c	d
4	a	b	c	d	23	a	b	c	d	41	a	b	c	d
5	a	b	c	d	24	a	b	c	d	42	a	b	c	d
6	a	b	c	d	25	a	b	c	d	43	a	b	c	d
7	a	b	c	d	26	a	b	c	d	44	a	b	c	d
8	a	b	c	d	27	a	b	c	d	45	a	b	c	d
9	a	b	c	d	28	a	b	c	d	46	a	b	c	d
10	a	b	c	d	29	a	b	c	d	47	a	b	c	d
11	a	b	c	d	30	a	b	c	d	48	a	b	c	d
12	a	b	c	d	31	a	b	c	d	49	a	b	c	d
13	a	b	c	d	32	a	b	c	d	50	a	b	c	d
14	a	b	c	d	33	a	b	c	d	51	a	b	c	d
15	a	b	c	d	34	a	b	c	d	52	a	b	c	d
16	a	b	c	d	35	a	b	c	d	53	a	b	c	d
17	a	b	c	d	36	a	b	c	d	54	a	b	c	d
18	a	b	c	d	37	a	b	c	d	55	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: __________

Total Correct Questions: __________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

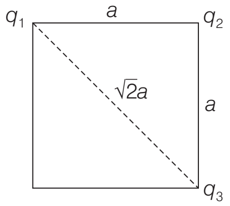
1. (c)	**2.** (b)	**3.** (d)	**4.** (c)	**5.** (b)	**6.** (d)	**7.** (a)	**8.** (d)	**9.** (a)	**10.** (b)
11. (b)	**12.** (d)	**13.** (c)	**14.** (a)	**15.** (c)	**16.** (d)	**17.** (a)	**18.** (a)	**19.** (c)	**20.** (b)
21. (b)	**22.** (b)	**23.** (d)	**24.** (b)	**25.** (a)	**26.** (d)	**27.** (a)	**28.** (b)	**29.** (a)	**30.** (b)
31. (c)	**32.** (c)	**33.** (c)	**34.** (a)	**35.** (a)	**36.** (c)	**37.** (c)	**38.** (d)	**39** (b)	**40** (d)
41. (c)	**42.** (b)	**43.** (a)	**44.** (d)	**45.** (c)	**46.** (b)	**47.** (d)	**48.** (a)	**49** (a)	**50** (b)
51. (d)	**52.** (a)	**53.** (d)	**54.** (d)	**55.** (a)					

SOLUTIONS

1. Electric lines of force never intersect the sphere. They are perpendicular and slightly curved near the surface of sphere as shown in Fig. (c).

Hence, option (c) is correct.

2.



Force, $F_{12} = \dfrac{K(q^2)}{a^2}$

Force, $F_{13} = \dfrac{K(q^2)}{(\sqrt{2}a)^2}$

$\therefore$ Ratio, $\dfrac{F_{12}}{F_{13}} = \dfrac{Kq^2}{a^2} \times \dfrac{2a^2}{Kq^2} = \dfrac{2}{1}$ or 2 : 1

3. Electric field at centre of circular loop, $E = \dfrac{kQ}{R^2}$

Total charge on loop, $Q = (2\pi R)\lambda$

$$\therefore \quad E = \frac{1}{4\pi\varepsilon_0} \times \frac{2\pi R\lambda}{R^2} = \frac{\lambda}{2\varepsilon_0 R}$$

4. Given, $q = 10\,\mu\text{C}$

$$= 10 \times 10^{-6}\text{C} = 10^{-5}\text{C}$$

Charge on one electron, $e = 1.6 \times 10^{-19}\text{C}$

From the property of quantisation of charge,

$$q = ne$$

$$\Rightarrow \quad n = \frac{q}{e} = \frac{10^{-5}}{1.6 \times 10^{-19}} = 6.25 \times 10^{13}$$

5. Here, $V = 500$ V, $R = 10\ \Omega$, $U = 1.25$ J

Energy stored in capacitor $= \dfrac{1}{2}CV^2$

$$1.25 = \frac{1}{2} \times C \times (500)^2$$

$$C = \frac{1.25 \times 2}{(500)^2} = 10\,\mu\text{F}$$

6. Here, $q = -5\text{C}$

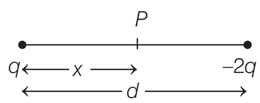
$$V = -20\text{V}$$

Work done,

$$W = q \times V$$
$$= -5 \times -20$$
$$= 100 \text{ J}$$

7. Let P be the required point at distance x from charge q, where potential is zero.

$$\therefore \frac{1}{4\pi\varepsilon_0}\frac{q}{x} + \frac{1}{4\pi\varepsilon_0}\frac{(-2q)}{d-x} = 0$$



$$\frac{1}{x} = \frac{2}{d-x}$$

$$\Rightarrow d - x = 2x$$

$$\Rightarrow \quad x = \frac{d}{3}$$

$\therefore$ At a distance of $d/3$ from charge q, electric potential is zero.

8. Given, $i = 5\text{A}$, $R = 10\ \Omega$, $r = 2\,\Omega$

According to Ohm's law, $V = iR$ ... (i)

Terminal potential across battery is given by

$$E - ir = V \quad \text{... (ii)}$$

Equating Eqs. (i) and (ii), we get

$$\Rightarrow E - ir = iR$$

$$\Rightarrow \quad E = i(R + r) = 5(10 + 2)$$

$$\Rightarrow \quad E = 60 \text{ V}$$

9. According to Ohm's law, $V = iR$

It is an equation of straight line.

$\therefore$ Ohm's law is followed in the region from A to B.

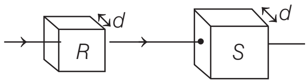
10. Mobility, $\mu = \dfrac{v_d}{E}$

As, $v_d = \dfrac{eE\tau}{m}$

$\Rightarrow \quad \mu = \dfrac{e\tau}{m}$

$\therefore \quad \mu \propto \tau$

11. Both plates have same thickness, let it is d.



Then, $R_R = \dfrac{\rho l}{ld}$

and $R_S = \dfrac{\rho 2l}{2ld} = \dfrac{\rho l}{ld}$

$\therefore \quad \dfrac{R_R}{R_S} = 1$ or $R_R = R_S$

Therefore, both plates have the same resistance.

12. The resistances are connected in parallel, hence voltage will remain constant.

Thermal energy developed,

$$E = \frac{V^2 t}{R}$$

$\Rightarrow \quad E \propto \dfrac{1}{R}$

$\therefore \quad \dfrac{E_1}{E_2} = \dfrac{R_2}{R_1} = \dfrac{2R}{R} = \dfrac{2}{1}$

Thus, the thermal energy developed in R and $2R$ is in the ratio of 2 : 1.

13. Given, $m = 700 \text{ g} = 0.7 \text{ kg}$

$l = 10 \text{ m}$

$i = 7 \text{A}$

As we know, $F = Bil \sin\theta$

or $mg = Bil \sin 90°$ ($\because B$ is horizontal)

$\Rightarrow \quad B = \dfrac{mg}{il}$

$= \dfrac{0.7 \times 10}{7 \times 10} = 0.1 \text{ T}$

14. According to Biot-Savart law, the magnetic field $d\mathbf{B}$ due to a current element $d\mathbf{l}$, carrying a steady current i, at a distance r from the current element,

$$d\mathbf{B} = \frac{\mu_0}{4\pi} i \frac{d\mathbf{l} \times \mathbf{r}}{r^3} = \frac{\mu_0}{4\pi} \frac{i\,dl \sin\theta}{r^2}$$

Therefore, magnetic field $\mathbf{B}$ is perpendicular to the product of current element ($d\mathbf{l}$) and distance ($\mathbf{r}$).

15. When a charged particle moves in the region of magnetic field, then force is perpendicular to the velocity and it produces a change in direction.

Therefore, the direction of motion keeps on changing.

16. Inside a bar magnet, lines of force are from south-pole to north-pole.

17. The relation between magnetic moment (μ_l) and angular momentum (L) is

$$\mu_l = -\frac{q}{2m} L$$

$\Rightarrow \quad \dfrac{\mu_l}{L} = -\dfrac{q}{2m}$

The negative sign indicates that the angular momentum of the electron is opposite in direction to the magnetic moment.

18. The statement given in option (a) is incorrect and it can be corrected as,

The vertical plane containing the longitude circle and the axis of rotation of the earth is called the geographic meridian. While, magnetic meridian of a place is the vertical plane which passes through the imaginary lines joining the magnetic north and the south-poles.

19. Eddy currents are the currents induced in bulk pieces of conductors. Some electromagnets are used to produce eddy currents in the train, which oppose the motion of the train and stop it. Therefore, these currents are used in the application of brakes in train.

20. Mutual inductance M between two coils is given by $M = \mu_0 n_1 n_2 \pi r_1^2 L$

where, n_1, n_2 are number of turns, r_1 is the radius of coil and L is its length.

From the above formula, it is clear that mutual inductance depends on distance between the coils and geometry (πr^2 = area) of two coils or their relative position and orientation.

21. As the magnet moves towards the coil, the magnetic flux increases (non-linearly). Also, there is a change in polarity of induced emf when the magnet passes on to the other side of the coil.

This is correctly shown in option (b).

22. Average power consumed, $P_{avg} = E_{rms} I_{rms} \cos\phi$

It will be zero, if the phase difference between voltage and current is $\dfrac{\pi}{2}$.

Here, in option (b), the phase difference is $\pi/2$.

23. A battery produces direct current (DC), but the transformer does not work on DC supply. Hence, no induction occurs in it and the output across secondary coil is zero.

24. As, power, $P = \frac{1}{2} V_0 I_0 \cos\phi$

$\Rightarrow \quad P = P_{peak} \cos\phi$

$\Rightarrow \quad \frac{1}{2}(P_{peak}) = P_{peak} \cos\phi \quad (\because P = 50\% \text{ of } P_{peak})$

$\Rightarrow \quad \cos\phi = \frac{1}{2}$

$\Rightarrow \quad \phi = \frac{\pi}{3}$

25. $\because$ Angular frequency at resonance,

$$\omega = \frac{1}{\sqrt{LC}} \quad \text{...(i)}$$

According to question, when inductance is made 2 times and capacitance is made 4 times, then

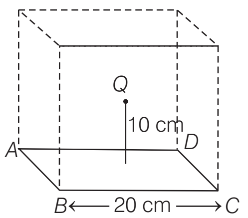
$$\omega' = \frac{1}{\sqrt{2L \times 4C}} = \left(\frac{1}{2\sqrt{2}}\right)\frac{1}{\sqrt{LC}}$$

$$= \frac{\omega}{2\sqrt{2}} \quad \text{[from Eq. (i)]}$$

26. Charge to mass ratio $\left(\frac{q}{m}\right)$ of the two particles is same but they are moving in opposite directions.

$\therefore \left(\frac{q}{m}\right)_1 + \left(\frac{q}{m}\right)_2 = 0$ satisfies the given condition.

27. By Gauss's theorem, total electric flux through all the six faces of the cube $= \frac{Q}{\varepsilon_0}$



$\therefore$ Electric flux through the square $ABCD$,

$$\phi = \frac{1}{6}\frac{Q}{\varepsilon_0}$$

$\Rightarrow \quad Q = 6\varepsilon_0 \times \phi$

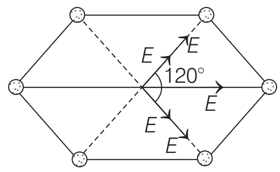
$= 6 \times 8.85 \times 10^{-12} \times 4 \times 10^5$

$= 212.4 \times 10^{-7}$ C

$= 21.2 \times 10^{-6}$ C

$\Rightarrow \quad Q = 21.2\ \mu$C

28. In Figs. (1), (3) and (4), net electric field is zero and for Fig. (2), net electric field is non-zero. It is because electric field at a point due to positive charge acts away from the charge and due to negative charge, it acts towards the charge.



Here, net electric field in Fig. (2) is

$= \sqrt{(2E)^2 + (2E)^2 + (2E)(2E) \cdot 2\cos 120°}$

$= 2E$

29. Given, $R = 10\ \Omega$, $X_C = 60\ \Omega$

$V = 300$ V and $\nu = 100$ Hz

Angular velocity, $\omega_0 = 2\pi\nu = 2\pi \times 100$

$\Rightarrow \quad \omega_0 = 2 \times 3 \times 100 = 600$ rads^{-1} $(\because \pi = 3)$

Further, $\omega_0 = \frac{1}{\sqrt{LC}}$ ...(i)

Also, $X_C = \frac{1}{C\omega_0} = 60\ \Omega$

$\Rightarrow \quad C = \frac{1}{\omega_0 \times 60} = \frac{1}{600 \times 60}$

$\Rightarrow \quad C = \frac{1}{36 \times 10^3}$ F

On putting values in Eq. (i), we get

$$600 = \frac{1}{\sqrt{L\left(\frac{1}{36 \times 10^3}\right)}}$$

$\Rightarrow 36 \times 10^4 = \frac{36 \times 10^3}{L}$

$\Rightarrow \quad L = \frac{36 \times 10^3}{36 \times 10^4} = \frac{1}{10} = 0.1$ H

30. In series combination , charge remains same on both capacitors.

$\therefore \quad U = \frac{Q^2}{2C}$ or $U \propto \frac{1}{C}$

$\Rightarrow \quad \frac{U_1}{U_2} = \frac{C_2}{C_1} = \frac{0.6}{0.3}$

$\therefore \quad U_1 : U_2 = 2 : 1$

31. Given, angle of suspension to the magnetic meridian, $\alpha = 30°$ and dip angle, $\delta' = 45°$.

Hence, $\tan\delta' = \frac{V_E}{H'_E} = \frac{V_E}{H_E \cos\alpha}$

$$= \frac{\tan\delta}{\cos\alpha} \qquad \left[\because \tan\delta = \frac{V_E}{H_E}\right]$$

$$\Rightarrow \quad \tan\delta = \cos\alpha \tan\delta'$$
$$= \cos 30^\circ \tan 45^\circ = \frac{\sqrt{3}}{2}$$
$$\Rightarrow \quad \delta = \tan^{-1}\frac{\sqrt{3}}{2}$$

$\therefore$ Angle of the real dip is $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$.

32. Given, electric field, $E = 9 \times 10^4 \text{ NC}^{-1}$

Distance, $r = 2 \text{ cm} = 2 \times 10^{-2} \text{ m}$

Electric field due to infinite line charge,

$$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{2\lambda}{4\pi\varepsilon_0 r}$$

Putting the values, we get

$$9 \times 10^4 = \frac{2 \times 9 \times 10^9 \times \lambda}{2 \times 10^{-2}}$$

$$\lambda = \frac{9 \times 10^4 \times 2 \times 10^{-2}}{2 \times 9 \times 10^9} = 10^{-7} \text{ cm}^{-1}$$

33. Induced emf, $e = Bvl$

$\therefore \quad e \propto v$

Also, $v = 0 + gt$

$\therefore \quad e \propto gt$

So, potential difference between its two ends will increase with time.

34. Here, the potential drop is taking place across AB. As R and R' are parallel, so potential drop across R and R' will be equal whatever may be the value of R'. Since, potential drop across R is V which is constant (the value of r is very small), so potential drop across R' will also be constant, when R' is varied.

Since, the equivalent resistance of parallel combination of R and R' is always less than R, therefore current drawn from the battery is $I \geq \frac{V}{r + R}$ always.

Thus, I is independent of R'. Also, as R' varies the value of current through R' changes linearly.

35. When key is closed, then capacitor becomes short circuited and bulb will light up. But when capacitor becomes fully charged, it act as open circuit and this time bulb will not glow.

Hence, the bulb will light up for an instant when the capacitor starts charging.

36. Given, current, $i = 10$ A

Area of cross-section, $A = 4 \times 10^{-6} \text{ m}^2$

Density of conductors, $\rho = 2.7$ g/cc

$$= 2.7 \times 10^3 \text{ kg/m}^3$$

Molecular weight of aluminium,

$$M_w = 27\text{g} = 27 \times 10^{-3} \text{ kg}$$

If n be the total number of electrons in the conductor per unit volume, then

$$n = \frac{\text{Total number of electrons}}{\text{Volume of conductor}}$$

$$= \frac{\text{Number of atoms per mole} \times \text{Number of moles}}{V}$$

$$= \frac{\text{Avogadro's number}}{V} \times \left(\frac{M}{M_w}\right)$$

$$= 6 \times 10^{23} \times \frac{\rho}{M_w} \qquad \left[\because \rho = \frac{M}{V}\right]$$

$$= 6 \times 10^{23} \times \frac{2.7 \times 10^3}{27 \times 10^{-3}}$$

$$\therefore \quad n = 6 \times 10^{28}$$

We know that, drift velocity,

$$v_d = \frac{i}{neA}$$
$$= \frac{10}{6 \times 10^{28} \times 1.6 \times 10^{-19} \times 4 \times 10^{-6}}$$
$$= 2.6 \times 10^{-4} \text{ m/s}$$

37. Circumference of circle $= 2\pi R$

$$\therefore 2\pi R = L \quad \Rightarrow \quad R = \left(\frac{L}{2\pi}\right)$$

Area, $A = \pi R^2 = \frac{\pi L^2}{4\pi^2} = \frac{L^2}{4\pi}$

Magnetic moment, $\mu = IA = \frac{IL^2}{4\pi}$

38. For a capacitor, $i = \left(\frac{dq}{dt}\right) = C \cdot \left(\frac{dV}{dt}\right)$

i.e. i = constant, if $\frac{dV}{dt}$ = constant.

Here, $i = 1$ A, $\frac{dV}{dt} = \frac{(8-2)}{(3-0)} = 2$

$\therefore$ Capacitance, $C = \frac{i}{\left(\frac{dV}{dt}\right)} = \frac{1}{2} = 0.5$ F

39. The emf induced between ends of conductor,

$$e = \frac{1}{2}B\omega L^2 = \frac{1}{2} \times 0.2 \times 10^{-4} \times 5 \times (1)^2$$
$$= 0.5 \times 10^{-4} \text{ V}$$
$$= 5 \times 10^{-5} \text{ V} = 50 \, \mu\text{V}$$

40. Given, $R = 3 \, \Omega$, $L = 25 \text{ mH} = 25 \times 10^{-3}$ H,

$C = 400 \, \mu\text{F} = 400 \times 10^{-6}$ F and $V = 283$ V

A series resonance circuit admits maximum current.

As, $\quad P = i^2 R$

So, power dissipated is maximum at resonance.

Therefore, frequency of the source at which maximum power is dissipated in the circuit is

$$\nu = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2 \times 3.14\sqrt{25 \times 10^{-3} \times 400 \times 10^{-6}}}$$

$$= \frac{1}{2 \times 3.14\sqrt{10^{-5}}} = 50.3 \text{ Hz}$$

41. Initially, $\frac{P}{Q} = \frac{20}{(100-20)} = \frac{20}{80} = \frac{1}{4}$

Let P be the smaller resistance.

In second case, $\frac{P+15}{Q} = \frac{40}{60}$

$$\Rightarrow \quad \frac{P}{Q} + \frac{15}{Q} = \frac{2}{3}$$

$$\Rightarrow \quad \frac{1}{4} + \frac{15}{Q} = \frac{2}{3}$$

$$\Rightarrow \quad \frac{15}{Q} = \frac{5}{12}$$

$$\Rightarrow \quad Q = 36\,\Omega$$

$\therefore$ Resistance, $P = \frac{1}{4} \times 36 = 9\Omega$

42. At the centre of coil-1,

$$B_1 = \frac{\mu_0}{4\pi} \times \frac{2\pi i_1}{r_1} \quad \text{...(i)}$$

At the centre of coil-2,

$$B_2 = \frac{\mu_0}{4\pi} \times \frac{2\pi i_2}{r_2} \quad \text{...(ii)}$$

But $\quad B_1 = B_2$

$$\therefore \quad \frac{\mu_0}{4\pi}\frac{2\pi i_1}{r_1} = \frac{\mu_0}{4\pi}\frac{2\pi i_2}{r_2}$$

or $\quad \frac{i_1}{r_1} = \frac{i_2}{r_2}$

As, $r_1 = 2r_2$

$$\therefore \frac{i_1}{2r_2} = \frac{i_2}{r_2} \Rightarrow \frac{i_1}{i_2} = \frac{2}{1} \text{ or } 2:1$$

43. For L-C oscillations,

Energy stored in inductor = Energy stored in capacitor

$$\frac{1}{2}Li_m^2 = \frac{1}{2}CV_m^2$$

Given, $V_m = 25$ V, $C = 10\mu\text{F} = 10^{-5}$ F

and $L = 100$ mH $= 10^{-1}$ H

$$\Rightarrow \quad i_m = V_m\sqrt{\frac{C}{L}} = 25\sqrt{\frac{10^{-5}}{10^{-1}}}$$

$$= 25 \times 10^{-2} \text{ A} = 0.25 \text{ A}$$

44. Resistance of coil, $R = \frac{V}{I} = \frac{200}{1} = 200\,\Omega$

With AC source, $I = \frac{V}{\sqrt{R^2 + X_L^2}}$

or $\quad 0.5 = \frac{200}{\sqrt{R^2 + X_L^2}}$

$$\Rightarrow \quad R^2 + (2\pi fL)^2 = (400)^2$$

$$\Rightarrow \quad \left(2\pi f \times \frac{2\sqrt{3}}{\pi}\right)^2 = (400)^2 - (200)^2 = 200 \times 600$$

$$\Rightarrow \quad 4f\sqrt{3} = 2\sqrt{3} \times 100$$

$$\Rightarrow \quad f = 50\,\text{Hz}$$

45. The resistance of the galvanometer is fixed in meter bridge experiment. To protect the galvanometer from high current, high resistance is connected in series with it.

For measurement of current more accurately, the resistance of galvanometer circuit should be reduced by using a low resistance in parallel.

Therefore, A is true but R is false.

46. Tyres of aircraft will get charged due to the friction between tyres and ground. That's why the tyres of aircraft are slightly conducting. When a conductor has an induced charge on its surface, then the extra charge will flow to the ground because it is considered as a neutral point.

Therefore, both A and R are true but R is not the correct explanation of A.

47. When a soft iron core is introduced in the bulb, it will glow dimmer. Here, as the inductance L of the solenoid increases, the inductor reactance $X_L (= \omega L)$ also increases.

Due to this, impedance increases which decreases the current through the bulb. Therefore, A is false and R is also false.

48. Ampere's circuital law states that, the integral of magnetic field density (B) along an imaginary closed path is equal to the product of current enclosed by the path and permeability of the medium.

i.e. $\quad \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i$

It gives the relationship between the current and magnetic field.

Therefore, both A and R are true and R is the correct explanation of A.

49. Proton and deuteron have same amount of charge, i.e. $(+e)$, so they will experience same coulomb's force due to electric field.

As, they have different masses, so according to $a = \frac{F}{m}$, they will experience different accelerations, when placed in same uniform electric field.

Therefore, both A and R are true and R is the correct explanation of A.

50. At $t = 0$, inductor behaves like an infinite resistance.

So, at $t = 0$, $I = \frac{V}{R_2}$ and at $t = \infty$, inductor behaves like a conducting wire, $I = \frac{V}{R_{eq}} = \frac{V(R_1 + R_2)}{R_1 R_2}$

51. After the introduction of dielectric slab, direction of electric field remains same as perpendicular to plate and is directed from positive to negative plate.

Electric field in air $= \frac{\sigma}{\varepsilon_0}$

and electric field in dielectric $= \frac{\sigma}{K\varepsilon_0}$

i.e. The magnitude of electric field decreases by $1/K$ times.

Positive plate is at higher potential and negative plate is at lower potential. So, electric potential increases continuously as we move from $x = 0$ to $x = 3d$.

52. The work done in moving a test charge from one equipotential surface to another is positive.

53. For a point charge, the equipotential surface will be represented by a sphere.

54. Work done to move a unit charge along an equipotential surface from P to Q is

$$W = -\int_P^Q \mathbf{E} \cdot d\mathbf{l}$$

As we know that, on equipotential surface,

$$\mathbf{E} \perp d\mathbf{l}$$

$$\therefore \quad W = -\int_P^Q E\,dl \cos 90° = 0$$

55. The electrical potential at any point on the circle of radius a due to charge Q at its centre,

$$V = \frac{1}{4\pi\varepsilon_0} \frac{Q}{a}$$

Work done, $W = \Delta V \times q$

Since in one round, $\Delta V = 0$

Hence, work done in carrying a charge q round the circle is zero.

SAMPLE PAPER 3

PHYSICS

*A Highly Simulated Practice Questions Paper for CBSE **Class XII** (Term I) Examination*

Instructions

1. *This question paper is divided into three sections.*
2. ***Section - A** contains 25 questions. Attempt **any 20** questions.*
3. ***Section - B** contains 24 questions. Attempt **any 20** questions.*
4. ***Section - C** contains 6 questions. Attempt **any 5** questions.*
5. *Each question carries 0.77 mark.*
6. *There is **no** negative marking.*

Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. The magnitude of electric field between two uniformly charged parallel sheets with surface charge density of 3.6×10^{-14} C/m^2 is

(a) 2 N/C (b) 20 N/C (c) 200 N/C (d) None of these

2. A cylinder of radius R and length L is placed in a uniform electric field E, parallel to the cylinder axis. The total flux for the curved surface of the cylinder is

(a) zero (b) $E\pi R^2$ (c) $\frac{\pi R^2}{E}$ (d) $2\pi R^2 E$

3. The unit of electric permittivity is

(a) V/m^2 (b) J/C (c) F/m (d) H/m

4. Three charges $-q$, $+Q$ and $-q$ are placed at equal distance on a straight line. If the potential energy of the system of the three charges is zero, then the ratio of $Q : q$ is

(a) 1 : 4 (b) 4 : 1 (c) 2 : 1 (d) 3 : 1

5. Conducting sphere of radius R_1 is covered by concentric sphere of radius R_2. Capacity of this combination is proportional to

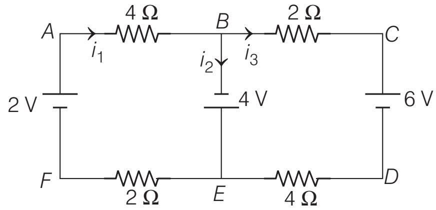
(a) $\frac{R_2 - R_1}{R_1 R_2}$ (b) $\frac{R_2 + R_1}{R_1 R_2}$ (c) $\frac{R_1 R_2}{R_1 + R_2}$ (d) $\frac{R_1 R_2}{R_2 - R_1}$

6. A parallel plate capacitor is made by stocking n equally spaced plates alternately. If the capacitance between any two plates is x, then the total capacitance is
(a) nm (b) n/m (c) mn^2 (d) $(n-1)x$

7. For a metallic wire, the ratio of potential difference (V) and current (i) flowing is
(a) independent of temperature
(b) increases as the temperature rises
(c) decreases as the temperature rises
(d) increases or decreases as temperature rises depending upon the metal

8. Four cells, each of emf E and internal resistance r, are connected in series across an external resistance R. By mistake one of the cells is connected in reverse. Then, the current in the external circuit is
(a) $\frac{2E}{4r+R}$ (b) $\frac{3E}{4r+R}$
(c) $\frac{3E}{3r+R}$ (d) $\frac{2E}{3r+R}$

9. A circuit diagram is shown below. For loop $ABEFA$, the expression for the net voltage is

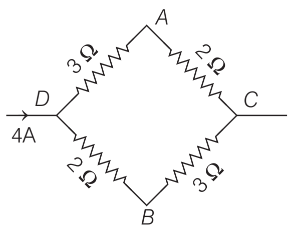


(a) $-4i_1+4-2i_1+2=0$ (b) $-2i_3-6-4i_3-4=0$
(c) $4i_1-4-2i_1+2=0$ (d) $+2i_3+6-4i_3-4=0$

10. A potential difference of V is applied at the ends of a copper wire of length l and diameter D. On doubling only D, drift speed
(a) becomes double (d) becomes half
(c) does not change (b) becomes one-fourth

11. Which of the following is the main cause of heat production in a current carrying? conductor?
(a) Collisions of free elctrons with one another
(b) High drift speed of free electrons
(c) Collision of free electrons with atoms or ions of the conductor
(d) High resistance value

12. A current of 4A flows in the resistance network as shown below. The potential difference $V_A - V_B$ will be

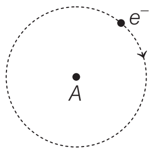


(a) +4 V (b) −2 V (c) +2 V (d) −1 V

13. A galvanometer is shunted by a resistance of $\frac{1}{r}$. The fraction of total current passing through the galvanometer is

(a) $\frac{1}{1+r^2}$ (b) $\frac{1}{1+r}$ (c) r (d) r^2+1

14. An electron is revolving around a circular loop as shown in the figure. The direction of magnetic field at the point A will be



(a) inward (b) outward (c) zero (d) Cannot determine

15. When the radius of a circular loop carrying current is doubled, its magnetic moment will be (Take, $n=1$)

(a) $\mathbf{M}$ (b) $\frac{\mathbf{M}}{4}$ (c) $4\mathbf{M}$ (d) zero

16. Magnetic moment of an atom is due to

(a) orbital motion of electron
(b) spin motion of electron
(c) radial motion of electrons
(d) Both (a) and (b)

17. The ratio of horizontal component to the total magnetic field of the earth at a place, where angle of dip is 30° will be

(a) $2:\sqrt{3}$ (b) $\sqrt{3}:2$ (c) $2:\sqrt{2}$ (d) 2 : 3

18. Two current carying coils are placed close to each other. The mutual inductance of the pair of coils depends upon which of the following factors?

(a) Distance between two coils (b) Geometry of two coils
(c) Both (a) and (b) (d) None of these

19. Self induction of an air core inductor increases from 0.01 mH to 10 mH on introducing an iron core into it. The relative permeability of the core used is

(a) 10 (b) 100 (c) 1000 (d) 1

20. Two coils have mutual inductance of 1.5 H. If current in primary coil is raised to 5A in one millisecond after closing the circuit, emf induced in the secondary coil is

(a) 2.5×10^3 V (b) 5.0×10^3 V (c) 7.5×10^3 V (d) 8.0×10^3 V

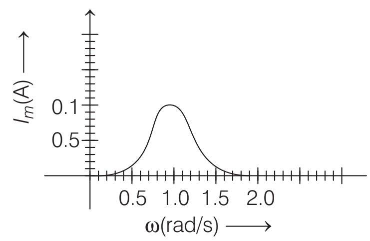
21. An expression for alternating current in a circuit is given as $I = 2\sin(100\pi t + \pi/3)$A. The first time, when the current is maximum will be

(a) 0.01 s (b) 0.002 s (c) 0.005 s (d) 0.05 s

22. The core of a transformer is laminated. Which of the following is the correct result of it?

(a) Energy losses due to eddy currents may be minimised.
(b) The weight of the transformer may be reduced.
(c) Rusting of the core may be prevented.
(d) Ratio of voltage in primary and secondary may be increased.

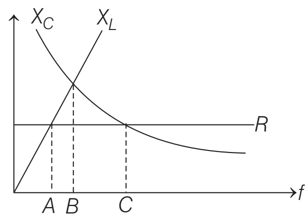
23. In series *L-C-R* circuit, the plot of I_{max} *versus* ω is shown in the figure. The bandwidth of the circuit (in rad/s) is



(a) 0.1 rad/s (b) 1.2 rad/s (c) 0.4 rad/s (d) 0.8 rad/s

24. In the fetching mechanism of a radio or a TV set, the phenomenon used in the circuit is
(a) eddy currents (b) resonance
(c) alternating current (d) None of these

25. The figure shows variation of R, X_L and X_C with frequency f in a series *L-C-R* circuit. Then, for what frequency point, the circuit is inductive?

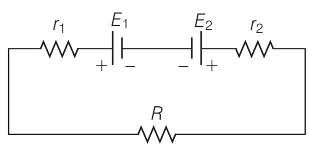


(a) *A* (b) *B* (c) *C* (d) All points

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. Two cells of emf E_1 and E_2 are joined in opposition (such that $E_1 > E_2$). If r_1 and r_2 be the internal resistances and R be the external resistance, then the terminal potential difference is



(a) $\frac{E_1 - E_2}{r_1 + r_2} \times R$ (b) $\frac{E_1 + E_2}{r_1 + r_2} \times R$ (c) $\frac{E_1 - E_2}{r_1 + r_2 + R} \times R$ (d) $\frac{E_1 + E_2}{r_1 + r_2 + R} \times R$

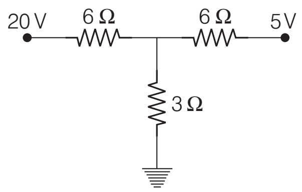
27. The instantaneous voltage through a device of impedance $20\,\Omega$ is $V = 80 \sin 100\pi t$. The effective value of the current is
(a) 3 A (b) 2.828 A (c) 1.732 A (d) 4 A

28. The amount of work done in increasing the voltage across the plates of a capacitor from 5V to 10 V is W. The work done in increasing it from 10 V to 5 V will be
(a) 0.6 W (b) 1 W (c) 1.25 W (d) 1.67 W

29. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area $1.0\times10^{-7}\ \text{m}^2$ carrying a current of 1.5 A. Assume that, each copper atom contributes roughly one conduction electron. (Take, $m_{Cu} = 63.5$ g and mass of one cubic meter of copper $= 9\times10^6$ g)

(a) 1.1 ms^{-1}
(b) 0.11 mms^{-1}
(c) 1.1 mms^{-1}
(d) 11 ms^{-1}

30. Three resistances are connected to form a T-shape as shown in the figure. Then, the current in $3\,\Omega$ resistor is



(a) 0.93 A
(b) 4.5 A
(c) 2 A
(d) 1.57 A

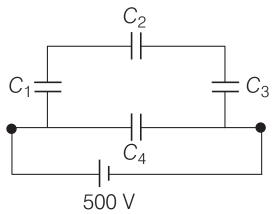
31. A parallel plate air capacitor is charged to a potential difference of V. After disconnecting the battery, distance between the plates of the capacitor is increased using an insulating handle. As a result, the potential difference between the plates

(a) decreases
(b) increases
(c) becomes zero
(d) does not change

32. Two similar magnetic poles, having pole strengths in the ratio 1 : 3 are placed 1 m apart. Find the point where a unit pole experiences no net force due to these two poles.

(a) 0.523 m
(b) 1.052 m
(c) 0.366 m
(d) 0.273 m

33. A network of four capacitors each of 12 μF capacitance is connected to a 500 V supply as shown in the figure. The equivalent capacitance of the network will be



(a) 6 μF
(b) 16 μF
(c) 60 μF
(d) 8 μF

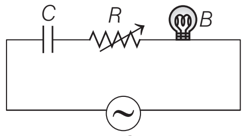
34. A cell of internal resistance r is connected across an external resistance R. The current in the circuit will be maximum, when

(a) $R > r$
(b) $R < r$
(c) $R = r$
(d) $R = r = \infty$

35. A charged particle is moving in circular path with velocity v in a uniform magnetic field B. If the velocity of the charged particle is doubled and the radius becomes four times, then the strength of magnetic field will be

(a) B
(b) $2B$
(c) $4B$
(d) $\frac{B}{2}$

36. A capacitor C, a variable resistance R and a bulb B are connected in series to the AC mains in a circuit as shown below. When a dielectric slab is introduced between the plates of capacitor, keeping resistance R fixed, then which of the following statement(s) is/are correct?



(a) The brightness of bulb will increase.
(b) The brightness of bulb will decrease.
(c) The brightness of bulb will remains the same.
(d) The bulb will get fused.

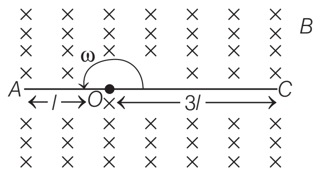
37. Two moving coil meters M_1 and M_2 having the particulars
$R_1 = 10\,\Omega$, $N_1 = 30$, $A_1 = 3.6 \times 10^{-3}\ \text{m}^2$, $B_1 = 0.25\ \text{T}$, $R_2 = 14\ \Omega$,
$N_2 = 42$, $A_2 = 1.8 \times 10^{-3}\ \text{m}^2$ and $B_2 = 0.50\ \text{T}$.

The ratio of their current sensitivity, for same restoring torque per twist (k) is
(a) 2 : 3 (b) 5 : 3 (c) 7 : 5 (d) 5 : 7

38. The flux associated with a coil changes from 1.35 Wb to 0.79 Wb within $\frac{1}{10}$ s. Then, the charge produced by the coil, if its resistance is $7\,\Omega$ is
(a) 0.08 C (b) 0.8 C (c) 0.008 C (d) 8 C

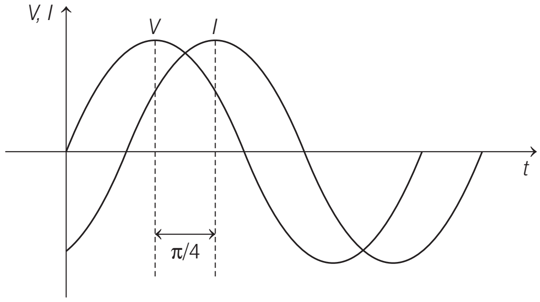
39. A wire AB carrying a steady current of 12 A and is lying on the table. Another wire CD carrying 5 A is held directly above AB at a height of 1 mm.
The mass per unit length of the wire CD, so that it remains suspended at its position when left free is (Take $g = 10\ \text{m/s}^2$)
(a) 1×10^{-3} kg/m (b) 2×10^{-3} kg/m
(c) 1.2×10^{-3} kg/m (d) 2.2×10^{-3} kg/m

40. A conducting rod AC of length $4l$ is rotated about a point O in a uniform magnetic field B directed into the paper. If $AO = l$ and $OC = 3l$, then which of the following relation is not correct?



(a) $V_O - V_A = \dfrac{B\omega l^2}{2}$ (b) $V_O - V_C = \dfrac{9}{2}\,B\omega l^2$ (c) $V_A - V_C = 4B\omega l^2$ (d) $V_C - V_O = \dfrac{9}{2}\,B\omega l^2$

41. An AC voltage $V = V_0 \sin 100t$ is applied to the circuit, the phase difference between current and voltage is found to be $\frac{\pi}{4}$, then which of the following statements is true?



(a) It shows variation for a RC-circuit, where $R = 100\ \Omega$ and $C = 1\ \mu F$.
(b) It shows variation for a RC-circuit, where $R = 1\ k\Omega$ and $C = 10\ \mu F$.
(c) It shows variation for a RL-circuit, where $R = 10\ k\Omega$ and $L = 1\ H$.
(d) It shows variation for a RL-circuit, where $R = 1\ k\Omega$ and $L = 10\ H$.

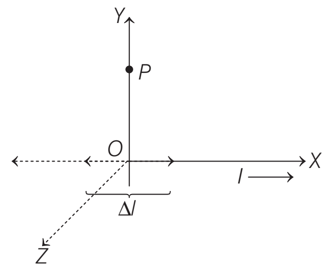
42. A dip circle shows an apparent dip of 45° at a place, where the true dip is 30°. If the dip circle is rotated through 90°, what apparent dip will it show?

(a) 35.2° (b) 27.8°
(c) 30° (d) 42.5°

43. The electrostatic force between two spheres of charge $0.2\ \mu C$ and $-0.4\ \mu C$ in air is 0.4 N. The distance between the two spheres is

(a) 43.2×10^{-6} m (b) 42.4×10^{-3} m
(c) 18.1×10^{-3} m (d) 19.2×10^{-6} m

44. An element $\Delta \mathbf{l} = \Delta x \hat{\mathbf{i}}$ m is placed at the origin (as shown in figure) and carries a current $I = 2$A. The magnetic field at a point P on the Y-axis at a distance of 1 m due to the element $\Delta x = \omega$ m will be



(a) $\frac{\mu_0}{2\pi\omega}$ (b) $\frac{\mu_0 \omega}{2\pi}$ (c) $\frac{\mu_0}{\pi\omega}$ (d) zero

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** The charge is uniformly distributed over the surface as a conductor. The surface of a conductor behaves as an equipotential surface.

Reason An equipotential surface is a surface over which potential is zero.

46. **Assertion** Torque on a current carrying coil in a magnetic field **B** is given by $\tau = nI(\mathbf{A} \times \mathbf{B})$, where **A** is area of the coil.

Reason Torque on the coil is maximum, when it is suspended in a radial magnetic field.

47. **Assertion** Generation of eddy currents depends on the principle of electromagnetic induction.

Reason The heat generated in the operations of eddy currents depends on current and resistance.

48. **Assertion** The formation of positive and negative charges inside the dielectric is due to the dielectric polarisation.

Reason An applied electric field will polarise the polar dielectric material.

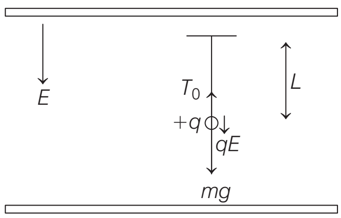
49. **Assertion** A transformer works on the principle of mutual induction in which a change of flux in primary coil, appears as a change of flux linked with the secondary coil.

Reason Transformer gives the desired AC voltage and current.

Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

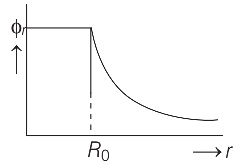
50. A pendulum ball having charge q and mass m, suspended from a string of length L is placed between the metal plates, where a vertical electric field E is established. The time period of the pendulum, if E is directed downwards is



(a) $2\pi\sqrt{\frac{L}{g}}$ (b) $2\pi\sqrt{\frac{gL}{g+qE}}$

(c) $2\pi\sqrt{\frac{L}{g-\frac{qE}{m}}}$ (d) $2\pi\sqrt{\frac{L}{g+\frac{qE}{m}}}$

51. The electrostatic potential ϕ_r of a spherical symmetrical system kept at origin as shown in the adjacent figure is given as



$$\phi_r = \frac{q}{4\pi\varepsilon_0 r} (r \geq R_0)$$

$$\phi_r = \frac{q}{4\pi\varepsilon_0 R_0} (r \leq R_0)$$

Which of the following statement(s) is/are incorrect?

I. For spherical region $r \leq R_0$, total electrostatic energy stored is zero.

II. Within $r = 2R_0$, total charge is $q/2$.

III. There will be no charge anywhere except at $r = R_0$.

(a) Only I (b) Only II

(c) Both I and II (d) I, II and III

Case Study

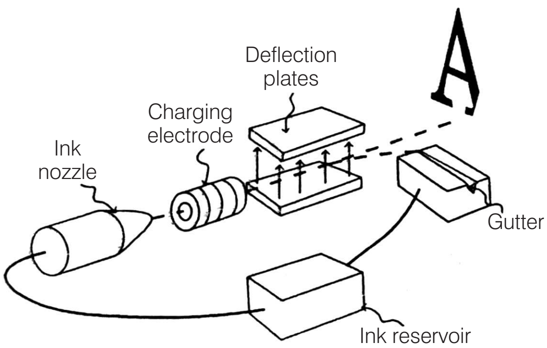
Read the following paragraph and answer the questions.

Ink- Jet Printer

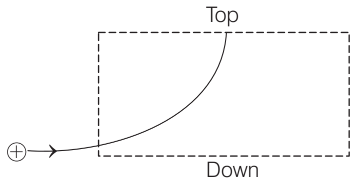
The ink-jet printer is commonly used to print computer-generated text and graphics, employs electrostatics. The nozzle of an ink-jet printer produces small ink droplets, which are sprayed with electrostatic charge.

Once charged, the droplets can be directed using pairs of charged metal plates, with great precision to form letters and images on paper. The direction in which charged ink droplets move can be controlled by charged metal plates. This is very similar to a cathode ray oscilloscope, where an electric beam is directed to a particular place on a screen.

A labelled ink-jet printer is as shown below

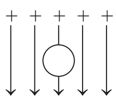
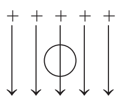
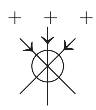
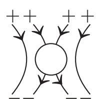


52. The figure shows the path of positively charged ink droplets through a region of uniform electric field as shown in the figure below. The direction of the electric field will be towards



(a) top (b) down (c) parallel to the down (d) anti-parallel to the top

53. An uncharged metallic sphere is placed between the two charged plates of ink-jet printer. The lines of force will be represented as

(a)  (b)  (c)  (d) 

54. The ink has 14.4×10^{-19} C positive charge, then which of the following statement(s) is/are correct about it? (Take, charge on electron, $e = 1.6 \times 10^{-19}$ C)

(a) It has 9 electrons in excess.
(b) It has 27 electrons in short.
(c) It has 27 electrons in excess.
(d) It has 9 electrons in short.

55. A positively charged ink droplet and an electron are placed 1.6 cm apart. The magnitude and nature of electrostatic force between them is

(a) 9×10^{-25} N, repulsive
(b) 6×10^{-24}, attractive
(c) 6×10^{-24}, repulsive
(d) 9×10^{-25} N, attractive

OMR SHEET

SP 3

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

● Correct ✔ Incorrect ✗ Incorrect ◓ Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	20	a	b	c	d	38	a	b	c	d
2	a	b	c	d	21	a	b	c	d	39	a	b	c	d
3	a	b	c	d	22	a	b	c	d	40	a	b	c	d
4	a	b	c	d	23	a	b	c	d	41	a	b	c	d
5	a	b	c	d	24	a	b	c	d	42	a	b	c	d
6	a	b	c	d	25	a	b	c	d	43	a	b	c	d
7	a	b	c	d	26	a	b	c	d	44	a	b	c	d
8	a	b	c	d	27	a	b	c	d	45	a	b	c	d
9	a	b	c	d	28	a	b	c	d	46	a	b	c	d
10	a	b	c	d	29	a	b	c	d	47	a	b	c	d
11	a	b	c	d	30	a	b	c	d	48	a	b	c	d
12	a	b	c	d	31	a	b	c	d	49	a	b	c	d
13	a	b	c	d	32	a	b	c	d	50	a	b	c	d
14	a	b	c	d	33	a	b	c	d	51	a	b	c	d
15	a	b	c	d	34	a	b	c	d	52	a	b	c	d
16	a	b	c	d	35	a	b	c	d	53	a	b	c	d
17	a	b	c	d	36	a	b	c	d	54	a	b	c	d
18	a	b	c	d	37	a	b	c	d	55	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (b)	**2.** (a)	**3.** (c)	**4.** (a)	**5.** (d)	**6.** (d)	**7.** (b)	**8.** (a)	**9.** (a)	**10.** (c)
11. (c)	**12.** (b)	**13.** (a)	**14.** (b)	**15.** (c)	**16.** (d)	**17.** (b)	**18.** (c)	**19.** (c)	**20.** (c)
21. (c)	**22.** (a)	**23.** (c)	**24.** (b)	**25.** (c)	**26.** (c)	**27.** (b)	**28.** (d)	**29.** (c)	**30.** (c)
31. (b)	**32.** (c)	**33.** (b)	**34.** (c)	**35.** (d)	**36.** (a)	**37.** (c)	**38.** (a)	**39.** (c)	**40.** (d)
41. (b)	**42.** (a)	**43.** (b)	**44.** (b)	**45.** (c)	**46.** (b)	**47.** (b)	**48.** (b)	**49.** (b)	**50.** (d)
51. (b)	**52.** (a)	**53.** (d)	**54.** (d)	**55.** (d)					

SOLUTIONS

1. Using Gauss's law, electric field intensity at any point P between the two plates is

$$E = \frac{\sigma}{2\varepsilon_0}$$

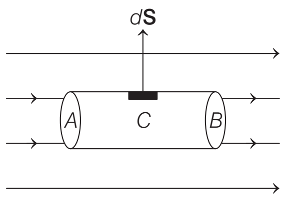
where, $\varepsilon_0 = 8.854 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$.

and $\sigma = 3.6 \times 10^{-14}\ \text{C/m}^2$.

$$\Rightarrow \quad E = \frac{3.6 \times 10^{-14}}{2 \times 8.854 \times 10^{-12}}$$

$$= 0.2 \times 10^2 = 20\ \text{N/C}$$

2. This situation is as shown below



Since, the area vector d**S** of curved surface is perpendicular to the magnetic field.

$\therefore$ Flux through curved surface C,

$$\phi_C = \int \mathbf{E} \cdot d\mathbf{S} = \int E dS \cos 90° = 0$$

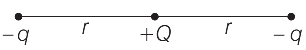
3. Capacity of parallel plate capacitor is given by

$$C = \frac{\varepsilon_0 A}{d}$$

$$\Rightarrow \quad \varepsilon_0 = \frac{Cd}{A}$$

$$\therefore \text{Unit of } \varepsilon_0 = \frac{\text{farad} \times \text{metre}}{(\text{metre})^2} = \frac{\text{farad(F)}}{\text{metre (m)}}$$

4. Let the three charges are located as shown



Potential energy of the system,

$$U = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(-q)Q}{r} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q(-q)}{r} \} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{(-q)(-q)}{2r}$$

$$\Rightarrow \quad \frac{1}{4\pi\varepsilon_0}\left(\frac{-qQ}{r} - \frac{qQ}{r} + \frac{q^2}{2r}\right) = 0 \qquad (\because U = 0)$$

$$\Rightarrow \quad \frac{2qQ}{r} = \frac{q^2}{2r} \Rightarrow \frac{Q}{q} = \frac{1}{4} \text{ or } 1:4$$

5. Potential between two spheres,

$$\Delta V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{q}{4\pi\varepsilon_0}\left(\frac{R_2 - R_1}{R_1 R_2}\right)$$

Charge on capacitor, $q = C\Delta V$

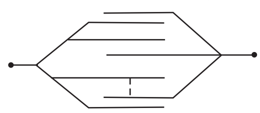
$$\Rightarrow \quad C = \frac{q}{\Delta V} = \frac{q}{q/4\pi\varepsilon_0\left(\frac{R_2 - R_1}{R_1 R_2}\right)}$$

$\therefore$ Capacity of two concentric spherical capacitors,

$$C = 4\pi\varepsilon_0\left(\frac{R_1 R_2}{R_2 - R_1}\right) \Rightarrow C \propto \frac{R_1 R_2}{R_2 - R_1}$$

6. Here, $(n - 1)$ capacitors are formed by n equally spaced plates.

All capacitors are connected in parallel because plates are connected alternately as shown



$\therefore$ Total capacitance $= (n - 1)\, x$

7. The resistance of a metallic wire at temperature 1°C is given by

$$R_t = R_0(1 + \alpha t)$$

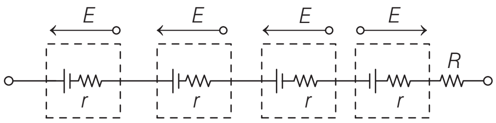
where, α is temperature coefficient.

Hence, resistance of wire increases on increasing the temperature. Also, from Ohm's law, ratio of $\frac{V}{i}$ is equal to R.

i.e. $\quad \frac{V}{i} = R$

Hence, on increasing the temperature, the ratio of $\frac{V}{i}$ increases.

8. Total emf of the cell $= 3E - E = 2E$



Total internal resistance of cells $= 4r$

$\therefore$ Total resistance of the circuit $= 4r + R$

So, the current in the external circuit,

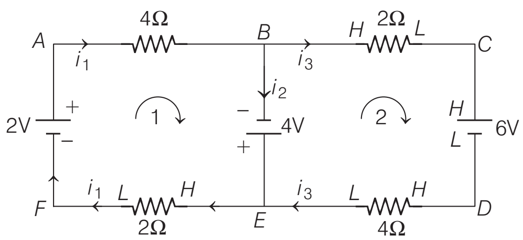
$$i = \frac{2E}{4r + R} \qquad \left(\because i = \frac{V}{R}\right)$$

9. According to Kirchhoff's second law, in any closed part of an electrical circuit, the algebraic sum of the emfs is equal to the algebraic sum of the products of the resistances and currents flowing through them. It is also known as **loop rule**.

i.e. $\quad \sum_{\text{closed loop}} \Delta V = 0$

Applying Kirchhoff's second law in loop 1 ($ABEFA$),

$$-4i_1 + 4 - 2i_1 + 2 = 0$$



10. Drift speed, $v_d = \frac{eE}{m}\tau = \frac{eV}{ml}\tau$

As, drift speed does not depend upon the diameter so long as V and l remain unchanged. Hence, drift speed does not change.

11. Due to collision of free electrons with the atoms or ions of the conductor, heat is generated in it.

12. As resistance of arm DBC is equal to that of arm DAC, so equal current (of 2 A) will be distributed in the two branches.

$\therefore \quad V_D - V_A = 3 \times 2 = 6$ V $\qquad$ ...(i)

and $V_D - V_B = 2 \times 2 = 4$ V $\qquad$ ...(ii)

Subtracting Eq. (i) from Eq. (ii), we get

$\therefore \quad V_A - V_B = -2$ V

13. Here, galvanometer resistance, $R_g = r$

Shunt resistance, $R_s = \frac{1}{r}$

Using the relation, $I = I_g\left(\frac{R_s + R_g}{R_s}\right)$

The fraction of total current passing through galvanometer is

$$\frac{I_g}{I} = \frac{R_s}{R_s + R_g} = \frac{\frac{1}{r}}{\frac{1}{r} + r} = \frac{1}{1 + r^2}$$

14. As, electron is revolving clockwise, so conventional current due to the motion of electron will be in anti-clockwise direction.

Hence, according to right hand rule, the magnetic field at point A will be in outward direction.

15. Magnetic dipole moment of the current loop

= Ampere turns × Area of the coil

Initially, magnetic moment, $\mathbf{M} = I\pi r^2$

New magnetic moment,

$$\mathbf{M}' = I\pi(2r)^2$$
$$= 4I(\pi r^2) = 4\mathbf{M}$$

So, when radius becomes doubled, the magnetic moment will become four times.

16. In an atom, electrons revolve around the nucleus and the circular orbits of electrons may be considered as the small current loops. In addition to orbital motion, an electron also has spin motion. So, the total magnetic moment of electron is the vector addition of its magnetic moments due to orbital and spin motions.

17. Here, $\delta = 30° = \frac{\pi}{6}$

$\because$ Horizontal component of the earth's magnetic field, $H_e = B_e \cos\delta$

where, B_e = earth's magnetic field.

$$\Rightarrow \quad \frac{H_e}{B_e} = \cos\delta$$
$$= \cos\frac{\pi}{6} = \frac{\sqrt{3}}{2}$$

$\Rightarrow H_e : B_e = \sqrt{3} : 2$

18. Mutual inductance of the pair of current carrying coils depends on distance between two coils and geometry of two coils.

19. Here, $L_0 = 0.01$ mH $= 10^{-5}$ H

$L = 10$ mH $= 10^{-2}$ H

We know that, $\mu_r = \frac{L}{L_0} = \frac{10^{-2}}{10^{-5}} = 10^3$

$\Rightarrow \qquad \mu_r = 1000$

20. Here, $M = 1.5$ H, $\Delta i_1 = 5$ A, $\Delta t = 10^{-3}$ s

We know that,

$$M = \frac{-e_2}{\Delta i_1 / \Delta t}$$

$\Rightarrow \quad |e_2| = M \times \frac{\Delta i_1}{\Delta t} = 1.5 \times \frac{5}{10^{-3}}$

$= 7.5 \times 10^3$ V

21. Here, $I = 2\sin(100\pi t + \pi/3)$ A

From this relation,

$$\omega t = \frac{2\pi t}{T} = 100\pi t$$

$$\Rightarrow \quad T = \frac{2\pi}{100\pi} = \frac{1}{50} \text{ s}$$

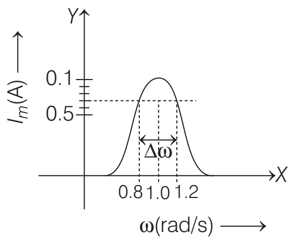
The first time, when the current is maximum is $T/4$.

$$\therefore \quad t = \frac{T}{4} = \frac{1}{50 \times 4} = \frac{1}{200} = 0.005 \text{ s}$$

22. Eddy currents produced in a coil oppose the cause of their origin, therefore due to eddy currents, a great amount of energy is wasted in form of heat energy. If the core of transformer is laminated, then energy losses due to eddy currents can be minimised.

23. Consider the diagram,

Bandwidth $= \omega_2 - \omega_1$



where, ω_1 and ω_2 corresponds to frequencies at which magnitude of current is $\frac{1}{\sqrt{2}}$ times of maximum value. i.e. 0.7 A.

Clearly, from the diagram, the corresponding frequencies are 0.8 rad/s and 1.2 rad/s.

$\therefore$ Bandwidth, $\Delta\omega = 1.2 - 0.8 = 0.4$ rad/s

24. The receiving antenna picks up the frequencies transmitted by different stations and a number of voltages appear in *L-C-R* circuit corresponding to different frequencies. But maximum current flows in the circuit for that AC voltage which have the frequency equal to the resonant frequency of circuit. Therefore, it is based on the phenomenon of resonance.

25. At point *A*, $X_C > X_L$,

At point *B*, $X_C = X_L$

and at point *C*, $X_C < X_L$.

So, at point *C*, circuit is inductive.

26. Given, two cells of emf E_1 and E_2 are joined in opposition, such that $E_1 > E_2$, then

Current, $I = \frac{E_1 - E_2}{r_1 + r_2 + R}$

Now, terminal potential difference across a circuit,

$$V = IR = \left(\frac{E_1 - E_2}{r_1 + r_2 + R}\right)R$$

27. The instantaneous voltage through the given device,

$$V = 80\sin 100\pi t$$

Comparing the given instantaneous voltage with standard instantaneous voltage $V = V_0 \sin\omega t$, we get

$$V_0 = 80 \text{ V}$$

where, V_0 is the peak value of voltage.

Impedance, $Z = 20\,\Omega$ (given)

Peak value of current, $I_0 = \frac{V_0}{Z} = \frac{80}{20} = 4$ A

Effective value of current (root mean square value of current),

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{4}{\sqrt{2}} = 2\sqrt{2} = 2.828 \text{ A}$$

28. As we know that, work done

$$= U_{final} - U_{initial} = \frac{1}{2}C(V_2^2 - V_1^2)$$

When potential difference increases from 5 V to 10 V, then

$$W = \frac{1}{2}C(10^2 - 5^2) = \frac{15 \times 5 \times C}{2} \quad \dots \text{(i)}$$

When potential difference increases from 10 V to 15 V, then

$$W' = \frac{1}{2}C(15^2 - 10^2) = \frac{25 \times 5 \times C}{2} \quad \dots \text{(ii)}$$

On solving Eqs. (i) and (ii), we get

$$W' = 1.67\,W$$

29. Given, $e = 1.6 \times 10^{-19}$C, $A = 1.0 \times 10^{-7}$ m^2

and $\quad I = 1.5$ A

As, a cubic metre of copper has a mass of 9.0×10^6 g. Since, 6.0×10^{23} copper atoms have a mass of 63.5 g.

$$\therefore \quad n = \frac{6.0 \times 10^{23}}{63.5} \times 9.0 \times 10^6$$

$$= 8.5 \times 10^{28} \text{ m}^{-3}$$

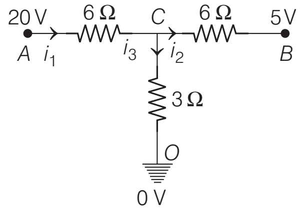
The drift speed (v_d) is given by

$$v_d = \frac{I}{neA}$$

$$\Rightarrow \quad v_d = \frac{1.5}{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 1.0 \times 10^{-7}}$$

$$= 1.1 \times 10^{-3} \text{ ms}^{-1} = 1.1 \text{ mms}^{-1}$$

30. Let at junction C, potential is V.



$$\therefore \frac{V_A - V_C}{6} + \frac{V_B - V_C}{6} = \frac{V_C - V_O}{3}$$

$$\Rightarrow \frac{20 - V}{6} + \frac{5 - V}{6} = \frac{V - 0}{3}$$

$$\Rightarrow V = 6.25 \text{ V}$$

$$\therefore \text{Current, } i = \frac{6.25}{3} \simeq 2 \text{ A}$$

31. Potential on parallel plate capacity, $V = \frac{Q}{C}$

Also, capacity of parallel plate capacitor is given by

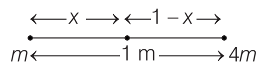
$$C = \frac{\varepsilon_0 KA}{d}$$

$$\therefore \quad V = \frac{Qd}{\varepsilon_0 KA}$$

$$\Rightarrow \quad V \propto d$$

So, on increasing the distance between plates of capacitor, the potential difference between plates also increases.

32. Let the pole strengths of the two magnetic poles be m and $3m$. Suppose the required point is located at distance x from the first pole, then



Force on unit pole due to first pole

= Force on unit pole due to second pole

$$\Rightarrow \frac{\mu_0}{4\pi} \cdot \frac{m \times 1}{x^2} = \frac{\mu_0}{4\pi} \cdot \frac{3m \times 1}{(1 - x)^2}$$

$$\Rightarrow 3x^2 = (1 - x)^2 \text{ or } \sqrt{3}x = 1 - x$$

$$\Rightarrow x = \frac{1}{1 + \sqrt{3}} = 0.366 \text{ m}$$

33. Here, C_1, C_2 and C_3 are in series.

Therefore, their equivalent capacitance,

$$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$C' = \frac{C}{3} = \frac{12}{3} = 4 \ \mu\text{F}$$

Now, C' and C_4 are in parallel combination.

$$\therefore \quad C_{\text{net}} = C' + C_4 = 4 + 12 = 16 \mu\text{F}$$

34. Current in a circuit will be maximum, when total internal resistance is equal to the total external resistance.

i.e. $\quad R = r$

35. As, magnetic force provides centripetal force for circular motion.

$$\Rightarrow \quad qvB = \frac{mv^2}{r}$$

$$\Rightarrow \quad B = \frac{mv}{qr} \quad \text{...(i)}$$

Here, $v' = 2v$ and $r' = 4r$

$$\therefore \quad B' = \frac{mv'}{qr'}$$

$$\Rightarrow \quad B' = \frac{m \times 2v}{q \times 4r} = \frac{1}{2}\frac{mV}{qr} = \frac{1}{2}B$$

[using Eq. (i)]

36. As, the dielectric slab is introduced between the plates of the capacitor, its capacitance will increase. Hence, the potential drop across the capacitor will decrease, because $V = \frac{Q}{C}$.

As a result, the potential drop across the bulb will increase. Thus, its brightness will increase.

37. Using the formula of current sensitivity,

$$I = \frac{NAB}{k}$$

$$\therefore \quad \frac{I_{s_2}}{I_{s_1}} = \frac{N_2 B_2 A_2 k}{N_1 B_1 A_1 k} \quad (\because k_1 = k_2)$$

$$= \frac{42 \times 0.50 \times 1.8 \times 10^{-3}}{30 \times 0.25 \times 3.6 \times 10^{-3}} = \frac{7}{5} \text{ or } 7:5$$

38. As, $I = \frac{e}{R} = \frac{d\phi}{Rdt} \Rightarrow Idt = \frac{d\phi}{R}$

Integrating the above equation, we get

$$\Rightarrow \int Idt = \int \frac{d\phi}{R} \Rightarrow q = \frac{\phi}{R}$$

If coil contains N turns, then $q = \frac{N\phi}{R}$

If there is a flux change of $\Delta\phi$, then

$$q = \frac{N\Delta\phi}{R} = \frac{1}{7} \times (1.35 - 0.79) = 0.08 \text{ C}$$

39. Force per unit length between the current carrying wires is given as $F = \frac{\mu_0}{4\pi} \cdot \frac{2 I_1 I_2}{r}$

where, I_1 = current in wire $AB = 12$A,

I_2 = current in wire $CD = 5$ A

r = height above AB

$= 1 \text{ mm} = 1 \times 10^{-3}$ m.

$\therefore \quad \frac{\mu_0}{4\pi} \cdot \frac{2 I_1 I_2}{r} = mg$

where, m = mass per unit length.

$\Rightarrow 10^{-7} \times \frac{2 \times 12 \times 5}{1 \times 10^{-3}} = m \times 10$

$\therefore \quad m = 1.2 \times 10^{-3}$ kg/m

40. For given rod, we can get potential as

$$V_O - V_A = \frac{B\omega l}{2} \times l = \frac{B\omega l^2}{2} \quad \ldots(i)$$

$$V_O - V_C = \frac{B\omega 3l \times 3l}{2} = \frac{9\, B\omega l^2}{2} \quad \ldots(ii)$$

Subtracting Eq. (i) from Eq. (ii), we get

$$V_A - V_C = 4 B\omega l^2$$

41. In the given graph, current is leading the voltage by 45°.

Therefore, from the graph it is R-C circuit.

As, $\tan\phi = \frac{X_C}{R}$ and $\phi = \frac{\pi}{4}$ (given)

$\Rightarrow \quad X_C = R \quad \left(\because \tan\frac{\pi}{4} = 1\right)$

$\Rightarrow \quad \omega CR = 1$

$\Rightarrow \quad CR = \frac{1}{\omega} = \frac{1}{100}$

When $R = 1\,\text{k}\Omega = 10^3\,\Omega$, then

$$C = \frac{1}{10^5} = 10^{-5}\,\text{F} = 10\,\mu\text{F}$$

42. Let θ_1 and θ_2 are the angles of dip in two arbitrary planes which are perpendicular to each other.

As, $\cot^2\theta = \cot^2\theta_1 + \cot^2\theta_2$

where, θ is true dip.

Here, $\theta_1 = 45°$ and $\theta = 30°$

$\Rightarrow \cot^2 30° = \cot^2 45° + \cot^2\theta_2$

$\cot^2\theta_2 = 3 - 1 = 2 \Rightarrow \cot\theta_2 = 1.414$

$\therefore \quad \theta_2 = 35.2°$

43. Given, $q_1 = 0.2\,\mu\text{C} = 0.2 \times 10^{-6}$ C

$q_2 = -0.4\,\mu\text{C} = -0.4 \times 10^{-6}$ C and $F = -0.4$ N

From Coulomb's law, force between the charges,

$$F = \frac{|q_1||q_2|}{4\pi\varepsilon_0 r^2}$$

$$\Rightarrow \quad r^2 = \frac{|q_1||q_2|}{4\pi\varepsilon_0 F}$$

$$= \frac{0.2 \times 10^{-6} \times 0.4 \times 10^{-6} \times 9 \times 10^9}{0.4}$$

$\Rightarrow \quad r^2 = 1.8 \times 10^{-3}$

$\Rightarrow \quad r = (1.8 \times 10^{-3})^{1/2}$

$= 0.0424$ m

$= 42.4 \times 10^{-3}$ m

44. According to Biot-Savart's law,

$$dB = \frac{\mu_0}{4\pi} \cdot \frac{I d\mathbf{l} \times \hat{\mathbf{r}}}{|r|^2}$$

Here, $\Delta x = \omega$ m,

$\Rightarrow \quad \Delta l = \Delta x \hat{\mathbf{i}}$ m $= \omega \hat{\mathbf{i}}$ m, $I = 2$ A and $r = 1$ m

$\therefore \quad dB = \frac{\mu_0}{4\pi} \cdot \frac{(2\omega\hat{\mathbf{i}} \times \hat{\mathbf{j}})}{(1)^2} \quad (\because \hat{\mathbf{r}} = \hat{\mathbf{j}})$

$\Rightarrow \quad dB = \frac{\mu_0 \omega}{2\pi}\hat{\mathbf{k}} \Rightarrow |dB| = \frac{\mu_0\omega}{2\pi}$

45. A surface on which the potential has the same value everywhere is called an equipotential surface. On the surface of a conductor, the value of potential remains the same, i.e. it behaves as an equipotential surface.

Therefore, A is true but R is false.

46. The torque on the coil in a magnetic field is given by $\tau - nI(\mathbf{A} \times \mathbf{B}) = nIBA\cos\theta$

For radial field, the coil is set with its plane parallel to the direction of the magnetic field.

Here, $\theta = 0°$ and $\cos 0° = 1$

$\Rightarrow$ Torque $= nIBA(1) = nIBA$ (maximum)

Therefore, both A and R are true but R is not the correct explanation of A.

47. Eddy currents generation is based on the principle of electromagnetic induction.

Generation of eddy currents leads to heat of metal. The heat generated by this method is given by $I^2 R$.

Therefore, both A and R are true but R is not the correct explanation of A.

48. When an electric field is applied to the dielectric, each molecule of dielectric gets polarised. Thus, centres of gravity of positive and negative charges gets displaced from each other.

An applied electric field will polarise the polar dielectric material by orienting the dipole moment of polar molecules.

Therefore, both A and R are true but R is not the correct explanation of A.

49. Transformer is a device which is used to increase or decrease the alternating voltage. It is based on the principle of mutual induction.

Thus, a transformer is used to obtain desired AC voltage and current.

Therefore, both A and R are correct but R is not the correct explanation of A.

50. For simple pendulum,

Time period, $T = 2\pi\sqrt{\frac{L}{a}}$

where, a = effective acceleration.

When electric field is downward,

$$a = \frac{\text{net external force on the ball}}{\text{mass of the ball}}$$

$$\Rightarrow \quad a = \frac{mg + qE}{m} = g + \frac{qE}{m}$$

$\therefore$ Time period, $T = 2\pi\sqrt{\dfrac{L}{g + \dfrac{qE}{m}}}$

51. As, total charge resides on the surface of conductor, so within $r = 2R_0$, total charge is q.

Hence, statement II is incorrect.

52. A positive charge experiences a force in the direction of the electric field.

Since, positively charged particle is diverted towards top.

$\therefore$ The direction of electric field is towards top.

53. Electric lines of force never intersect the conductor and never pass through it.

They are perpendicular and slightly curved near the surface of conductor as shown in option (d).

54. As conductor has positive charge, so there is a deficiency of electrons.

$\therefore$ Number of electrons $= \dfrac{14.4 \times 10^{-19}}{1.6 \times 10^{-19}} = 9$

Hence, it has 9 electrons in short.

55. We know that, charge on an electron,

$$q_1 = -1.6 \times 10^{-19}\ \text{C}$$

Charge on proton, $q_2 = 1.6 \times 10^{-19}$ C

and distance, $r = 1.6$ cm $= 1.6 \times 10^{-2}$ m

Using Coulomb's law,

$F = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r^2}$, where r is the distance between proton and electron.

$$\Rightarrow \quad F = \frac{9 \times 10^9 \times (-1.6 \times 10^{-19})(1.6 \times 10^{-19})}{(1.6 \times 10^{-2})^2}$$

$$= -9 \times 10^{-25}\ \text{N}$$

Negative sign indicates that the force is attractive in nature.

SAMPLE PAPER 4

PHYSICS

*A Highly Simulated Practice Questions Paper for CBSE **Class XII** (Term I) Examination*

Instructions

1. *This question paper is divided into three sections.*
2. ***Section - A** contains 25 questions. Attempt **any 20** questions.*
3. ***Section - B** contains 24 questions. Attempt **any 20** questions.*
4. ***Section - C** contains 6 questions. Attempt **any 5** questions.*
5. *Each question carries 0.77 mark.*
6. *There is **no** negative marking.*

Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

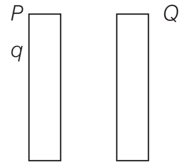
Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. A spherical ball with charge $-10e$ is placed at the centre of the hollow sphere which has a charge of $+10e$ on its surface. The charge on the sphere's outer surface will become

(a) $+20\,e$ (b) zero (c) $-10\,e$ (d) $-20\,e$

2. Two conducting plates P and Q with large surface area A are placed as shown in the figure. A charge q is given to plate P. The electric field between the plates at any point is

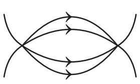
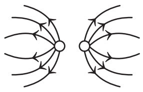
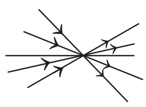
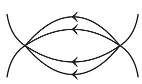


(a) $\frac{q}{3A\varepsilon_0}$ (b) $\frac{q}{2A\varepsilon_0}$ (c) $\frac{q}{A\varepsilon_0}$ (d) $\frac{2q}{A\varepsilon_0}$

3. Two point charges $+2\,\mu C$ and $-4\,\mu C$ are kept at distance r between them in air. The ratio of the magnitude of forces acting on them will be

(a) 2 : 1 (b) 1 : 2 (c) 1 : 1 (d) 4 : 1

4. The correct diagram of electric lines of forces for a system of two positive charges is

(a)  (b)  (c)  (d) 

5. A hemispherical body of radius R is placed in a uniform electric field E. The flux linked with the curved surface, if the field is parallel to the base, is

(a) zero (b) $E\pi R^2$ (c) $-E\pi R^2$ (d) $\frac{\pi R^2}{E}$

6. When a capacitor is charged, the energy resides in

(a) the positive charges (b) Both the positive and negative charges
(c) the field between the plates (d) around the edge of the capacitor plates

7. The potential difference between a cloud and the earth is 10^7 V. Calculate the amount of energy dissipated, when the charge of 100 C is transferred from the cloud to the ground due to lightning bolt.

(a) zero (b) 10^9 J (c) 60 J (d) 10^7 J

8. A capacitor of capacity C_1, is charged by connecting it across a battery of emf V_0. The battery is then removed and the capacitor is connected in parallel with an uncharged capacitor of capacity C_2. The potential difference across this combination is

(a) $\frac{C_2}{C_1+C_2}V_0$ (b) $\frac{C_1}{C_1+C_2}V_0$ (c) $\frac{C_1+C_2}{C_2}V_0$ (d) $\frac{C_1+C_2}{C_1}V_0$

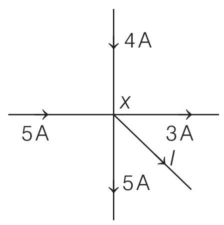
9. Which of the following statement(s) is/are incorrect?

(a) In a balanced Wheatstone bridge, if the cell and the galvanometer are exchanged, the null point is disturbed.
(b) A rheostat can be used as a potential divider.
(c) Kirchhoff's second law represents energy conservation.
(d) Wheatstone bridge is most sensitive, when all the four resistances are of the same order of magnitude.

10. The drift speed of electrons in aluminium wire of diameter d and length l is v. If the potential difference across the wire is halved, then the new drift velocity becomes

(a) $2v$ (b) $v/2$ (c) v (d) $v/4$

11. Five conductors are meeting at a point x as shown in the figure. What is the value of current in fifth conductor?

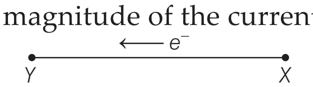


(a) 3A, away from x (b) 1A, away from x (c) 4A, away from x (d) 1A, towards x

12. If resistivity of copper conductor is 1.7×10^{-8} Ω-m and electric field is 100 Vm^{-1}, then current density will be

(a) 6×10^9 Am^{-2} (b) 1.7×10^{-6} Am^{-2} (c) 1.7×10^{-10} Am^{-2} (d) 6×10^7 Am^{-2}

13. Twenty million electrons reaches from point X to point Y in two microsecond as shown in the figure. Direction and magnitude of the current is



(a) 1.5×10^{-10} A from X to Y (b) 1.6×10^{-6} A from Y to X
(c) 1.5×10^{-13} A from Y to X (d) 1.6×10^{-4} A from X to Y

14. For a velocity selector in a region of perpendicular electric and magnetic fields, which of the following statement(s) is/are correct?
(a) It dllows charged particles to pass straight, when $v = E/B$.
(b) It does not deflect particles in a direction perpendicular to both **v** and **B**, when $v > E/B$.
(c) It does not deflect particles in the direction of electric field, when $v < E/B$.
(d) It deflects all particles in a direction perpendicular to both **E** and **B**.

15. A solenoid of length 0.2 m has a radius of 5 cm and is made up of 200 turns. If it carries a current of 5 A, then the magnitude of magnetic field inside the solenoid is
(a) $0.2\ \pi \times 10^{-2}$ T
(b) $2\ \pi \times 10^{-4}$ T
(c) $2\ \pi \times 10^{-2}$ T
(d) $0.02\ \pi \times 10^{-3}$ T

16. Consider a moving charged particle in a region of magnetic field.
Which of the following statement(s) is/are correct related to it?
(a) If **v** is parallel to **B**, then path of particle is spiral.
(b) If **v** is perpendicular to **B**, then path of particle is a parabola.
(c) If **v** has a component along **B**, then path of particle is helical.
(d) If **v** is along **B**, then path of particle is a circle.

17. Choose the correct option regarding the functioning of the various parts of a galvanometer.
(a) Soft iron core $\rightarrow$ produces deflection torque
(b) Pole pieces $\rightarrow$ produces radial field
(c) Spring $\rightarrow$ increases field strength
(d) Coil $\rightarrow$ produces restoring torque

18. The force between magnetic poles, when their pole strength is halved and the distance between them is doubled, is
(a) increases to two times the previous value
(b) decreases to four times the previous value
(c) no change
(d) decreases to sixteen times the previous value

19. A horizontal circular loop carries a current that loops anti-clockwise, when viewed from above. It is replaced by an equivalent magnetic dipole N-S. Which of the following statement(s) is/are correct?
(a) The line N-S should be along a diameter of the loop.
(b) The line N-S should be parallel to the plane of the loop.
(c) South pole should be below the loop.
(d) North pole should be below the loop.

20. A semi-circular shaped iron rod of diameter L has magnetic moment $\frac{2M}{\pi}$. If it is unbend to become a straight rod, its new magnetic moment will be
(a) $M\pi/2$
(b) $M\pi$
(c) $2M\pi$
(d) M

21. Two identical circular loops of metal wires are lying on a table without touching each other. Loop P carries a current which is increasing with time. In response, loop Q will
(a) be attracted to P
(b) remains stationary
(c) be repelled by P
(d) be rotated

22. A wire of circular loop is rotated in a magnetic field. The frequency of change of the direction of the induced emf is

(a) once per revolution (b) four times per revolution
(c) twice per revolution (d) six times per revolution

23. What will be the rms value of the alternating voltage represented by the equation $V = \cos \omega t + 2 \cos 2\omega t + 3 \cos 3\omega t$?

(a) 3.24 (b) 5.19 (c) 2.64 (d) 4.52

24. In an L-R circuit, the inductive reactance is equal to the resistance R of the circuit. An emf $E = E_0 \cos \omega t$ is applied to the circuit. The power consumed in the circuit is

(a) $\frac{E_0^2}{\sqrt{2}R}$ (b) $\frac{E_0^2}{4R}$ (c) $\frac{E_0^2}{2R}$ (d) $\frac{E_0^2}{8R}$

25. A transistor-oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produce oscillation of frequency f. If L is halved and C is doubled, the frequency will be

(a) $f/2\sqrt{2}$ (b) $2f$ (c) $f/2$ (d) f

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. A condenser of capacity 20 μF is first charged and then discharged through a 10 mH inductor. Neglecting the resistance of the coil, the frequency of the resulting vibrations will be

(a) 356 cycles/s (b) 35.6 cycles/s (c) 356×10^3 cycles/s (d) 3.56 cycles/s

27. Which of the following statement(s) is/are incorrect?

(a) The magnetic field possesses what is called a cylindrical symmetry.
(b) The lines of constant magnitude of magnetic field form concentric circles called magnetic field lines, originating from negative charges.
(c) Even though the wire is infinite, the field due to it at a non-zero distance is not infinite.
(d) The direction of magnetic field is given by right-hand rule in which fingers will curl around in the direction of the magnetic field.

28. Two identical thin bar magnets each of length l and pole strength m are placed at right angles to each other with north pole of one touching south pole of the other. Magnetic moment of the system is

(a) ml (b) $2ml$ (c) $\sqrt{2}ml$ (d) $\frac{1}{2}ml$

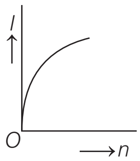
29. Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 V and the average resistance per km is 0.5 Ω. The power loss in the wire is

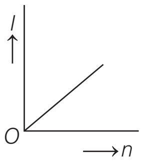
(a) 19.2 W (b) 19.2 kW (c) 19.2 J (d) 12.2 kW

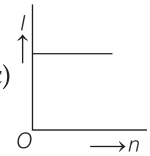
30. A choke coil and capacitor are connected in series and the current through the combination is maximum for AC of frequency n. If they are connected in parallel, at what frequency is the current through the combination minimum?

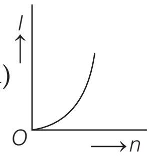
(a) n (b) $n/2$ (c) $2n$ (d) None of these

31. A battery consists of a variable number (n) of identical cells (having internal resistance r each) which are connected in series. The terminals of the battery are short-circuited and the current I is measured. Which of the graphs shows the correct relationship between I and n?

(a) 

(b) 

(c) 

(d) 

32. If the angles of dip at two places are 30° and 45° respectively, then the ratio of horizontal components of earth's magnetic field at the two places will be

(a) $\sqrt{3}:\sqrt{2}$ (b) $1:\sqrt{2}$ (c) $1:\sqrt{3}$ (d) $1:2$

33. A proton and an α-particle both enter a region of uniform magnetic field B, moving at right angles to the field B. If the radius of circular orbits for both the particles is equal and the kinetic energy acquired by proton is 1 MeV, the energy acquired by the α-particle will be

(a) 4 MeV (b) 0.5 MeV (c) 1.5 MeV (d) 1 MeV

34. In an L-R circuit, the value of L is $\left(\frac{0.4}{\pi}\right)$ H and the value of R is 30 Ω. If in the circuit, an alternating emf of 200 V at 50 cycle s^{-1} is connected, the impedance of the circuit and current will be

(a) 11.4 Ω, 17.5 A (b) 30.7 Ω, 6.5 A (c) 40.4 Ω, 5 A (d) 50 Ω, 4 A

35. The galvanometer cannot be used as an ammeter to measure the value of current in a given circuit.

Which of the following statement(s) is/are incorrect about given information?

(a) Galvanometer gives full scale deflection for a small current.
(b) Galvanometer has a large resistance.
(c) A linear scale cannot be designed, so that $I \propto \alpha$.
(d) A galvanometer can give accurate values.

36. Three point charges $+q_1$, $-2q$ and $-2q$ are placed at the vertices of an equilateral triangle of side a. The work done by some external force to increase their separation to $2a$ will be

(a) $\frac{1}{4\pi\varepsilon_0}\frac{2q^2}{a}$ (b) $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2a}$ (c) $\frac{1}{4\pi\varepsilon_0}\frac{\delta q}{a^2}$ (d) zero

37. Which of the following statement(s) is/are correct?

(a) In case of resistor, both V and i reach zero, minimum and maximum values at the different time.
(b) The sum of the instantaneous current values over one complete cycle is unity and the average current is one.
(c) The average power dissipated in a resistance is $P_{avg} = \frac{1}{2} I_m^2 R$.
(d) To show phase relationship between voltage and current in an AC circuit, we use the notion of scalars.

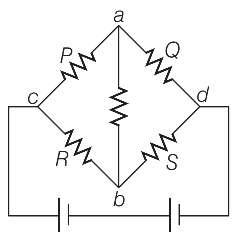
38. Two cells of equal emf and of internal resistances r_1 and $r_2 (r_1 > r_2)$ are connected in series. On connecting this combination with an external resistance R, it is observed that the potential difference across the first cell becomes zero. The value of R will be

(a) $r_1 + r_2$ (b) $r_1 - r_2$ (c) $\frac{r_1 + r_2}{2}$ (d) $\frac{r_1 - r_2}{2}$

39. Two similar coils of radius r are lying concentrically with their planes at right angle to each other. The current flowing in them are I and $3I$, respectively. The resultant magnetic field induction at the centre will be

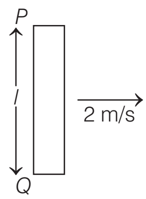
(a) $\frac{\sqrt{5}\mu_0 I}{2R}$ (b) $\frac{\sqrt{10}\mu_0 I}{2R}$ (c) $\frac{\mu_0 I}{2R}$ (d) $\frac{\mu_0 I}{R}$

40. In the following Wheatstone bridge, $R = S$ and $P > Q$. The direction of the current between ab will be



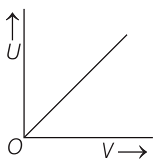
(a) from a to b (b) from b to a through c
(c) from b to a (d) from a to b through c

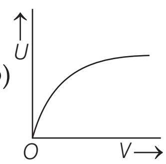
41. A conducting rod of unit length moves with a velocity of 2 m/s in a direction perpendicular to its length. Also, it is perpendicular to the uniform magnetic field of magnitude 0.2 T. The emf induced between the ends of the stick is

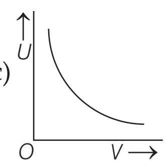


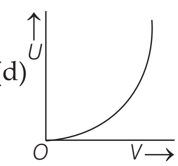
(a) 2 V (b) 6 V
(c) 9 V (d) 0.4 V

42. Which of the following graphs correctly represents the variation of heat energy (U) produced in a metallic conductor in a given time as a function of potential difference (V) across the conductor?

(a) 

(b) 

(c) 

(d) 

43. Which of the following statement(s) is/are incorrect?

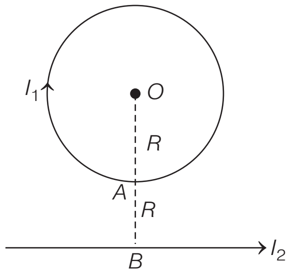
(a) A varying current in a coil can induce emf in a neighbouring coil, whose magnitude depends upon the rate of change of current and mutual inductance of the two coils.

(b) Electromotive force is induced in a single isolated coil due to change of flux through the coil by means of varying the current through it and this process is called self-inductance.

(c) For the current I at an instant in a circuit, the rate of work done is $\frac{dW}{dt} = |\varepsilon| I$ and total work done is $W = \int dW = \int_0^I LI\, dI$.

(d) The flux linked with one coil will be the difference of two fluxes which exists independently (when current is flowing simultaneously in two nearby coils).

44. In the diagram, I_1, I_2 are the strengths of the current in the loop and straight conductors respectively and $OA = AB = R$. The net magnetic field at the centre O is zero. Then, the ratio of the current in the loop and the straight conductor is



(a) π (b) 2π

(c) $\frac{1}{\pi}$ (d) $\frac{1}{2\pi}$

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** When the capacitor is connected to an AC source, it limits or regulates the current, but does not completely prevent the flow of charge.

Reason The capacitor is alternately charged and discharged as the current reverses each half-cycle.

46. **Assertion** If the inner solenoid is much shorter than (and placed well inside) the outer solenoid, then the flux linkage ($N_1\ \phi_1$) can still be calculated.

Reason The inner solenoid is effectively immersed in a uniform magnetic field due to the outer solenoid.

47. **Assertion** A positive point charge initially at rest, when placed in a uniform electric field, it starts moving along electric lines of force (neglect all other forces except electric forces).

Reason A point charge released from rest in an electric field always moves along the line of force.

48. **Assertion** At increased temperature, average speed of the electrons, which acts as the carriers of current increases, resulting in more frequent collisions.

Reason The average time of collisions τ decreases with increasing temperature.

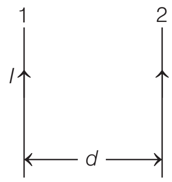
49. **Assertion** When coil in galvanometer with metallic core oscillates, then electromagnetic damping occurs.

Reason Eddy currents generated in the core oppose the motion and bring the coil to rest quickly.

Section C

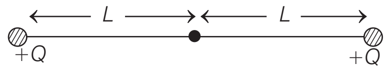
This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. Two very long, straight and parallel wires carry same steady current I flowing in the same direction. The distance between the wires is d. At a certain instant of time, a point charge q is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity v is perpendicular to this plane.
The magnitude of the force due to the magnetic field acting on the charge at this instant is



(a) $\frac{\mu_0 Iqv}{2\pi d}$ (b) $\frac{\mu_0 Iqv}{\pi d}$ (c) $\frac{2\mu_0 Iqv}{\pi d}$ (d) zero

51. Two small spheres each having the charge $+Q$ are suspended by insulating threads of length L from a hook. This arrangement is taken in space, where there is no gravitational effect, then which of the following statement(s) is/are correct?



I. The angle between the two suspensions and tension in each thread will be respectively 180° and $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{(2L)^2}$.

II. The angle between the two suspensions and tension in each thread will be respectively 90° and $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{L^2}$.

III. The angle between the two suspensions and tension in each thread will be respectively 180° and $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{2L^2}$.

(a) Only I (b) Only II (c) Both I and III (d) Only III

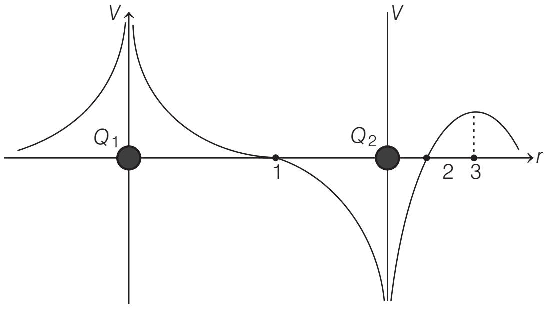
Case Study

Read the following paragraph and answer the questions.

Potential of Two Point Charges

The potential at any observation point of a static electric field is defined as the work done by the external agent (or negative of work done by electrostatic field) in slowly bringing a unit positive point charge from infinity to the observation point. Work done on a test charge by the electrostatic field due to any given charge configuration depends only on the position of initial and final points. The figure given below shows the potential variation along the line of charges.

Two point charges Q_1 and Q_2 lie along a line at a distance from each other.



52. At point 3, which of the following quantity is zero?

(a) Coulomb's force (b) Magnetic flux
(c) Electric field (d) Electric dipole

53. Which of the following statement is correct about the potential?

(a) Due to charges Q_1 and Q_2 are equal in magnitude.
(b) Due to charge Q_1 is zero but due to Q_2 is non-zero.
(c) Due to charge Q_1 is greater than Q_2.
(d) Due to charge Q_1 is smaller than Q_2.

54. In the graph shown above, it can be concluded that

(a) Q_1 is positive and Q_2 is negative
(b) Q_1 is negative and Q_2 is positive
(c) Both the charges are positive in nature
(d) None of the above

55. Two charges of magnitude $+q$ and $-3q$ are placed 100 cm apart. The distance from $+q$ between the charges, where the electrostatic potential is zero will be

(a) 25 cm (b) 50 cm (c) 75 cm (d) 80 cm

OMR SHEET

SP 4

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

● Correct ✔ Incorrect ✗ Incorrect ◓ Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	**20**	a	b	c	d	**38**	a	b	c	d
2	a	b	c	d	**21**	a	b	c	d	**39**	a	b	c	d
3	a	b	c	d	**22**	a	b	c	d	**40**	a	b	c	d
4	a	b	c	d	**23**	a	b	c	d	**41**	a	b	c	d
5	a	b	c	d	**24**	a	b	c	d	**42**	a	b	c	d
6	a	b	c	d	**25**	a	b	c	d	**43**	a	b	c	d
7	a	b	c	d	**26**	a	b	c	d	**44**	a	b	c	d
8	a	b	c	d	**27**	a	b	c	d	**45**	a	b	c	d
9	a	b	c	d	**28**	a	b	c	d	**46**	a	b	c	d
10	a	b	c	d	**29**	a	b	c	d	**47**	a	b	c	d
11	a	b	c	d	**30**	a	b	c	d	**48**	a	b	c	d
12	a	b	c	d	**31**	a	b	c	d	**49**	a	b	c	d
13	a	b	c	d	**32**	a	b	c	d	**50**	a	b	c	d
14	a	b	c	d	**33**	a	b	c	d	**51**	a	b	c	d
15	a	b	c	d	**34**	a	b	c	d	**52**	a	b	c	d
16	a	b	c	d	**35**	a	b	c	d	**53**	a	b	c	d
17	a	b	c	d	**36**	a	b	c	d	**54**	a	b	c	d
18	a	b	c	d	**37**	a	b	c	d	**55**	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

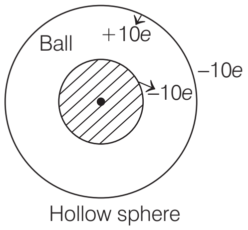
- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (b)	**2.** (b)	**3.** (c)	**4.** (b)	**5.** (a)	**6.** (c)	**7.** (b)	**8.** (b)	**9.** (a)	**10.** (b)
11. (b)	**12.** (a)	**13.** (b)	**14.** (a)	**15.** (a)	**16.** (c)	**17.** (b)	**18.** (d)	**19.** (c)	**20.** (a)
21. (c)	**22.** (c)	**23.** (c)	**24.** (b)	**25.** (d)	**26.** (a)	**27.** (b)	**28.** (c)	**29.** (b)	**30.** (a)
31. (c)	**32.** (a)	**33.** (d)	**34.** (d)	**35.** (c)	**36.** (d)	**37.** (c)	**38.** (b)	**39.** (b)	**40.** (c)
41. (d)	**42.** (d)	**43.** (d)	**44.** (d)	**45.** (a)	**46.** (a)	**47.** (c)	**48.** (a)	**49.** (a)	**50.** (d)
51. (a)	**52.** (c)	**53.** (c)	**54.** (a)	**55.** (a)					

SOLUTIONS

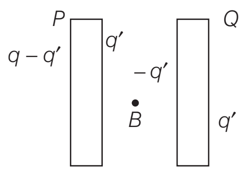
1. According to the question, the charge distribution is shown below



As, the hollow sphere has a charge of + 10e.

$\therefore$ Charge on outer surface $= +10e - 10e = 0$

2. Charge distribution will be as shown below



Field at point B between the plates,

$$E_B = \frac{q-q'}{2A\varepsilon_0} + \frac{q'}{2A\varepsilon_0} + \frac{q'}{2A\varepsilon_0} - \frac{q'}{2A\varepsilon_0} = \frac{q}{2A\varepsilon_0}$$

3. The electric force is an action-reaction pair, i.e. the two charges exert equal and opposite forces on each other. Thus, Coulomb's law obeys Newton's third law.

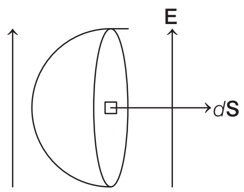
i.e. $\mathbf{F}_{12} = -\mathbf{F}_{21}$

Hence, the ratio of the magnitude of forces acting on 2 μC and − 4 μC charges is 1 : 1.

4. Electric lines of forces emerge from a single positive charge and goes to infinity.

However, electric lines of forces enter into a single negative charge coming from infinity. So, electric lines of forces are repelled away, when they are produced by the pair of positive charges as shown in option (b) .

5. We know that, flux passing through closed surface, $\phi = \oint \mathbf{E}\cdot d\mathbf{S} = \frac{q_{in}}{\varepsilon_0}$



Charge inside hemisphere, $q_{in} = 0$.

i.e. $\oint \mathbf{E}\cdot d\mathbf{S} = 0$

$\Rightarrow \phi_{curved} + \phi_{plane} = 0$

$\Rightarrow \phi_{curved} + ES\cos 90° = 0 \Rightarrow \phi_{curved} = 0$

6. As, the electric field outside the capacitor plates is zero and the field exist only in between the plates. Thus, the energy will resides in the field which is present in between the plates.

7. Given, $q = 100$ C

and potential difference between the cloud and the earth,

$V = 10^7$ V

Thus, energy dissipated, $W = qV$

$= 100 \times 10^7 = 10^9$ J

8. In parallel combination, $C_{net} = C_1 + C_2$

$\therefore \quad V = \frac{q_{net}}{C_{net}} = \frac{C_1V_0}{C_1 + C_2}$

9. In a balanced Wheatstone bridge, there is no effect on position of null point, if we exchange the battery and galvanometer. So, statement given in option (a) is incorrect.

10. We know that, drift velocity, $v = \frac{eE\tau}{m} = \frac{e\tau}{m}\frac{V}{l}$

where, V is the potential difference.

$\Rightarrow \quad v \propto V$

Given, $V_1 = V$, $V_2 = V/2$

$\Rightarrow \quad \frac{v_1}{v_2} = \frac{V_1}{V_2} = \frac{V}{V/2} = 2$

$\Rightarrow \quad v_2 = \frac{v_1}{2} = \frac{v}{2} \qquad (\because v_1 = v)$

11. According to Kirchhoff's first law,

$$5 + 4 - 3 - 5 - I = 0$$

$$\Rightarrow \quad I = 1\text{ A}$$

So, current in fifth conductor is 1A flowing away from x.

12. Current density, $J = \sigma E$

where, σ = conductivity = $\frac{1}{\text{resistivity}}$

$$= \frac{1}{\rho} = \frac{1}{1.7\times10^{-8}\,\Omega\text{-m}}$$

$$\Rightarrow \quad J = \frac{1}{1.7\times10^{-8}}\times100$$

$$= \frac{100}{17}\times10^{9} \simeq 6\times10^{9}\,\text{Am}^{-2}$$

13. Given, number of electrons,
$n = 20$ million $= 2\times10^{7}$

Total charge on twenty million electrons,

$$q = ne$$
$$= 2\times10^{7}\times1.6\times10^{-19} \quad (\because e = 1.6\times10^{-19}\text{C})$$
$$= 3.2\times10^{-12}\text{C}$$

Now, time taken by twenty million electrons to pass from point X to point Y,

$$t = 2\,\mu\text{s} = 2\times10^{-6}\text{s}$$

$$\Rightarrow \quad i = \frac{q}{t} = \frac{3.2\times10^{-12}}{2\times10^{-6}} = 1.6\times10^{-6}\text{ A}$$

Since, the direction of the current is always opposite to the direction of flow of electrons. Therefore, due to flow of electrons from point X to point Y, the current will flow from point Y to point X.

14. In a velocity selector, let F_e and F_B are electric and magnetic forces.

Case I When $v = E/B \Rightarrow F_e = F_B$

i.e. Particles pass straight undeflected through the region.

Case II When $v > E/B \Rightarrow F_e < F_B$

i.e. Particles deflects in a direction perpendicular to both **v** and **B**.

Case III When $v < E/B \Rightarrow F_e > F_B$

i.e. Particles deflects in the direction of electric field.

So, statement in option(a) is correct and rest are incorrect.

15. Given, current, $i = 5$A

Total number of turns, $N = 200$

Length of solenoid, $l = 0.2$ m

Radius, $r = 5$ cm $= 5\times10^{-2}$ m

Number of turns per unit length,

$$n = \frac{N}{l} = \frac{200}{0.2} = 1000\text{ turns/m}$$

Magnitude of magnetic field inside the solenoid, $B = \mu_0 ni = 4\pi\times10^{-7}\times1000\times5$

$$= 0.2\pi\times10^{-2}\text{T}$$

16. Statement given in option (c) is correct but rest are incorrect and these can be corrected as,

When **v** is parallel to **B** or **v** is along **B**, then path of the particle is straight line.

When **v** is perpendicular to **B**, then path of particle is a circle.

17. In a moving coil galvanometer, soft iron core increases field strength, pole pieces produces radial field, spring produces restoring torque and coil produces deflecting torque.

18. Force of attraction between the magnetic poles is given as, $F \propto \frac{m_1 m_2}{r^2}$

$$\therefore \quad \frac{F_2}{F_1} = \frac{\frac{\frac{m_1}{2}\times\frac{m_2}{2}}{(2r)^2}}{\frac{m_1\times m_2}{r}} = \frac{1}{16}$$

or $\quad F_2 = (1/16)\,F_1$

$\therefore$ The force decreases to 16 times its previous value.

19. The statement given in option (c) is correct but rest are incorrect and these can be corrected as,

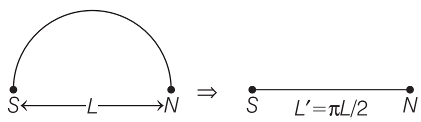
Since, a current carrying circular loop behaves as a magnetic dipole whose magnetic moment's direction is perpendicular to the plane of the loop.

Therefore, when dipole is replaced by equivalent bar magnet, then the line joining N-S will be perpendicular to the plane of loop. As current is anti-clockwise, so north-pole lies above the loop and south-pole lies below the loop.

20. On unbending the rod, its pole strength remains unchanged whereas its magnetic moment changes.

Magnetic moment of semi-circular rod,

$$M = mL \quad \ldots\text{(i)}$$



New magnetic moment, $M' = mL'$

$$= \frac{m\pi L}{2} = \frac{\pi M}{2} \quad [\because \text{from Eq. (i)}]$$

21. As the current in loop P increases, magnetic field associated with Q also increases. Thus, in response, current will flow in the loop Q.

So, in accordance with Lenz law, the direction of the current in loop Q will be in such a way that it opposes the cause of effect. If current in loop P is in clockwise direction, then current in loop Q will also be clockwise direction. Hence, they both will repel each other.

22. When wire loop is rotated in a magnetic field, the frequency of change of the direction of the induced emf is two times per revolution.

23. RMS value of voltage, $V_{rms} = \sqrt{\frac{V_1^2}{2} + \frac{V_2^2}{2} + \frac{V_3^2}{2}}$

$$= \sqrt{\frac{1^2}{2} + \frac{2^2}{2} + \frac{3^2}{2}} = 2.64 \text{ unit}$$

24. Given $X_L = R \Rightarrow Z = \sqrt{2}R$

$$\therefore \quad P = \left(\frac{V_{rms}}{Z}\right)^2 \cdot R = \left(\frac{E_0/\sqrt{2}}{\sqrt{2}R}\right)^2 \cdot R = \frac{E_0^2}{4R}$$

25. Frequency of L-C oscillation, $f = \frac{1}{2\pi\sqrt{LC}}$

$$\Rightarrow \frac{f_1}{f_2} = \frac{1}{\sqrt{L_1C_1}}\sqrt{L_2C_2} = \left(\frac{L_2C_2}{L_1C_1}\right)^{1/2}$$

$$= \left(\frac{L/2 \times 2C}{L \times C}\right)^{1/2} = (1)^{1/2}$$

$$\therefore \quad \frac{f_1}{f_2} = 1$$

As, $f_1 = f \Rightarrow f_2 = f$.

26. Given, $C = 20\mu\text{F} = 20 \times 10^{-6}$ F

and $\quad L = 10 \text{ mH} = 10 \times 10^{-3}$ H

$$\therefore f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{20 \times 10^{-6} \times 10 \times 10^{-3}}}$$

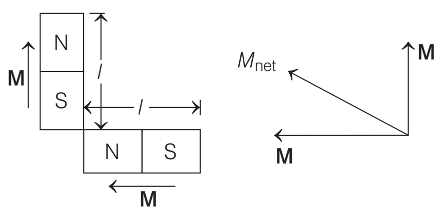
$= 356$ Hz or cycles/s

27. Statement given in option (b) is incorrect and it can be corrected as,

The lines of constant magnitude of magnetic field form concentric circles called magnetic field lines. They originate from positive charges and ends at negative charges.

Rest statements are correct.

28. Net magnetic moment of the system is given by



$$M = \sqrt{M^2 + M^2} = \sqrt{2}M = \sqrt{2}ml$$

29. Given, distance between two cities, $d = 150$ km

Fall of potential per km, $V = 8$ V

Average resistance per km, $R = 0.5\ \Omega$

Power loss per km, $P_1 = \frac{V^2}{R} = \frac{8^2}{0.5} = 128$ W

$\therefore$ Total power loss in wire $= P_1 \times d = 128 \times 150$

$= 19200$ W

$= 19.2$ kW

30. When the X_L is in resonance with X_C, then the current is minimum and the frequency,

$$f = \frac{\omega}{2\pi} \quad \dots \text{(i)}$$

We have given series frequency,

$$f = \frac{\omega}{2\pi\sqrt{LC}} = n$$

Putting in Eq. (i), we get

$$f = n\sqrt{LC}$$

Since, current in a parallel L-C circuit is

$I = \frac{V}{Z}$, where Z is the impedance and V is the voltage.

When the impedance is maximum, the current through a circuit is minimum. Therefore, at resonance the frequency will be n.

31. If n identical cells are connected in series, then equivalent emf of the combination, $E_{eq} = nE$.

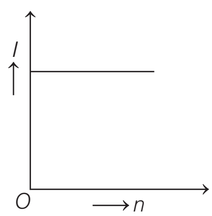
Equivalent internal resistance, $r_{eq} = nr$

$\therefore$ Current, $\quad I = \frac{E_{eq}}{r_{eq}} = \frac{nE}{nr}$

or $\quad I = \frac{E}{r} = \text{constant}$

Thus, current I is independent of the number of cells n present in the circuit.

Therefore, the graph showing the relationship between I and n would be as shown below



This is correctly shown in option (c).

32. As, $H = B\cos\theta$

$$\Rightarrow \frac{H_1}{H_2} = \frac{B\cos\theta_1}{B\cos\theta_2} = \frac{\cos\theta_1}{\cos\theta_2} = \frac{\cos 30^\circ}{\cos 45^\circ}$$

$$= \frac{\sqrt{3}}{2} \times \sqrt{2} = \frac{\sqrt{3}}{\sqrt{2}}$$

33. Radius of circular orbit of a particle in magnetic field,

$$R = \frac{mv}{qB} = \frac{\sqrt{2mE}}{qB}$$

$$\left[\because \text{Kinetic energy, } E = \frac{1}{2}mv^2 \Rightarrow mv = \sqrt{2mE}\right]$$

and total energy of a moving particle in a circular orbit,

$$E = \frac{q^2B^2R^2}{2m}$$

For a proton entering in a region of magnetic field,

$$E_1 = \frac{e^2 \times B^2 \times R^2}{2 \times m_p} \quad \ldots(\text{i})$$

where, m_p is the mass of proton.

Similarly, for an α-particle moving in an uniform magnetic field,

$$E_2 = \frac{(2e)^2 \times B^2 \times R^2}{2 \times (4m_p)}$$

$$(\because q_\alpha = 2e \text{ and } m_\alpha = 4m_p) \ldots(\text{ii})$$

Dividing Eq. (ii) by Eq. (i), we get

$$\frac{E_2}{E_1} = \frac{(2e)^2 \times B^2 \times R^2}{2 \times (4m_p)} \times \frac{2 \times m_p}{e^2 \times B^2 \times R^2}$$

$$\frac{E_2}{E_1} = 1 \Rightarrow E_2 = E_1 = 1 \text{ MeV}$$

34. Given, $X_L = \omega L = 2\pi f L = 2\pi \times 50 \times \frac{0.4}{\pi} = 40\,\Omega$

$R = 30\,\Omega$

$\therefore \quad Z = \sqrt{R^2 + X_L^2}$

$= \sqrt{(30)^2 + (40)^2} = 50\,\Omega$

$\therefore \quad I_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{200}{50} = 4\text{ A}$

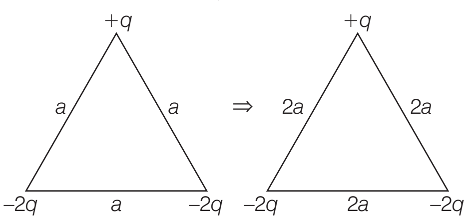
35. Statements (a), (b) and (d) are correct but (c) is incorrect and it can be corrected as,

As the deflection (α) of the coil is proportional to the current passed through it, so a linear scale can be used to measure the deflection.

i.e. $\quad I \propto \alpha$

36. Work done in increasing the separation from a to $2a$ is

$$W = U_f - U_i \quad \ldots(\text{i})$$



Here,

$$U_i = \frac{1}{4\pi\varepsilon_0}\left[\frac{q(-2q)}{a} + \frac{q(-2q)}{a} + \frac{(-2q)(-2q)}{a}\right]$$

$$= \frac{1}{4\pi\varepsilon_0 a}[-2q^2 - 2q^2 + 4q^2] = 0$$

Similarly, $U_f = \frac{1}{4\pi\varepsilon_0(2a)}(-2q^2 - 2q^2 + 4q^2) = 0$

Hence, from Eq. (i)

$$W = U_f - U_i = 0$$

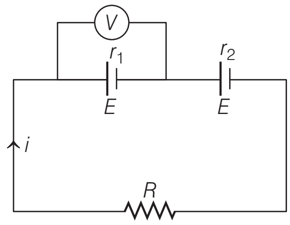
37. Statement given in option (c) is correct but rest are incorrect and these can be corrected as,

In case of a resistor, both V and i reach zero, minimum and maximum values at the same time. Clearly, the voltage and current are in phase with each other.

Like applied voltage, the current varies sinusoidally and has corresponding positive and negative values during each cycle. Thus, the sum of instantaneous current values over one complete cycle is zero and the average current is zero.

To show phase relationship between voltage and current in an AC circuit, we use the notion of phasors. A phasor is a vector which rotates about the origin with angular speed ω.

38. Let the voltage across first cell is V, then



$$V = E - ir_1 = E - r_1\left(\frac{2E}{r_1 + r_2 + R}\right)$$

$$\left(\because i = \frac{E_{\text{eq}}}{R_{\text{eq}}}\right)$$

But $\quad V = 0$

$\Rightarrow E - \frac{2Er_1}{r_1 + r_2 + R} = 0$

$\Rightarrow \quad r_1 + r_2 + R = 2r_1$

$\Rightarrow \quad R = r_1 - r_2$

39. The magnetic field (B) at the centre of circular current carrying coil of radius R and current I,

$$B = \frac{\mu_0 I}{2R}$$

Similarly, if current $= 3I$, then

Magnetic field $= \frac{\mu_0 3I}{2R} = 3B$

So, resultant magnetic field

$$= \sqrt{B^2 + (3B)^2} = \sqrt{10B^2}$$

$$= \sqrt{10}\,B = \frac{\mu_0 I\sqrt{10}}{2R}$$

40. For the balanced Wheatstone bridge,

In the part cbd,

$$V_c - V_b = V_b - V_d$$

$$\Rightarrow \quad V_b = \frac{V_c + V_d}{2} \quad \text{...(i)}$$

In the part $c\,a\,d$,

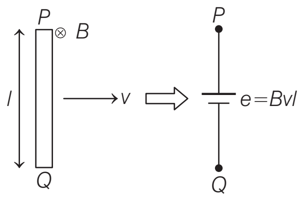
$$V_c - V_a > V_a - V_d \quad [\because P > Q]$$

$$\Rightarrow \quad \frac{V_c + V_d}{2} > V_a$$

$$\Rightarrow \quad V_b > V_a \quad \text{[using Eq. (i)]}$$

$\therefore$ The current flows from b to a.

41.



The negative terminal is that end towards which electrons are moving due to magnetic force and the magnetic force on electron is acting along Q, hence Q is negative terminal of battery.

As we know that, induced emf for a moving rod is given by

$$\Rightarrow \quad e = Bvl = 0.2 \times 2 \times 1$$

$$= 0.4 \text{ V}$$

42. According to Joule's law of heating, $U = \frac{V^2}{R}t$.

It shows that, the graph between heat energy (U) and potential difference (V) is upwards parabola and is represented by option (d).

43. Statement given in option (d) is incorrect and it can be corrected as,

The flux linked with one coil will be the sum of two fluxes which exist independently (when current is flowing simultaneously in two nearby coils).

$\therefore N_1\phi_1 = M_{11}I_1 + M_{12}I_2$, where M_{11} represents inductance due to the same coil.

44. Magnetic field at centre O due to current I_1 in loop,

$$B_1 = \frac{\mu_0}{4\pi}\frac{2\pi I_1}{R}$$

Magnetic field at centre O due to current I_2 through straight conductor,

$$B_2 = \frac{\mu_0}{4\pi}\frac{2I_2}{2R} = \frac{\mu_0}{4\pi}\frac{I_2}{R}$$

As, net magnetic field at O is zero (given).

$$\therefore \quad B_1 = B_2$$

$$\frac{\mu_0}{4\pi}\frac{2\pi I_1}{R} = \frac{\mu_0}{4\pi}\frac{I_2}{R}$$

$$\Rightarrow \quad \frac{I_1}{I_2} = \frac{1}{2\pi}$$

45. When the capacitor is connected to an AC source, it limits or regulates the current, but does not completely prevent the flow of charge.

It is because, the capacitor is alternately charged and discharged as the current reverses each half cycle.

Therefore, both A and R are true and R is the correct explanation of A.

46. If the the inner solenoid is much shorter than (and placed well inside) the outer solenoid, then the flux linkage $(N_1\phi_1)$ can still be calculated.

It is because, the inner solenoid is effectively immersed in a uniform magnetic field due to the outer solenoid.

Therefore, both A and R are true and R is the correct explanation of A.

47. When a positive charge initially at rest is placed in a uniform electric field, then it moves along the electric lines of force.

But if a point charge is released from rest in a direction making an angle with the field, then it follows a parabolic path.

Therefore, A is true, but R is false.

48. With increase in temperature, average speed of the electrons, which acts as the carriers of current increases, resulting in more frequent collisions.

Thus, the average time of collisions τ decreases with increasing temperature.

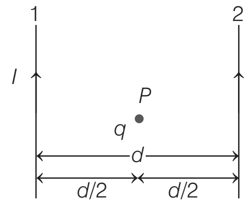
Therefore, both A and R are true and R is the correct explanation of A.

49. Certain galvanometers have a fixed core made of non-magnetic metallic material.

When the coil oscillates, the eddy currents generated the core oppose the motion and bring the coil to rest quickly. This is called electromagnetic damping.

Therefore, both A and R are true and R is the correct explanation of A.

50. The given situation can be drawn as below



The magnetic field $\mathbf{B}_1$ at mid-point P due to first wire is in downward direction, according to right-hand rule. Similarly, magnetic field $\mathbf{B}_2$ due to second wire is in upward direction.

Let the charge q is moving with instantaneous velocity $\mathbf{v}$ in upward direction, then magnitude of force on q, due to first wire is

$$F_1 = q(\mathbf{v} \times \mathbf{B}_1) = qvB_1 \sin\theta = qvB_1 \sin 180° = 0$$

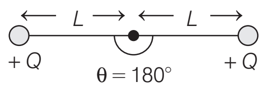
Similarly, magnitude of force on q, due to second wire is

$$F_2 = q(\mathbf{v} \times \mathbf{B}_2) = qvB_2 \sin\theta = qvB_2 \sin 0° = 0$$

Thus, net magnitude of force on q,

$$F_{\text{net}} = F_1 + F_2 = 0$$

51. Two small spheres of charge $+Q$ are suspended by threads of length L as shown below



When this arrangement is in space, i.e. there is no gravitational force, then angle between two suspensions will be 180° due to repulsive force.

$\therefore$ Tension in each thread,

$$T = \frac{KQQ}{(2L)^2} = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{(2L)^2} \qquad \left[\because K = \frac{1}{4\pi\varepsilon_0}\right]$$

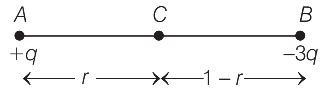
52. Here, we will use the relation $E_r = \frac{-dV}{dr}$. The negative slope of the V *versus* r curve represents the component of the electric field along r. The slope of the curve is zero only at point 3, therefore the electric field is zero at point 3.

53. From the figure, it can be seen that the net potential due to two charges is positive everywhere in the region left to charge Q_1. Therefore, the magnitude of potential due to charge Q_1 is greater than Q_2.

54. Near a positive charge, net potential is positive and near a negative charge, net potential is negative. Thus, charge Q_1 is positive and Q_2 is negative.

55. Let two charges be placed 100 cm (1 m) apart at points A, B and C be a point of zero potential at a distance r from $+q$.

Potential at point C due to two charges will be



$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{r} + \frac{(-3q)}{1-r}\right] = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r} - \frac{3q}{1-r}\right)$$

Since, potential at point C is zero, i.e. $V = 0$.

$$\Rightarrow \quad \frac{q}{r} - \frac{3q}{1-r} = 0$$

$$\Rightarrow \quad \frac{q}{r} = \frac{3q}{1-r}$$

or $\quad 3r = 1 - r$

or $\quad r = \frac{1}{4} = 0.25 \text{ m} = 25 \text{ cm}$

SAMPLE PAPER 5

PHYSICS

A Highly Simulated Practice Questions Paper
*for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

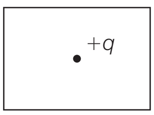
Roll No. | | | | | | | |

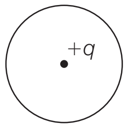
Maximum Marks : 35
Time allowed : 90 min

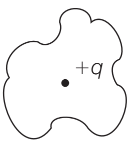
Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. Amongst the given options, through which surface electric flux will be least?

(a) 

(b) 

(c) 

(d) Same for all figures given in options (a), (b) and (c)

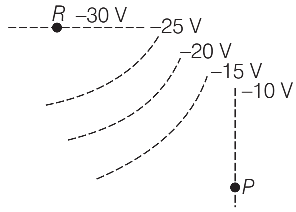
2. Two charged spheres separated by a distance d exert a force F on each other. If they are immersed in a liquid of dielectric constant K, then the force becomes $\frac{F}{2}$. The value of K is

(a) 2 (b) $\frac{1}{2}$ (c) 4 (d) $\frac{1}{4}$

3. Three capacitors of capacitances $3\,\mu F$, $9\,\mu F$ and $18\,\mu F$ are once connected in series and then in parallel. The ratio of equivalent capacitance in the two cases $\left(\frac{C_S}{C_P}\right)$ will be

(a) 1 : 15 (b) 15 : 1 (c) 1 : 1 (d) 1 : 3

4. The figure given below shows various equipotential surfaces.



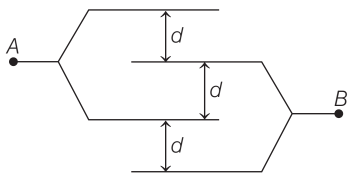
What is the direction of electric field **E** at P and R?

(a) At P, **E** is to the left and at R, **E** is upward
(b) At P, **E** is to the right and at R, **E** is downward
(c) At P, **E** is to downward and at R, **E** is to the left
(d) At P, **E** is to upward and at R, **E** is to the right

5. Which amongst the following statement(s) is/are correct regarding electric field (**E**), electric displacement (**D**) and electric polarisation (**P**)?

(a) **E**, **D** and **P** are related by $\mathbf{D} = \varepsilon_0 \mathbf{E} - \mathbf{P}$.
(b) **E**, **D** and **P** are mutually perpendicular to each other.
(c) **E**, **D** and **P** are mutually parallel to each other.
(d) Both (a) and (c)

6. The equivalent capacitance between points A and B in the following figure is, (Take, capacitance of each capacitor as 2μF)



(a) 9μF (b) 4μF (c) 2 μF (d) 6μF

7. If a wire is stretched to make it 0.1% longer, its resistance will

(a) increase by 0.2% (b) decrease by 0.2%
(c) decrease by 0.05% (d) increase by 0.05%

8. The Kirchhoff's first law ($\Sigma i = 0$) and second law ($\Sigma iR = \Sigma E$) are respectively based on

(a) conservation of charge, conservation of momentum
(b) conservation of energy, conservation of charge
(c) conservation of momentum, conservation of charge
(d) conservation of charge, conservation of energy

9. A current i is flowing through the wire of diameter d. Drift velocity of electrons is v_d. When the diameter of wire becomes $d/4$, the new drift velocity will be

(a) $4v_d$ (b) $\frac{v_d}{4}$ (c) $16\,v_d$ (d) $\frac{v_d}{16}$

10. Is it possible that any battery has some constant non-zero value of emf but the potential difference between the plates is zero?

(a) Not possible
(b) Yes, if another identical battery is joined in series
(c) Yes, if another identical battery is joined in opposition
(d) Yes, if another similar battery is joined in parallel

11. For measurement of potential difference, potentiometer is preferred in comparison to voltmeter because

(a) potentiometer is more sensitive than voltmeter
(b) the resistance of potentiometer is less than voltmeter
(c) potentiometer is cheaper than voltmeter
(d) potentiometer does not take current from the circuit

12. A heater coil is cut into two equal parts and only one part is used in the heater. The heat generated will now be

(a) doubled (b) four times
(c) one-fourth (d) halved

13. The electric field in a copper wire of cross-sectional area 2 mm^2 carrying current of 1 A, is (Take , conductivity of copper, $\sigma = 6.25 \times 10^7 \, Sm^{-1}$)

(a) $6 \times 10^7 \, Vm^{-1}$ (b) $2 \times 10^2 \, Vm^{-1}$
(c) $8 \times 10^{-3} \, Vm^{-1}$ (d) $9 \times 10^{-4} \, Vm^{-1}$

14. If an electron is at rest in a strong magnetic field (**B**), it will move in

(a) opposite direction of **B** (b) direction of **B**
(c) a direction perpendicular to **B** (d) None of these

15. In two galvanometers P and Q, to produce a deflection of 10 divisions, currents of 3 mA and 6 mA are required respectively, then choose the correct statement from the following options.

(a) P is more sensitive than Q.
(b) Q is more sensitive than P.
(c) Both are equally sensitive.
(d) Sensitivity of Q is 2 times of P.

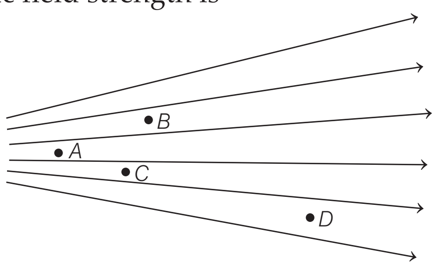
16. Magnetic field intensity at the centre of a circular current carrying coil of radius a is B. If the radius is doubled, then the value of magnetic field intensity will be

(a) $2B$ (b) $4B$
(c) $B/2$ (d) $B/4$

17. In the magnetic meridian of a certain place, the horizontal component of earth's magnetic field is 0.46 G and the angle of dip is 30°. The vertical component of earth's magnetic field is

(a) 0.26 (b) 0.46
(c) 2.46 (d) 1.28

18. A non-uniform magnetic field is shown in figure below. The point that lies in the region of least magnetic field strength is



(a) A (b) B (c) C (d) D

19. Magnetic moment of an electron moving around the nucleus with an angular momentum L increases with the

(a) increase in L (b) decrease in L (c) increase in m (d) remains constant

20. A pair of adjacent coils has a mutual inductance of 2.5 H. If the current in one coil changes from 0 to 10A in 0.5 s, the change in flux (in Wb) linkage with the other coil is

(a) 10 (b) 25 (c) 35 (d) 50

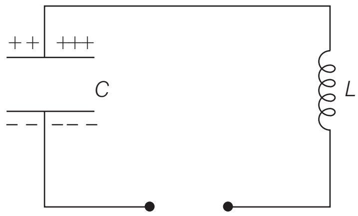
21. South-pole of a long horizontal bar magnet is being brought closer to a vertical conducting plane along the perpendicular direction. The direction of the induced current in the conducting plane will be

(a) horizontal (b) vertical (c) clockwise (d) anti-clockwise

22. A charged 20μF capacitor is connected to a 30 mH inductor. The angular frequency of free oscillations of the circuit is

(a) 0.129×10^{3} rad s^{-1} (b) 1.29×10^{6} rad s^{-1} (c) 0.129×10^{4} rad s^{-1} (d) 1.39×10^{2} rad s^{-1}

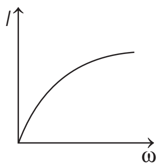
23. For the given circuit diagram of L-C oscillator, mark the correct relation for electric and magnetic energies.

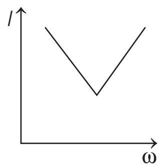


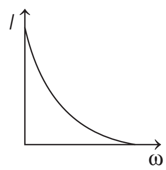
(a) $U_E \to \frac{q^2}{2C}, U_B \to 0$ (b) $U_E \to \frac{q}{2C}, U_B \to \frac{1}{2}LI^2$

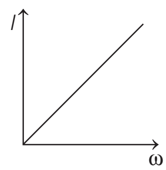
(c) $U_E \to 0, U_B \to \frac{1}{2}LI^2$ (d) $U_E \to \frac{1}{2}LI^2, U_B \to \frac{q}{2C}$

24. In a purely capacitive circuit, a constant voltage at different frequencies is applied across a capacitor. Which of the following graph correctly represents the variation of current (I) with frequency (ω) in the circuit?

(a) 

(b) 

(c) 

(d) 

25. In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is

(a) $NABR\omega$ (b) NAB (c) $NABR$ (d) $NAB\omega$

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. A capacitor with capacitance 5 μF is charged to 5μC. If plates are pulled apart to reduce the capacitance to C μF, then the work done is 2×10^{-6} J. The value of C is

(a) 1 (b) 2 (c) 6.25 (d) 0.25

27. An electron of energy 2000 eV describes a circular path in magnetic field of flux density 0.2 T. The radius of the path is (Take, electronic charge, $e = 1.6\times10^{-19}$ C, mass of electron, $m = 9\times10^{-31}$ kg)

(a) 6.2×10^{-3} m (b) 7.5×10^{-4} m (c) 9.1×10^{-6} m (d) 2.4×10^{-6} m

28. The voltage supplied to a circuit is $V = V_0 t^{3/2}$, where t is in seconds. The rms value of voltage for the period, $t = 0$ to $t = 1$ s, is

(a) $\frac{V_0}{2}$ (b) $2V_0$ (c) $\frac{V_0^2}{3}$ (d) $\frac{4V_0}{3}$

29. A charged particle is projected in a magnetic field, $\mathbf{B} = (2\hat{\mathbf{i}} + 4\hat{\mathbf{j}})\times10^{-2}$ T. The acceleration of the particle, $\mathbf{a} = (x\hat{\mathbf{i}} + 2\hat{\mathbf{j}})\,\text{ms}^{-2}$. The value of x is

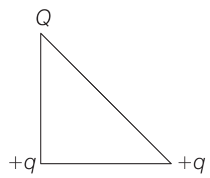
(a) $\frac{-8}{3}$ (b) 4 (c) $\frac{3}{8}$ (d) –4

30. In finding the electric field using Gauss law, the formula $|\mathbf{E}| = \frac{q_{\text{enc}}}{\varepsilon_0 |A|}$ is applicable. In this formula, ε_0 is permittivity of free space, A is the area of Gaussian surface and q_{enc} is charge enclosed by the Gaussian surface.

This equation can be used in which of this following situation?

(a) Only when the Gaussian surface is an equipotential surface and $|\mathbf{E}|$ is constant on the surface.
(b) Only when the Gaussian surface is an equipotential surface.
(c) For any choice of Gaussian surface.
(d) Only when $|\mathbf{E}|$ is constant on the surface.

31. Three charges Q, $+q$ and $+q$ are placed at the vertices of a right angle isosceles triangle as shown below. The net electrostatic energy of the configuration is zero, if the value of Q is

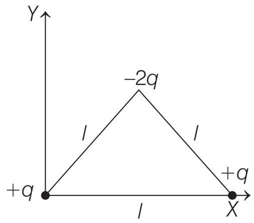


(a) $-2q$ (b) $\frac{-q}{1+\sqrt{2}}$ (c) $+q$ (d) $\frac{-\sqrt{2}q}{\sqrt{2}+1}$

32. An electric bulb is rated 220 V-100 W. The power consumed by it, when operated on 110 V will be

(a) 75 W (b) 40 W (c) 25 W (d) 50 W

33. Electric dipole moment of the system of three charges, placed on the vertices of an equilateral triangle as shown in the figure, is



(a) $\sqrt{3}\, ql \dfrac{\hat{\mathbf{j}}-\hat{\mathbf{i}}}{\sqrt{2}}$ (b) $2ql\,\hat{\mathbf{j}}$ (c) $-\sqrt{3}\, ql\,\hat{\mathbf{j}}$ (d) $(ql)\dfrac{\hat{\mathbf{i}}+\hat{\mathbf{j}}}{\sqrt{2}}$

34. A circuit to verify Ohm's law uses an ammeter and a voltmeter in series or parallel connected correctly to the resistor. Then, which of the following statement is correct regarding the circuit?

(a) Ammeter is always used in parallel and voltmeter in series.
(b) Both ammeter and voltmeter must be connected in parallel.
(c) Ammeter is always connected in series and voltmeter in parallel.
(d) Both ammeter and voltmeter must be connected in series.

35. In an *L-C-R* series AC circuit, the voltage across each of the components *L*, *C* and *R* is 50 V. The voltage across the *L-C* combination will be

(a) 50 V (b) $50\sqrt{2}$ V
(c) 100 V (d) zero

36. A cylinder of radius *R* and length *L* is placed in a uniform electric field *E* parallel to the cylinder axis. The total flux through the surface of the cylinder is given by

(a) $2\pi R^2 E$ (b) $\pi R^2 / E$ (c) $(R^2/\pi E)$ (d) zero

37. The plane of a dip circle is set in the geographic meridian and the apparent dip is δ_1. It is then set in vertical plane perpendicular to the geographic meridian. The apparent dip angle is δ_2. The declination θ at the plane is

(a) $\theta = \tan^{-1}(\tan\delta_1 \tan\delta_2)$ (b) $\theta = \tan^{-1}(\tan\delta_1 + \tan\delta_2)$
(c) $\theta = \tan^{-1}\left(\dfrac{\tan\delta_1}{\tan\delta_2}\right)$ (d) $\theta = \tan^{-1}(\tan\delta_1 - \tan\delta_2)$

38. A long straight wire of radius *a* carries a steady current *I*. The current is uniformly distributed across its cross-section. The ratio of the magnetic fields at $\dfrac{a}{2}$ and $2a$ is

(a) 1/4 (b) 4 (c) 1 (d) 1/2

39. In an *L-C-R* circuit, capacitance is changed from *C* to 2*C*. For the resonant frequency to remains unchanged, the inductance should be changed from *L* to

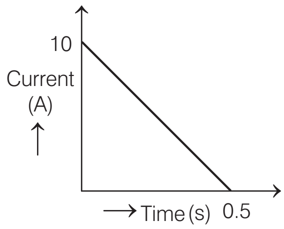
(a) 4*L* (b) 2 *L* (c) *L*/2 (d) *L*/4

40. There are two long co-axial solenoids of same length *l*. The inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2, respectively. The ratio of mutual inductance to the self-inductance of the inner coil is

(a) $\dfrac{n_2}{n_1} \cdot \dfrac{r_1}{r_2}$ (b) $\dfrac{n_2}{n_1} \cdot \dfrac{r_2^2}{r_1^2}$ (c) $\dfrac{n_2}{n_1}$ (d) $\dfrac{n_1}{n_2}$

SAMPLE PAPER 5

41. In a coil of resistance 100 Ω, a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is



(a) 225 Wb (b) 250 Wb (c) 275 Wb (d) 200 Wb

42. An electric charge 10^{-3} μC is placed at the origin (0, 0) of *xy*-coordinate system. Two points *A* and *B* are situated at $(\sqrt{2}, \sqrt{2})$ and (2, 0) respectively. The potential difference between the points *A* and *B* will be

(a) 9 V (b) zero (c) 2 V (d) 4.5 V

43. A current carrying coil is placed with its axis perpendicular to *N-S* direction. Let horizontal component of earth's magnetic field be H_0 and magnetic field inside the loop be *H*. If a magnet is suspended inside the loop, it makes angle θ with *H*, then θ equal to

(a) $\tan^{-1}\left(\frac{H_0}{H}\right)$ (b) $\tan^{-1}\left(\frac{H}{H_0}\right)$ (c) $\text{cosec}^{-1}\left(\frac{H}{H_0}\right)$ (d) $\cot^{-1}\left(\frac{H_0}{H}\right)$

44. An alternating emf of angular frequency ω is applied across an inductance. The instantaneous power developed in the circuit has an angular frequency

(a) ω / 4 (b) ω / 2 (c) ω (d) 2ω

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** At the surface of a charged conductor, electrostatic field must be parallel to the surface at every point.

Reason Electrostatic field at the surface of a charged conductor is zero.

46. **Assertion** Electromotive force can be induced in a single isolated coil due to change of flux through the coil by varying the current in the same coil.

Reason Self-inductance is analogous to inertia.

47. **Assertion** For a velocity selector, when $v = \frac{E}{B}$, the charged particles passes in a straight line.

Reason Total force on the charge is zero, as $\mathbf{E} = \mathbf{B}$.

48. **Assertion** Charge on all capacitors connected in parallel combination remains same, while potential difference is different for each capacitor.

Reason Capacitance of a capacitor is directly proportional to the charge on it.

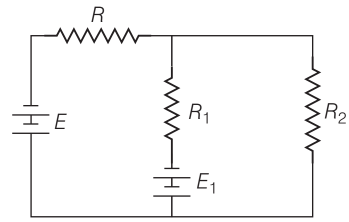
49. **Assertion** When a capacitor is charged in a DC circuit, it limits or opposes the current in the circuit.

Reason When the capacitor is fully charged, the current in the circuit falls to zero.

Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. Figure shows a circuit with known resistances R_1 and R_2. Neglect the internal resistance of the sources of current and resistance of the connecting wire. The magnitude of electromotive force E, such that the current through the resistance R is zero will be



(a) ER_1/R_2
(b) ER_2/R_1
(c) $E(R_1+R_2)/R_2$
(d) $ER_1/(R_1+R_2)$

51. A coil is suspended in a uniform magnetic field with its plane parallel to the magnetic lines of force. When a current is passed through the coil, it starts oscillating and is very difficult to stop. But, if an aluminium plate is placed near to the coil, it stops. This is due to which of the following reason?

I. Development of air current when the plate is placed.
II. Shielding of magnetic lines f force as aluminium is a paramagnetic material.
III. Electromagnetic induction in the aluminium plate giving rise to electromagnetic damping.

(a) Only I
(b) Only III
(c) II and III
(d) All of these

Case Study

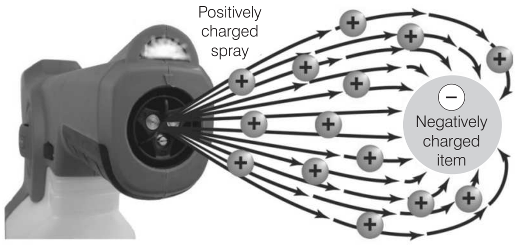
Read the following paragraph and answers the questions.

Electrostatic Painting

Electrostatic painting is the process of charging particles in paint to more efficiently paint a work piece.

It works on the basic properties of electric charges. Since, like charges repel, while unlike charges attract. Therefore, if we put a powerful electrical charge on atomised paint by passing the paint through a field of electrons and project it towards grounded object (or it has a neutral electrical condition). We will then have created an environment that results in a natural electrical attraction between electrons and neutrons. This results in more paint being applied to the target.

Painting with electrostatics leads to process improvements in painting operations, ranging from automotive and aerospace to various applications that involve solvent and water based-paints.



52. If the paint in the electrostatic sprayer is positively charged, it implies that

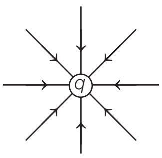
(a) there is only positive charge in the body

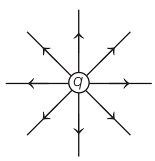
(b) there is positive as well as negative charge in the body but the positive charge is more than negative charge

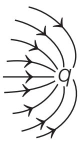
(c) there is equal positive and negative charges in the body but the positive charge lies in the outer region

(d) negative charge is displaced from its position

53. The field lines corresponding to the positive charges in the paint of electrostatic sprayer is

(a) 

(b) 

(c) 

(d) None of these

54. In a certain region of paint, instead of positive charges, there is 80 μC of negative charge. So, the number of additional electrons in it will be

(a) 5×10^{14} (b) 80×10^{-17} (c) 8×10^{-5} (d) 1.28×10^{-17}

55. Consider two charges 1C and –4C exists in air instead of paint, then the direction of force between them is

(a) away from 1C (b) away from –4 C (c) from 1C to –4 C (d) None of these

OMR SHEET

SP 5

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

Correct   Incorrect   Incorrect   Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	**20**	a	b	c	d	**38**	a	b	c	d
2	a	b	c	d	**21**	a	b	c	d	**39**	a	b	c	d
3	a	b	c	d	**22**	a	b	c	d	**40**	a	b	c	d
4	a	b	c	d	**23**	a	b	c	d	**41**	a	b	c	d
5	a	b	c	d	**24**	a	b	c	d	**42**	a	b	c	d
6	a	b	c	d	**25**	a	b	c	d	**43**	a	b	c	d
7	a	b	c	d	**26**	a	b	c	d	**44**	a	b	c	d
8	a	b	c	d	**27**	a	b	c	d	**45**	a	b	c	d
9	a	b	c	d	**28**	a	b	c	d	**46**	a	b	c	d
10	a	b	c	d	**29**	a	b	c	d	**47**	a	b	c	d
11	a	b	c	d	**30**	a	b	c	d	**48**	a	b	c	d
12	a	b	c	d	**31**	a	b	c	d	**49**	a	b	c	d
13	a	b	c	d	**32**	a	b	c	d	**50**	a	b	c	d
14	a	b	c	d	**33**	a	b	c	d	**51**	a	b	c	d
15	a	b	c	d	**34**	a	b	c	d	**52**	a	b	c	d
16	a	b	c	d	**35**	a	b	c	d	**53**	a	b	c	d
17	a	b	c	d	**36**	a	b	c	d	**54**	a	b	c	d
18	a	b	c	d	**37**	a	b	c	d	**55**	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ___________

Total Correct Questions: ___________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (d)	**2.** (a)	**3.** (a)	**4.** (a)	**5.** (c)	**6.** (d)	**7.** (a)	**8.** (d)	**9.** (c)	**10.** (c)
11. (d)	**12.** (a)	**13.** (c)	**14.** (d)	**15.** (a)	**16.** (c)	**17.** (a)	**18.** (d)	**19.** (a)	**20.** (b)
21. (d)	**22.** (c)	**23.** (a)	**24.** (d)	**25.** (d)	**26.** (d)	**27.** (b)	**28.** (a)	**29.** (d)	**30.** (a)
31. (d)	**32.** (c)	**33.** (c)	**34.** (c)	**35.** (d)	**36.** (d)	**37.** (c)	**38.** (c)	**39.** (c)	**40.** (c)
41. (b)	**42.** (b)	**43.** (a)	**44.** (d)	**45.** (d)	**46.** (b)	**47.** (a)	**48.** (d)	**49.** (b)	**50.** (c)
51. (b)	**52.** (b)	**53.** (b)	**54.** (a)	**55.** (c)					

SOLUTIONS

1. Electric flux through a surface does not depend on the shape, size or area of the surface but it depends on charges enclosed by it.

As there is same charge $+q$ present in all the given figures, so electric flux is same for all of them.

2. As, dielectric constant,

$$K = \frac{F_{\text{in air}}}{F_{\text{in medium}}}$$

$$K = \frac{F}{\frac{F}{2}} \Rightarrow K = 2$$

3. When capacitors are connected in series, then

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{3} + \frac{1}{9} + \frac{1}{18}$$

$$\frac{1}{C_S} = \frac{1}{2}$$

$$\Rightarrow \quad C_S = 2\ \mu\text{F}$$

When capacitors are connected in parallel, then

$$C_P = C_1 + C_2 + C_3 = 3 + 9 + 18 = 30\ \mu\text{F}$$

$$\therefore \quad \frac{C_S}{C_P} = \frac{2}{30} = \frac{1}{15}$$

4. Electric field lines are perpendicular to the equipotential surfaces and point in the direction of decreasing potential. So, at P, electric field **E** is to the left and at R, **E** is upward.

5. Electric field (**E**), electric displacement (**D**) and electric polarisation (**P**) are related as

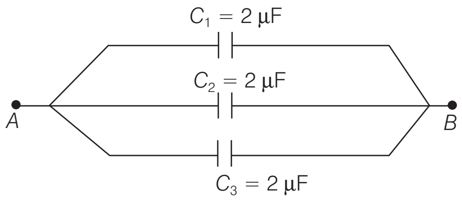
$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P} \qquad \ldots\text{(i)}$$

where, ε_0 is permittivity of free space.

From Eq. (i), it is clear that **D**, **E** and **P** are in same direction, i.e. they are mutually parallel to each other.

Hence, statement given in option (c) is correct but rest are incorrect.

6. The combination of capacitors can be redrawn as



So, the equivalent capacitance between points A and B,

$$C_{eq} = C_1 + C_2 + C_3$$
$$= 2 + 2 + 2 = 6\mu\text{F}$$

7. Resistance of wire is given as,

$$R = \frac{\rho l}{A} = \frac{\rho l^2}{V}$$

As, volume of the wire remains constant on stretching, so

$$\frac{\Delta R}{R} = 2\frac{\Delta l}{l} = +\ 0.2\%$$

8. Kirchhoff's first law or KCL states that, the algebraic sum of current meeting at any junction in a closed loop is equals to zero, i.e. $\Sigma i = 0$.

This law follows law of conservation of charge.

Kirchhoff's second law or KVL states that, algebraic sum of all the potential differences in any closed circuit is zero.

i.e. $\quad \Sigma V = 0 \Rightarrow \Sigma E = \Sigma iR$

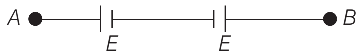
This law follows law of conservation of energy.

9. Current flowing in the wire, $i = nAev_d$

$\Rightarrow \quad v_d \propto \frac{1}{A} \propto \frac{1}{d^2}$, where d is the diameter of the wire.

If diameter of wire is $\frac{d}{4}$, then area will be $\frac{A}{16}$, so new drift velocity is $16\ v_d$.

10. Yes, when an identical battery is connected in opposition, i.e. in opposite order to a battery as shown below, then the potential difference between its two ends A and B is zero ($V_{net} = E - E = 0$).



But each one of the battery has a constant non-zero emf.

11. Potentiometer works on null deflection method. In balance condition, potentiometer does not draw any current from the circuit.

12. Resistance of the coil initially be R.

It is given as,

$$R = \rho \frac{l}{A}$$

$$\Rightarrow \quad R \propto l \quad \text{...(i)}$$

($\because \rho$ and A are constants)

When the coil is cut into two equal parts such that, $l_1 = l_2 = \frac{l}{2}$.

Now, resistance of each part of the coil $= \frac{R}{2}$.

(using Eq. (i))

Heat generated,

$$H_1 = \frac{V^2}{R} t \quad \text{and} \quad H_2 = \frac{V^2}{(R/2)} t$$

$$\therefore \quad \frac{H_2}{H_1} = 2 \quad \text{or} \quad H_2 = 2H_1$$

13. Given, area, $A = 2\,\text{mm}^2 = 2 \times 10^{-6}\,\text{m}^2$,

current, $I = 1\text{A}$ and $\sigma = 6.25 \times 10^7\,\text{Sm}^{-1}$

As, current density, $J = \frac{I}{A} = \sigma E$

Electric field, $E = \frac{I}{A\sigma} = \frac{1}{2 \times 10^{-6} \times 6.25 \times 10^7}$

$$= 8 \times 10^{-3}\,\text{Vm}^{-1}$$

14. When a charged particle is kept stationary or is at rest in a strong magnetic field, then no force acts on the charged particle. As, magnetic force is given as,

$$F = Bqv \sin\theta$$

Since, the particle is at rest, i.e. $v = 0$, so

$$F = 0$$

Hence, when an electron at rest is kept in a strong magnetic field, it will remain stationary at the same position.

15. In two galvanometers P and Q, to produce a deflection of 10 divisions, 3 mA and 6 mA currents are required. So, minimum current measured by $P \rightarrow 0.3$ mA / div and by $Q \rightarrow 0.6$ mA/div. Hence, P is more sensitive than Q.

16. Magnetic field intensity at the centre of a circular current carrying coil is given as

$$B = \frac{\mu_0 I}{2\pi a}$$

where, I is the current in coil and a is the radius of the coil.

$$\Rightarrow \quad B \propto \frac{1}{a}$$

$\therefore$ When a is doubled, B will be halved.

17. Given, $H = 0.46$ G

and $\delta = 30°$

As, $\tan\delta = \frac{V}{H} \Rightarrow V = H\tan\delta$

$$= 0.46 \tan 30° = \frac{0.46}{1.73} = 0.26$$

18. Lesser the number of field lines crossing per unit area, weaker is the magnitude of the magnetic field strength. Since, here point D lies in the region which has minimum number of field lines crossing per unit area. Hence, it lies in the region of least magnetic field strength.

19. An electron moving around the nucleus has a magnetic moment μ which is given by

$$\mu = \frac{e}{2m} L$$

where, L is the magnitude of the angular momentum of the circulating electron around the nucleus.

$$\Rightarrow \quad \mu \propto L$$

($\because e$ and m for an electron is constant)

So, magnetic moment increases with increase in L.

20. Given, mutual inductance of the coil,

$$M = 2.5\,\text{H},$$

Change in current in the coil, $dI = 10 - 0 = 10\,\text{A}$

Time taken, $dt = 0.5$ s

Induced emf in the coil, $|\varepsilon| = \frac{MdI}{dt} = \frac{d\phi}{dt}$

or $\quad d\phi = M \cdot dI = 2.5 \times 10 = 25$ Wb

21. When south-pole of a bar magnet is brought closer to the plane, induced current will oppose this, in accordance with Lenz law. So, south-pole will be formed in the conducting plane. Thus, the induced current will be anti-clockwise.

22. Given, $C = 20\mu F = 20 \times 10^{-6}$ F

and $L = 30 mH = 30 \times 10^{-3}$ H

Resonant angular frequency of oscillation of the circuit,

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{20 \times 10^{-6} \times 30 \times 10^{-3}}}$$
$$= \frac{1}{\sqrt{600 \times 10^{-9}}} = \frac{10^4}{\sqrt{60}}$$
$$= \frac{10^4}{7.745} = 0.129 \times 10^4 \text{ rad s}^{-1}$$

23. In an L-C circuit, when the circuit is open. The electrical energy stored in the charged capacitor is $U_E = \frac{1}{2}\frac{q^2}{C}$. Since, there is no current in the circuit, energy in the inductor is zero (i.e. $U_B = 0$). Thus, the total energy of L-C circuit is

$$U = U_E = \frac{1}{2}\frac{q^2}{C}$$

24. For capacitive circuit, $X_C = \frac{1}{\omega C}$

and $I = \frac{V}{X_C} = V\omega C \Rightarrow I \propto \omega$

Hence, graph given in option (d) is correct.

25. The emf generated would be maximum when flux would be maximum, i.e. angle between area vector of coil and magnetic field is 0°. The emf generated is given by (as a function of time)

$$e = NBA\omega \cos \omega t$$
$$\Rightarrow \quad e_{max} = NAB\omega$$
$$(\because \cos \omega t = \cos\theta = 1 \Rightarrow \theta = 0°)$$

26. Potential energy stored in a capacitor,

$$U = \frac{1}{2}\frac{Q^2}{C}$$

Work done, $W = \Delta U = U_f - U_i$

$$= \frac{1}{2}Q^2\left(\frac{1}{C_2} - \frac{1}{C_1}\right) \quad \ldots(i)$$

Here, $W = 2 \times 10^{-6}$ J

$Q = 5\mu C = 5 \times 10^{-6}$ C

$C_1 = 5\mu F = 5 \times 10^{-6}$ F

$C_2 = C\,\mu F$

Substituting the given values in Eq. (i), we get

$$2 \times 10^{-6} = \frac{1}{2} \times (5 \times 10^{-6})^2\left(\frac{1}{5 \times 10^{-6}} - \frac{1}{C}\right)$$
$$\Rightarrow \quad \frac{4 \times 10^{-6}}{25 \times 10^{-12}} = \frac{1}{5 \times 10^{-6}} - \frac{1}{C}$$
$$1.6 \times 10^5 = \frac{1}{5 \times 10^{-6}} - \frac{1}{C}$$

or
$$\frac{1}{C} = \frac{1}{5 \times 10^{-6}} - 1.6 \times 10^5$$
$$= \frac{1 - 0.8}{5 \times 10^{-6}} = \frac{0.2}{5 \times 10^{-6}}$$

or
$$C = 2.5 \times 10^{-5} \text{F}$$
$$= 0.25\mu\text{F}$$

So, the value of C is 0.25.

27. Given, energy of electron,

$$E = 2000 \text{ eV}$$
$$= 2000 \times 1.6 \times 10^{-19} \text{ J}$$
$$= 3.2 \times 10^{-16} \text{J}$$
$$B = 0.2 \text{ T}$$

As we know, $E = \frac{1}{2}mv^2$

$$\Rightarrow \quad v = \sqrt{\frac{2E}{m}} \quad \ldots(i)$$

Also, $Bev = \frac{mv^2}{r}$

$$\Rightarrow \quad r = \frac{mv}{Be} = \frac{m}{Be}\sqrt{\frac{2E}{m}} \quad \text{[from Eq. (i)]}$$
$$= \frac{\sqrt{2Em}}{Be}$$
$$r = \frac{\sqrt{2 \times 3.2 \times 10^{-16} \times 9 \times 10^{-31}}}{0.2 \times 1.6 \times 10^{-19}}$$
$$= 7.5 \times 10^{-4} \text{ m}$$

28. The mean squared voltage,

$$\overline{V}^2 = \frac{1}{t}\int_0^t V^2 dt$$
$$= \frac{1}{t}\int_0^t (V_0 t^{3/2})^2 dt$$
$$= \frac{V_0^2}{t}\left[\frac{t^4}{4}\right]_0^1 = \frac{V_0^2}{4}$$
$$V_{rms} = \sqrt{\overline{V}^2} = \frac{V_0}{2}$$

29. As we know, $\mathbf{F}_m \perp \mathbf{B}$

where $\mathbf{F}_m$ is magnetic force.

Since, acceleration ($\mathbf{a}$) is directly proportional to force.

$$\Rightarrow \quad \mathbf{a} \perp \mathbf{B} \text{ or } \mathbf{a} \cdot \mathbf{B} = 0$$

Here, $\mathbf{a} = (x\hat{\mathbf{i}} + 2\hat{\mathbf{j}})\text{ ms}^{-2}$

$$\mathbf{B} = (2\hat{\mathbf{i}} + 4\hat{\mathbf{j}}) \times 10^{-2} \text{ T}$$
$$\Rightarrow (x\hat{\mathbf{i}} + 2\hat{\mathbf{j}}) \cdot (2\hat{\mathbf{i}} + 4\hat{\mathbf{j}}) = 0$$
$$2x + 8 = 0$$

or
$$x = \frac{-8}{2} = -4$$

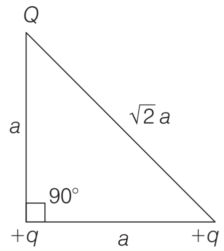
30. Equation, $|\mathbf{E}| = \dfrac{q_{\text{enc}}}{\varepsilon_0 \, |A|}$ gives $\int \mathbf{E} \cdot d\mathbf{A} = \dfrac{q_{\text{enc}}}{\varepsilon_0}$.

Now, in finding the electric field by above equation, the integral will be easy to evaluate, if $|\mathbf{E}|$ = constant. Also, if $|\mathbf{E}|$ = constant for the surface, then surface is equipotential.

31. Electrostatic energy between two charges q_1 and q_2 such that the distance between them is r is given as

$$U = \frac{K\,q_1 q_2}{r}$$

In accordance to the principle of superposition, total energy of the charge system as shown in the figure below



$$U = \frac{Kq^2}{a} + \frac{KQq}{a} + \frac{KQq}{\sqrt{2}a}$$

It is given that, $U = 0$

$$\therefore \quad \frac{Kq}{a}\left(q + Q + \frac{Q}{\sqrt{2}}\right) = 0$$

$$\Rightarrow \quad Q = \frac{-\sqrt{2} \times q}{(\sqrt{2} + 1)}$$

32. Resistance of an electric bulb, $R = \dfrac{V^2}{P}$.

Given, 100 W of power is consumed at 220 V.

$$\Rightarrow \quad R = \frac{(220)^2}{100} \quad \text{...... (i)}$$

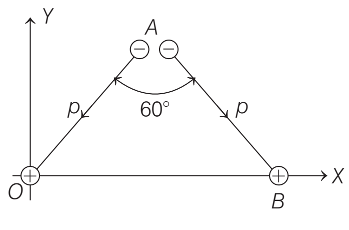
Now, power consumed at 110 V,

$$P_{\text{consumed}} = \frac{V^2}{R}$$

$$\Rightarrow \quad P_{\text{consumed}} = \frac{(110)^2}{(220)^2/100} \quad \text{[using Eq. (i)]}$$

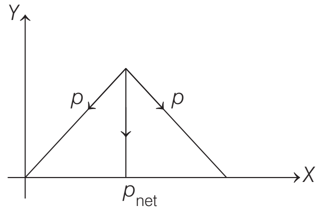
or $P_{\text{consumed}} = 25$ W

33. Given system is equivalent to two dipoles inclined at 60° to each other as shown in the figure below



Now, magnitude of resultant of these dipole moments is

$$p_{\text{net}} = \sqrt{p^2 + p^2 + 2\,p \cdot p\cos 60^\circ}$$
$$= \sqrt{3}p = \sqrt{3}ql$$



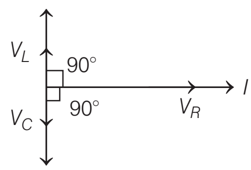
As, resultant is directed along negative Y-direction, so $p_{\text{net}} = -\sqrt{3}p\hat{\mathbf{j}} = -\sqrt{3}ql\,\hat{\mathbf{j}}$

34. In the circuit used to verify Ohm's law, the ammeter is connected in series as it measures the current through the resistor. While the voltmeter is connected in parallel as it measures the potential difference across the ends of resistor.

Hence, correct option is (c).

35. In an L-C-R series AC circuit, the voltage across inductor L leads the current by 90° and the voltage across capacitor C lags behind the current by 90°. So, for L-C combination,

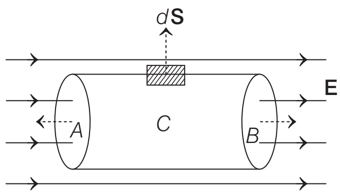
$$V = V_L - V_C = 50 - 50 = 0$$



Hence, the voltage across L-C combination will be zero.

36. Flux through surfaces A and B, $\phi_A = E \times \pi R^2$

and $\quad \phi_B = -E \times \pi R^2$



Flux through curved surface C

$$= \int \mathbf{E} \cdot d\,\mathbf{S} = \int EdS\cos 90^\circ = 0$$

$\therefore$ Total flux through cylinder

$$= \phi_A + \phi_B + \phi_C = 0$$

37. Here, $\tan\delta_1 = \dfrac{V}{H\cos\theta}$

$$\tan\delta_2 = \frac{V}{H\cos(90^\circ - \theta)} = \frac{V}{H\sin\theta}$$

$$\therefore \quad \frac{\tan\delta_1}{\tan\delta_2} = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

or $\quad \theta = \tan^{-1}\left(\frac{\tan\delta_1}{\tan\delta_2}\right)$

38. Current density, $J = \frac{I}{\pi a^2}$

From Ampere's circuital law,

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 \cdot I_{\text{enclosed}}$$

For a long cylindrical shaped wire,

When $r < a$,

$$B \times 2\pi r = \mu_0 \times J \times \pi r^2$$

$$\Rightarrow \quad B = \frac{\mu_0 I}{\pi a^2} \times \frac{r}{2}$$

$$\therefore \text{ At } r = \frac{a}{2}, \; B_1 = \frac{\mu_0 I}{4\pi a}$$

For $r > a$, $B \times 2\pi r = \mu_0 I \Rightarrow B = \frac{\mu_0 I}{2\pi r}$

At $r = 2a$, $B_2 = \frac{\mu_0 I}{4\pi a} \quad \therefore \frac{B_1}{B_2} = 1$

39. In the condition of resonance,

$$X_L = X_C \text{ or } \omega L = \frac{1}{\omega C}$$

Since, resonance frequency remains unchanged, so

$$\sqrt{LC} = \text{constant or } LC = \text{constant}$$

$$\therefore \quad L_1C_1 = L_2C_2$$

or $L \times C = L_2 \times 2C$

or $\quad L_2 = L/2$

40. Mutual inductance for a co-axial solenoid of radius r_1 and r_2 and number of turns n_1 and n_2, respectively is given as,

$M = \mu_0 n_1 n_2 \pi r_1^2 l$ (for inner coil of radius r_1)

Self-inductance for the inner coil,

$$L = \mu_0 n_1^2 \pi r_1^2 l$$

$$\therefore \quad \frac{M}{L} = \frac{n_1 n_2}{n_1^2} = \frac{n_2}{n_1}$$

41. Induced current, $I = \frac{|e|}{R}$

$$= \left(\frac{d\phi}{dt}\right) \cdot \frac{1}{R}$$

$$\Rightarrow \quad d\phi = IRdt$$

$$\phi = \int IRdt$$

where, R is constant.

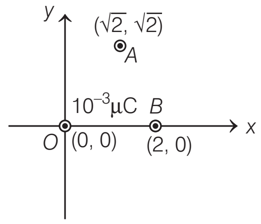
$$\Rightarrow \quad \phi = R\int Idt$$

As, $\int I \cdot dt$ = area under I-t graph

$$= \frac{1}{2} \times 10 \times 0.5 = 2.5$$

$$\therefore \quad \phi = R \times 2.5 = 100 \times 2.5 = 250 \text{ Wb}$$

42. Potential at A due to charge at O,



$$V_A = \frac{1}{4\pi\varepsilon_0} \frac{(10^{-3})}{OA}$$

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{(10^{-3})}{\sqrt{(\sqrt{2})^2 + (\sqrt{2})^2}}$$

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{(10^{-3})}{2}$$

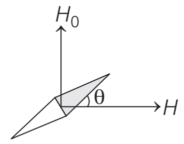
Potential at B due to charge at O,

$$V_B = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(10^{-3})}{OB} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(10^{-3})}{2}$$

So, $V_A - V_B = 0$

43. In given case, H and H_0 are perpendicular to each other.

From figure, $\tan\theta = \frac{H_0}{H}$



$$\Rightarrow \quad \theta = \tan^{-1}\left(\frac{H_0}{H}\right)$$

44. The instantaneous value of emf and current in inductive circuit are given by $E = E_0 \sin\omega t$ and $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$, respectively.

So, $\quad P_{\text{inst}} = EI$

$$= E_0 \sin\omega t \times I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= E_0 I_0 \sin\omega t \left(\sin\omega t \cos\frac{\pi}{2} - \cos\omega t \sin\frac{\pi}{2}\right)$$

$$= E_0 I_0 \sin\omega t \cos\omega t$$

$$= \frac{1}{2} E_0 I_0 \sin 2\omega t$$

$$(\because \sin 2\omega t = 2\sin\omega t \cos\omega t)$$

Hence, angular frequency of instantaneous power is 2ω.

45. At the surface of a charged conductor, electrostatic field must be normal to the surface at every point.

Also, electrostatic field at the surface of a charged conductor is non-zero and is equals to $\left(\frac{\sigma}{\varepsilon_0}\right)$.

Therefore, A is false and R is also false.

46. Self-induction is the phenomenon of induction of emf in a single isolated coil due to change of flux through the coil by means of varying the current in the same coil.

In this case, flux linkage through the coil of N-turns is proportional to the current through the coil and is expressed as

$$N\phi_B \propto I \text{ or } N\phi_B = LI$$

where, constant of proportionality is called the coefficient of self-induction of the coil.

The self-induced emf is also called the back emf, as it opposes any change in the current in a circuit. Thus, self-inductance plays the role of inertia.

Therefore, both A and R are true but R is not the correct explanation of A.

47. When values of E and B are equal, total force on the charged particle is zero and it will move in the fields undeflected, i.e

$$qE = qvB \text{ or } v = \frac{E}{B}$$

This condition can be used to select charged particles of a particular velocity out of a beam.

Thus, the crossed E and B fields, serve as a velocity selector.

In this condition of velocity selector, the charged particle passes straight, without any deviation.

Therefore, both A and R are true and R is the correct explanation of A.

48. In a series connection of capacitors, charge on each capacitor remains same and equals to the main charge supplied by the battery, but potential difference across each capacitor is different.

However, in parallel connection, potential across each capacitor remains same. Also, the capacitance of a capacitor is dependent only on its geometrical configuration and is independent of the charge on it.

Therefore, A is false and R is also false.

49. When a capacitor is connected to DC source, capacitive reactance

$$X_C = \frac{1}{\omega C} = \frac{1}{0} = \infty$$

$(\because \text{for DC}, \omega = 2\pi f = 0, \text{ as } f = 0)$

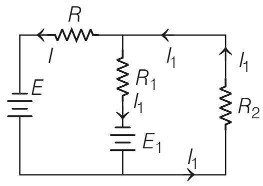
Thus, capacitor blocks DC and acts as an open circuit.

When a capacitor is fully charged, no current flows in the circuit. As, capacitor voltage is equals to the source voltage at that instance.

Therefore, both A and R are true but R is not the correct explanation of A .

50. Current through resistance R will be zero.

i.e. $I = 0$



$$\Rightarrow \quad \frac{E}{R_2} = \frac{E_1}{R_1 + R_2}$$

or $$E_1 = \frac{E(R_1 + R_2)}{R_2}$$

51. According to Lenz's law, electromagnetic induction takes place in the aluminium plate due to which eddy current is developed which oppose the motion or vibrations of coil.

This causes loss in energy which results in damping of oscillatory motion of the coil.

52. In general, a body always remains neutral. So, if the paint is said to be positively charged, it means there is positive as well as negative charge in the paint but the positive charge is more than negative charge.

53. Electric field lines always begin from a positive charge and end on a negative charge. They do not start or stop in mid-space.

Thus, the field lines for the positive charges in paint is correctly depicted in option (b).

54. As, $q = Ne$ or $N = \frac{q}{e}$

$\therefore$ Number of electrons,

$$N = \frac{80 \times 10^{-6}}{1.6 \times 10^{-19}} = 5 \times 10^{14}$$

55. Since, the given charges are of opposite polarity. So, the force will be attractive. Thus, the force directs from 1C to –4 C.

SAMPLE PAPER 6

PHYSICS

*A Highly Simulated Practice Questions Paper for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

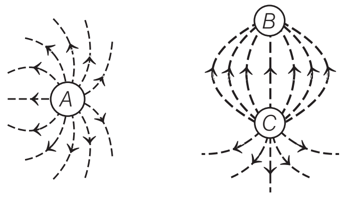
Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

Section A

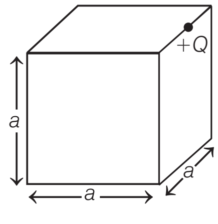
This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. The following figure shows the electric field lines around three point charges A, B and C. Which charge has the largest magnitude?



(a) Charge A (b) Charge B (c) Charges A and B (d) Charge C

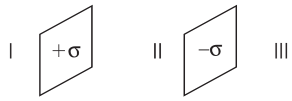
2. In the figure shown below, $+Q$ charge is located at one of the edge of the cube. Then, electric flux through cube due to $+Q$ charge is



(a) $\frac{+Q}{\varepsilon_0}$ (b) $\frac{+Q}{2\varepsilon_0}$ (c) $\frac{+Q}{4\varepsilon_0}$ (d) $\frac{+Q}{8\varepsilon_0}$

3. For a given surface, the Gauss's, theorem is stated as $\oint \mathbf{E} \cdot d\mathbf{S} = 0$. From this, which of the following observations can be concluded?
(a) E is necessarily zero on the surface
(b) E is perpendicular to the surface at every point
(c) the total flux through the surface is zero
(d) the flux is only going out to the surface

4. A system consists of two large thin metal plates held parallel and close to each other as shown in figure.



The electric field in region II is 3×10^{-10} N/C. The value of surface density (in magnitude) is
(a) 26.5×10^{-23} Cm^{-2} (b) 2.65×10^{-22} Cm^{-2} (c) 26.65×10^{-22} Cm^{-2} (d) 2.65×10^{-21} Cm^{-2}

5. Two capacitors C_1 and C_2 are charged to 120 V and 200 V, respectively. It is found that by connecting them together, the potential on each one of them can be made zero. Then,
(a) $5C_1 = 3C_2$ (b) $3C_1 = 5C_2$ (c) $3C_1 \pm 5C_2 = 0$ (d) $9C_1 = 4C_2$

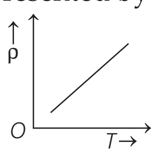
6. The amount of energy released by a capacitor is 10 J. If the charge stored in it is 0.1 C, then the potential difference across it the capacitor will be
(a) 1 V (b) 0.1 V (c) 10 V (d) 200 V

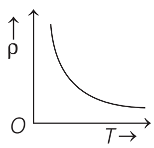
7. A hollow metal sphere of radius 5 cm is charged, such that the potential on its surface becomes 90 V. The potential at the centre of the sphere, will be
(a) greater than 90 V (b) smaller than 90 V
(c) same as 90 V (d) zero

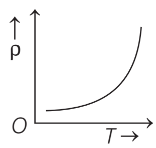
8. Out of two copper spheres of the same size, x is hollow while y is solid. If they are charged to the same potential, then which of the following statement(s) is/are correct about the charges on them?
(a) Charge on both the spheres is zero. (b) Charge on both the spheres is equal.
(c) Sphere y will have more charge. (d) Sphere x will have more charge.

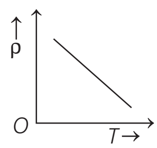
9. A cell of emf E is connected in series with an external resistance R. If potential difference across cell is V_0, the value of internal resistance is
(a) $\left(\frac{V_0 - E}{E}\right) R$ (b) $\left(\frac{V_0 - E}{V_0}\right) R$ (c) $\left(\frac{E - V_0}{E}\right) R$ (d) $\left(\frac{E - V_0}{V_0}\right) R$

10. With the increase in temperature (T), variation of resistivity (ρ) of a semiconductor is represented by

(a) 

(b) 

(c) 

(d) 

11. Two wires of the same dimensions but resistivities ρ_1 and ρ_2 respectively, are connected in series. The equivalent resistivity (ρ) of the combination is
(a) $\frac{\rho_1 + \rho_2}{2}$ (b) $\rho_1 + \rho_2$ (c) $2(\rho_1 + \rho_2)$ (d) $\sqrt{\rho_1 \rho_2}$

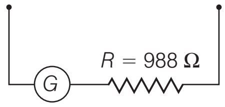
12. Electric field and current density are related as

(a) $\mathbf{J} \propto \mathbf{E}$ (b) $\mathbf{E} \propto \mathbf{J}^2$ (c) $\mathbf{E} \propto \frac{1}{\mathbf{J}^2}$ (d) $\mathbf{E}^2 \propto \frac{1}{\mathbf{J}}$

13. In a Wheatstone bridge, three resistors P, Q and R are connected in three arms in order and 4th arm is formed by two resistors S_1 and S_2 which are connected in parallel. The condition for bridge to be balanced is $\frac{P}{Q} =$

(a) $\frac{R(S_1 + S_2)}{S_1 S_2}$ (b) $\frac{S_1 S_2}{R(S_1 + S_2)}$ (c) $\frac{RS_1 S_2}{(S_1 + S_2)}$ (d) $\frac{(S_1 + S_2)}{R S_1 S_2}$

14. A voltmeter is constructed by using a galvanometer of resistance 12 Ω and produces maximum deflection for the current of 2mA. If the resistance in series is 988 Ω, then the potential which a voltmeter can measure in the following circuit will be



(a) 0 V (b) 2 V (c) 20 V (d) 10 V

15. The magnetic force **F** acting on a charged particle moving with some velocity **v** in magnetic field **B** can be expressed in the vector form as

(a) $\mathbf{F} = \mathbf{v}(\mathbf{B} \times q)$ (b) $\mathbf{F} = q(\mathbf{v} \cdot \mathbf{B})$ (c) $\mathbf{F} = \mathbf{B}(q \times \mathbf{v})$ (d) $\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$

16. In a moving coil galvanometer, the deflection (ϕ) on the scale by a pointer attached to the spring is

(a) $\left(\frac{NA}{kB}\right)i$ (b) $\left(\frac{NAB}{i}\right)k$ (c) $\left(\frac{NAB}{k}\right)i$ (d) $\left(\frac{NB}{ki}\right)A$

17. Two identical particles traversing in circular path in an uniform field with radii in the ratio of 3 : 2, then the ratio of their velocities is

(a) 4 : 9 (b) 3 : 2 (c) 9 : 4 (d) 2 : 3

18. The magnetic field produced by a current element at a distance of 1 m in perpendicular direction is 5×10^{-8} T. The element is of length 0.05 m and is placed at origin. So, the value of current in it is

(a) 1 A (b) 10 A (c) 100 A (d) zero

19. A closely wound solenoid of 800 turns and area of cross-section 2.5×10^{-4} m^2 carries a current of x A. Magnetic moment associated with it is 0.6 A-m^2. So, the value of x is

(a) 1 (b) 2 (c) 3 (d) zero

20. Two concentric different loops lie on the same plane. The current in the inner loop is clockwise and is a function of time. The induced current in the outer loop is

(a) zero (b) counter-clockwise

(c) in the direction that depends on the ratio of loops radii

(d) clockwise

21. A coil of resistance R and inductance L is connected to a battery of emf E. The final current in the coil is

(a) $\frac{E}{R}$ (b) $\frac{E}{L}$ (c) $\sqrt{\left(\frac{E}{R^2 + L^2}\right)}$ (d) $\sqrt{\left(\frac{EL}{R^2 + L^2}\right)}$

22. For a step-up transformer, which of the following statament(s) is/are true?

(a) The number of turns in secondary coil (N_s) is greater than the number of turns in primary coil (N_p).

(b) The number of turns in primary coil (N_p) is greater than the number of turns in secondary coil (N_s).

(c) The number of turns in secondary coil (N_s) is equal to the number of turns in primary coil (N_p).

(d) The number of turns in primary coil (N_p) is two times the number of turns in secondary coil (N_s).

23. The angular frequency of free oscillations of L-C circuit is 1.1×10^3 rad s^{-1}. If a 27 mH inductor is connected with a charged capacitor, its capacitance is

(a) 10 μF (b) 20 μF (c) 40 μF (d) 30 μF

24. An inductor of inductive reactance $18.85\,\Omega$ is connected to a 220 V, 100 Hz AC source. The inductance is

(a) 3 mH (b) 300 mH (c) 30 mH (d) 30 H

25. The output of a step-down transformer is measured to be V volts, when connected to a P watt light bulb. The value of peak current is $(I_0/\sqrt{2})$ A, so P is equals to

(a) (VI_0) W (b) $\left(\frac{VI_0}{\sqrt{2}}\right)$ W (c) $\left(\frac{VI_0}{2}\right)$ W (d) $(\sqrt{2}\,VI_0)$ W

Section B

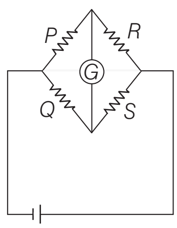
This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. A parallel plate capacitor is initially charged and then is isolated. The effect of increasing the plate separation on charge, potential and capacitance respectively are

(a) constant, decrease, increase (b) constant, decrease, decrease

(c) constant, increase, decrease (d) increase, decrease, decrease

27. In a Wheatstone bridge, $P = 2\,\Omega$, $Q = 2\,\Omega$, $R = 2\,\Omega$ and $S = 3\,\Omega$. The resistance with which S is to be shunted in order that the bridge may be balanced, is



(a) 4 Ω (b) 1 Ω

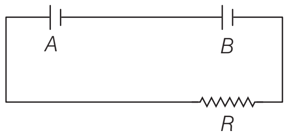
(c) 6 Ω (d) 2 Ω

28. The electric charges are distributed in a small volume. The flux of the electric field through a spherical surface of radius 10 cm surrounding the total charge is 20 V-m. The flux over a concentric sphere of radius 20 cm will be

(a) 20 V-m (b) 25 V-m

(c) 40 V-m (d) 200 V-m

29. Two batteries A and B whose emf is 2V are connected in series with external resistance $R = 1\ \Omega$. Internal resistance of battery A is $1.9\ \Omega$ and that of B is $0.9\ \Omega$. Potential difference across the battery A will be



(a) 2 V (b) 3.8 V
(c) zero (d) None of these

30. A parallel plate condenser with a dielectric of dielectric constant K between the plates has a capacity C and is charged to a potential V. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is

(a) $\frac{1}{2}(K-1)CV^2$ (b) $CV^2(K-1)/K$
(c) $(K-1)CV^2$ (d) zero

31. A series R-C circuit is connected to an AC voltage source. Consider two cases; Case A when C is without a dielectric medium and Case B when C is filled with dielectric of constant 4. The current I_R through the resistor and voltage V_C across the capacitor are compared in the two cases. Which of the following is/are true?

(a) $I_R^A > I_R^B$ (b) $I_R^A < I_R^B$
(c) $V_C^A > V_C^B$ (d) $V_C^A < V_C^B$

32. An additional charge of $-6\mu C$ is given to two point charges $+3\mu C$ and $+4\mu C$, which repel each other initially with same force F. The new force between them becomes 5 N, then the value of F is

(a) 1 N (b) 10 N (c) 100 N (d) 0 N

33. A circular coil, having 100 turns of wire, of radius 10 cm lie in a plane. The magnetic field at the point $20\sqrt{3}$ cm away from axial line, when coil carries a current of $(4/\pi)$ A is

(a) 17×10^6 T (b) 1.7×10^{-6} T
(c) 1.7×10^{-5} T (d) 17×10^5 T

34. In potentiometer experiment, null point is obtained at a particular point for a cell on potentiometer wire at x cm. If the length of the potentiometer wire is increased without changing the cell, the balancing length will (driving source is not changed)

(a) increase (b) decrease
(c) not change (d) become zero

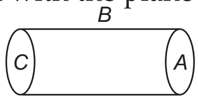
35. A fully charged capacitor C with initial charge q_0 is connected to a coil of self-inductance L at $t = 0$. The time at which the energy is stored equally between the electric and magnetic fields is

(a) $\frac{\pi}{4}\sqrt{LC}$ (b) $2\pi\sqrt{LC}$
(c) $\sqrt{LC}$ (d) $\pi\sqrt{LC}$

36. All the edges of a block with parallel faces are unequal. Its longest edge is twice its shortest edge, then ratio of the maximum and minimum resistances between parallel faces is

(a) 8 (b) 4 (c) 2 (d) None of these

37. A hollow cylinder has a charge q C within it. If ϕ is the electric flux associated with the curved surface B, the flux linked with the plane surface A (in V-m) will be



(a) $\frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$ (b) $\frac{q}{2\varepsilon_0}$ (c) $\frac{\phi}{3}$ (d) $\frac{q}{\varepsilon_0} - \phi$

38. A wire has resistance of 10 Ω. If it is stretched by (1/10)th of its length, then its resistance is nearly

(a) 9 Ω (b) 10 Ω (c) 11 Ω (d) 12 Ω

39. A very small circular loop of radius a is initially (at $t = 0$) co-planar and concentric with a much larger fixed circular loop of radius b. A constant current I flows in the larger loop. The smaller loop is rotated with a constant angular speed ω about the common diameter. The emf induced in the smaller loop as a function of time t is

(a) $\frac{\pi a^2 \mu_0 I}{2b} \omega \cos \omega t$ (b) $\frac{\pi a^2 \mu_0 I}{2b} \omega \sin \omega^2 t^2$

(c) $\frac{\pi a^2 \mu_0 I}{2b} \omega \sin \omega t$ (d) $\frac{\pi a^2 \mu_0 I}{2b} \omega \sin^2 \omega t$

40. Identify the incorrect statement.

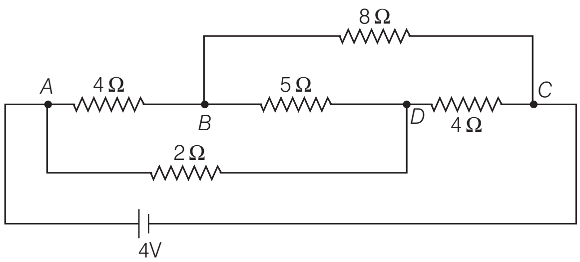
(a) The electrical potential energy of a system of two protons shall increase, if the separation between the two is decreased.
(b) The electrical potential energy of a proton-electron system will increase, if the separation between the two is decreased.
(c) The electrical potential energy of a proton-electron system will increase, if the separation between the two is increased.
(d) The electrical potential energy of a system of two electrons shall increase, if the separation between the two is decreased.

41. A 2 m long metallic rod rotates with some angular frequency about an axis normal to the rod passing through its one end. The other end of the rod is in contact with a circular metallic ring. A constant magnetic field of 0.5 T parallel to the axis exists everywhere. If the emf developed between the centre and the ring is 200 V, then angular frequency will be

(a) 20 rad s^{-1} (b) 200 rad s^{-1}

(c) zero (d) 2.0 rad s^{-1}

42. The value of current drawn from the battery by the network of resistors as shown, is

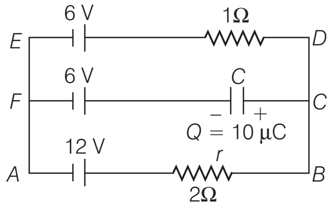


(a) zero (b) 2A

(c) 4A (d) 1A

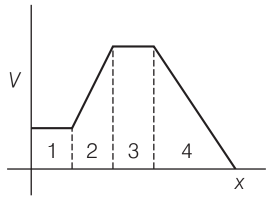
SAMPLE PAPER 6

43. In the given circuit, with the steady current, the capacitance of a capacitor will be



(a) 1 μF (b) 2 μF (c) 3 μF (d) 5 μF

44. The figure shows electric potential V as a function of x. Rank the four regions according to the magnitude of x-component of the electric field E within them with greatest first.



(a) $E_4 > E_2 > E_3 > E_1$
(b) $E_4 > E_1 = E_3 > E_2$
(c) $E_1 > E_2 > E_3 > E_4$
(d) $E_1 = E_3 > E_2 > E_4$

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. Assertion An electric field line pattern can include an infinite number of field lines, but two electric field lines can never intersect each other.

Reason The tangent drawn at the point of intersection of two field lines gives different directions of electric field.

46. Assertion Long distance transmission of AC is carried out at extremely low voltages to reduce energy dissipation.

Reason For long distance transmission, thin wires are used.

47. Assertion Magnetic field lines will be circular, if the current is flowing through a straight wire.

Reason According to Fleming's left hand rule, the direction of force is parallel to the magnetic field.

48. Assertion Gauss's law of electrostatics is applicable for any closed surface independent of its size and shape.

Reason For long straight charged wire, electric field is inversely proportional to the square of distance from the wire.

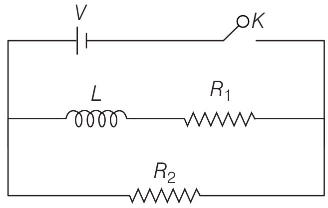
49. **Assertion** Two identical heaters are connected to two different sources one DC and other AC having same potential difference across their terminals. The heat produced in heater supplied with AC source is greater.

Reason The net impedance of an AC source is greater than resistance.

Section C

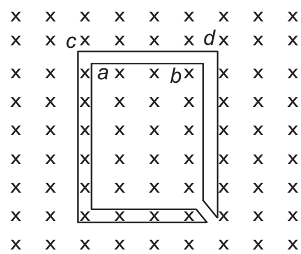
This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. In the circuit shown below, the key K is closed at $t = 0$. The current through the battery is



(a) $\dfrac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at $t=0$ and $\dfrac{V}{R_2}$ at $t=\infty$
(b) $\dfrac{V}{R_2}$ at $t=0$ and $\dfrac{V(R_1+R_2)}{R_1R_2}$ at $t=\infty$
(c) $\dfrac{V}{R_2}$ at $t=0$ and $\dfrac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at $t=\infty$
(d) $\dfrac{V(R_1+R_2)}{R_1R_2}$ at $t=0$ and $\dfrac{V}{R_2}$ at $t=\infty$

51. The figure shows certain wire segments joined together to form a co-planar loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time and I_1 & I_2 are the currents in the segments *ab* and *cd*.



I. I_1 is less than I_2.
II. I_1 is in the direction *ba* and I_2 is in the direction *cd*.
III. I_1 is in the direction *ab* and I_2 is in the direction *dc*.

Which of the following statement(s) is/are correct?

(a) Only I (b) Only II (c) Only III (d) Both I and III

Case Study

Read the following paragraph and answer the questions.

Magnets

A magnet is a material or object that produces a magnetic field. This magnetic field is invisible but is responsible for the most notable property of a magnet which is a force that pulls on other ferromagnetic materials, such as iron, steel, nickel, cobalt, etc., and attracts or repels other magnets. An everyday example is a refrigerator magnet used to hold notes on a refrigerator door.

Magnet's magnetic moment (also called **magnetic dipole moment** and usually denoted by *m*) is a vector that characterises the magnet's overall magnetic properties.

For a bar magnet, the direction of the magnetic moment points from the magnet's south-pole to its north-pole and the magnitude relates to how strong and how far apart these poles are.

52. A magnetic dipole which is the arrangement of two magnetic poles of equal and opposite strength separated by some distance is placed in a uniform magnetic field. The net magnetic force on the dipole

(a) is always zero
(b) depends on the orientation of the dipole
(c) can never be zero
(d) depends on the strength of the dipole

53. **Statement I** Two lines of force due to a bar magnet intersect each other at a point near the pole.

Statement II Two lines of force due to magnet intersect each other at neutral points.

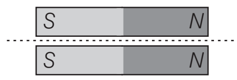
Which of the following statement(s) is/are correct?

(a) Only I (b) Only II
(c) Both I and II (d) None of these

54. The ultimate individual unit of magnetism in any magnet is a

(a) north-pole (b) south-pole
(c) dipole (d) quadrupole

55. A magnet of magnetic moment M and pole strength m is divided in two equal parts shown below, then magnetic moment of each part will be



(a) M (b) $M/2$ (c) $M/4$ (d) $2M$

OMR SHEET

SP 6

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

  Correct Incorrect Incorrect Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	**20**	a	b	c	d	**38**	a	b	c	d
2	a	b	c	d	**21**	a	b	c	d	**39**	a	b	c	d
3	a	b	c	d	**22**	a	b	c	d	**40**	a	b	c	d
4	a	b	c	d	**23**	a	b	c	d	**41**	a	b	c	d
5	a	b	c	d	**24**	a	b	c	d	**42**	a	b	c	d
6	a	b	c	d	**25**	a	b	c	d	**43**	a	b	c	d
7	a	b	c	d	**26**	a	b	c	d	**44**	a	b	c	d
8	a	b	c	d	**27**	a	b	c	d	**45**	a	b	c	d
9	a	b	c	d	**28**	a	b	c	d	**46**	a	b	c	d
10	a	b	c	d	**29**	a	b	c	d	**47**	a	b	c	d
11	a	b	c	d	**30**	a	b	c	d	**48**	a	b	c	d
12	a	b	c	d	**31**	a	b	c	d	**49**	a	b	c	d
13	a	b	c	d	**32**	a	b	c	d	**50**	a	b	c	d
14	a	b	c	d	**33**	a	b	c	d	**51**	a	b	c	d
15	a	b	c	d	**34**	a	b	c	d	**52**	a	b	c	d
16	a	b	c	d	**35**	a	b	c	d	**53**	a	b	c	d
17	a	b	c	d	**36**	a	b	c	d	**54**	a	b	c	d
18	a	b	c	d	**37**	a	b	c	d	**55**	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (d)	**2.** (c)	**3.** (c)	**4.** (d)	**5.** (c)	**6.** (d)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (b)
11. (a)	**12.** (a)	**13.** (a)	**14.** (b)	**15.** (d)	**16.** (c)	**17.** (b)	**18.** (b)	**19.** (c)	**20.** (b)
21. (a)	**22.** (a)	**23.** (d)	**24.** (c)	**25.** (c)	**26.** (c)	**27.** (c)	**28.** (a)	**29.** (c)	**30.** (d)
31. (b)	**32.** (b)	**33.** (c)	**34.** (a)	**35.** (a)	**36.** (b)	**37.** (a)	**38.** (d)	**39.** (c)	**40.** (b)
41. (b)	**42.** (d)	**43.** (d)	**44.** (b)	**45.** (a)	**46.** (d)	**47.** (c)	**48.** (c)	**49.** (a)	**50.** (b)
51. (c)	**52.** (a)	**53.** (d)	**54.** (c)	**55.** (b)					

SOLUTIONS

1. As, maximum number of field lines are associated with charge C. So, it has the largest magnitude.

2. Since, electric lines of force passes only through the four faces of cube. So electric flux in accordance with Gauss' law is given by

$$\phi = \frac{1}{4}\left(\frac{q_{\text{enclosed}}}{\varepsilon_0}\right) = \frac{+Q}{4\varepsilon_0}$$

3. According to Gauss's, law, net flux over any closed surface is $\frac{1}{\varepsilon_0}$ times the net charge enclosed within the surface. i.e.

$$\phi_E = \oint \mathbf{E}\cdot d\mathbf{S} = \frac{q_{\text{enclosed}}}{\varepsilon_0}$$

Here, $\oint \mathbf{E}\cdot d\mathbf{S} = 0$

This means, the net flux through the surface is zero.

4. Electric field in the region II between the plates is given by

$$E = \frac{\sigma}{\varepsilon_0}$$

$$\Rightarrow \quad \sigma = E\varepsilon_0 = 3\times 10^{-10} \times 8.85 \times 10^{-12}$$

$$\Rightarrow \quad \sigma = 2.65 \times 10^{-21}\ \text{Cm}^{-2}$$

5. Potential on each capacitor can be made zero, if $q_{\text{net}} = 0$.

$$\Rightarrow \quad q_1 \pm q_2 = 0$$

$$\Rightarrow 120\,C_1 \pm 200\,C_2 = 0 \qquad [\because q = CV]$$

$$\Rightarrow \quad 3C_1 \pm 5C_2 = 0$$

6. Given, $U = 10$ J, $q = 0.1$ C

Energy stored, $U = \frac{1}{2}qV$

$$\Rightarrow \quad 10 = \frac{1}{2}\times 0.1 \times V$$

$$\Rightarrow \quad V = \frac{2\times 10}{0.1} = 200\text{V}$$

7. Electric field at the centre of a charged hollow sphere,

$$E_{\text{inside}} = 0$$

As, $E = \frac{-dV}{dr}$, where V is potential.

$$\Rightarrow \quad \frac{dV}{dr} = 0$$

or $V = \text{constant} = 90$ V

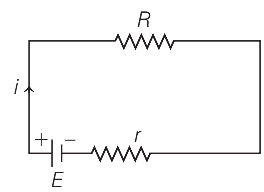
8. For a charged sphere,

Potential, $V_s = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$

Since, V_s and r is same for both spheres.

Hence, charge on both the spheres will be equal.

9. The circuit diagram is as shown below



Current drawn from cell, $i = \frac{E}{R+r}$ … (i)

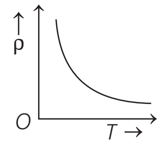
From Ohm's law, $V_0 = iR$

$$\Rightarrow \quad i = \frac{V_0}{R} \qquad \text{… (ii)}$$

From Eqs. (i) and (ii), we get

$$\frac{E}{R+r} = \frac{V_0}{R} \Rightarrow r = \left(\frac{E - V_0}{V_0}\right)R$$

10. The resistivity of a semiconductor decreases with increase in temperature exponentially as shown in figure



11. The effective resistance of combined wire,

$$R = R_1 + R_2$$

$$\Rightarrow \rho\left(\frac{l+l}{A}\right) = \frac{\rho_1 l}{A} + \frac{\rho_2 l}{A}$$

[$\because$ total length, $L = l + l$]

or $$\rho = \frac{\rho_1 + \rho_2}{2}$$

12. Current density is related to electric field as

$$\mathbf{J} = \sigma\ \mathbf{E} = \frac{\mathbf{E}}{\rho}$$

$$\Rightarrow \mathbf{J} \propto \mathbf{E}$$

13. Balanced condition for Wheatstone bridge,

$$\frac{P}{Q} = \frac{R}{S} \quad \text{...(i)}$$

where, $$\frac{1}{S} = \frac{1}{S_1} + \frac{1}{S_2}$$

$$\Rightarrow S = \frac{S_1 S_2}{S_1 + S_2} \quad \text{...(ii)}$$

From Eqs. (i) and (ii), we get

$$\frac{P}{Q} = \frac{R(S_1 + S_2)}{S_1 S_2}$$

14. Given, $R_G = 12\ \Omega$, $R = 988\,\Omega$

$$I_G = 2\,\text{mA} = 2 \times 10^{-3}\ \text{A}$$

$$\therefore R = \frac{V}{I_G} - R_G$$

$$(R + R_G)\, I_G = V$$

$$\Rightarrow V = (988 + 12) \times 2 \times 10^{-3}$$

$$\Rightarrow V = 2\text{V}$$

15. Magnetic force **F** acting on a charged particle having charge q and moving with some velocity **v** in the magnetic field **B** is given by

$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B}) \quad \text{[in vector form]}$$

16. Torque on the coil of galvanometer,

$$\tau = NiAB$$

This torque is balanced by counter torque.

$$\therefore k\phi = NiAB \quad \text{or} \quad \phi = \left(\frac{NAB}{k}\right) i$$

where, k is torsional constant.

17. Radius of the circular path in magnetic field is given as

$$r = \frac{mv}{Bq}$$

As, the particles are identical.

$$\therefore m_1 = m_2 \text{ and } q_1 = q_2$$

Since, B is same for both particles.

$$\Rightarrow r \propto v \Rightarrow \frac{r_1}{r_2} = \frac{v_1}{v_2}$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{3}{2}$$

18. Magnetic field due to straight current carrying elements,

$$dB = \frac{\mu_0}{4\pi} \frac{Idl \sin\theta}{r^2}$$

Given, $dB = 5 \times 10^{-8}$ T, $dl = 0.05$ m,

$r = 1$ m

and $\sin\theta = \sin 90° = 1$

$$\therefore 5 \times 10^{-8} = \frac{10^{-7} \times I \times 0.05 \times 1}{(1)^2}$$

$$\Rightarrow I = \frac{5 \times 10^{-8}}{0.05 \times 10^{-7}} = 10\ \text{A}$$

19. The magnetic moment of current carrying loop having N turns, $M = NIA$

Substituting the given values, we get

$$0.6 = 800 \times I \times 2.5 \times 10^{-4}$$

$$I = \frac{0.6}{800 \times 2.5 \times 10^{-4}} = 3\text{A}$$

20. According to Lenz's law, the induced current is in the direction such that it opposes the change due to which it is produced. So, induced current in the outer loop will be in counter-clockwise direction.

21. In steady state, inductor will not provide any hindrance to the current and the circuit works as a simple DC circuit with only resistor.

Therefore, $i = \frac{E}{R}$.

22. In a step-up transformer, number of turns in primary coil (N_p) is less than the number of turns in secondary coil (N_s).

i.e. $N_s > N_p$

23. Given, $L = 27$ mH $= 27 \times 10^{-3}$H

$$\omega = 1.1 \times 10^3 \text{ rad s}^{-1}$$

$$\therefore \omega = \frac{1}{\sqrt{LC}}$$

$$\Rightarrow C = \frac{1}{\omega^2 L} \Rightarrow C = \frac{1}{(1.1 \times 10^3)^2 \times 27 \times 10^{-3}}$$

$$\Rightarrow C \simeq 30\,\mu\text{F}$$

24. Given, $X_L = 18.85\ \Omega$

$V_{\text{rms}} = 220$ V, $\nu = 100$ Hz

Inductive reactance, $X_L = 2\pi\nu L$

$$\Rightarrow 18.85 = 2 \times 3.14 \times 100 \times L$$

$$\Rightarrow L = 30 \times 10^{-3}\ \text{H} = 30\ \text{mH}$$

25. Given, $V_s = V$ and $I_0' = (I_0/\sqrt{2})$ A

Peak current, $I_0' = I_s\sqrt{2}$

$\Rightarrow \quad I_s = \dfrac{I_0'}{\sqrt{2}} = \dfrac{I_0}{2}$ A

$\therefore$ Power, $P_s = P = V_s I_s = \dfrac{VI_0}{2}$ W

26. As, separation between the plates d increases, charge remains constant. However,

Potential, $V = E \cdot d$, so it increases.

Capacitance, $C = \dfrac{\varepsilon_0 A}{d}$, so it decreases.

27. Given, $P = 2\,\Omega$, $Q = 2\,\Omega$, $R = 2\,\Omega$ and $S = 3\,\Omega$

Let, S is to be shunted by using a resistance of x.

So, according to the Wheatstone bridge, for balanced condition,

$$\frac{P}{Q} = \frac{R}{S} = \frac{R}{\frac{S \times x}{S + x}}$$

$$\frac{2}{2} = \frac{2}{\frac{3 \times x}{3 + x}} \Rightarrow 1 = \frac{(3 + x)2}{3x}$$

$\Rightarrow \quad 3x = 6 + 2x$

$\Rightarrow \quad 3x - 2x = 6$

$\Rightarrow \quad x = 6\,\Omega$

28. According to Gauss' theorem, electric flux,

$$\phi_E = \oint_s \mathbf{E} \cdot d\mathbf{S} = \frac{1}{\varepsilon_0}(q)$$

i.e. The flux linked with a closed body is independent of its shape and size. So, electric flux remains constant.

Hence, $\phi_E = 20$ V-m.

29. Total resistance, $R = 1.9 + 0.9 + 1 = 3.8\,\Omega$

Total emf, $E = 2 + 2 = 4$ V

$\therefore \quad E = iR$

$\Rightarrow \quad i = \dfrac{E}{R} = \dfrac{4}{3.8}$ A

Potential difference across the battery A,

$$V_A = E - irA$$
$$= 2 - \frac{4}{3.8} \times 1.9 = 0$$

30. On introduction and removal and again on introduction, the capacity and potential remain same. So, net work done by the system in this process,

$$W = U_f - U_i$$
$$= \frac{1}{2}CV^2 - \frac{1}{2}CV^2 = 0$$

31. Impedance, $Z = \sqrt{R^2 + X_C^2}$

$$= \sqrt{(R)^2 + \left(\frac{1}{\omega C}\right)^2}$$

With the introduction of the dielectric, the capacitance of the capacitor increases.

$\therefore$ In Case (B), capacitance C will be more while potential remains same. Therefore, impedance Z will be less. Hence, current will be more.

i.e. $\quad I_R^A < I_R^B$

32. Given, $q_1 = +3\mu C$, $q_2 = +4\mu C$

$$q_1' = +3 - 6 = -3\,\mu C$$
$$q_2' = +4 - 6 = -2\mu C$$

As, we know, $F = \dfrac{kq_1q_2}{r^2}$

Since, k and r are constants.

$$\Rightarrow \quad \frac{F'}{F} = \frac{(q_1')(q_2')}{q_1\, q_2}$$
$$= \frac{(-3) \times (-2)}{3 \times 4} = \frac{6}{12} = \frac{1}{2}$$

$\Rightarrow \quad F = 2F'$

$\Rightarrow \quad F = 2 \times 5\text{N} = 10$ N

33. Given, $N = 100$

$$R = 10 \text{ cm} = 10 \times 10^{-2}\text{m} = 0.1 \text{ m}$$
$$i = (4/\pi) \text{ A}$$
$$r = 20\sqrt{3} \text{ cm} = 20\sqrt{3} \times 10^{-2}\text{m}$$
$$= 0.2\sqrt{3} \text{ m}$$

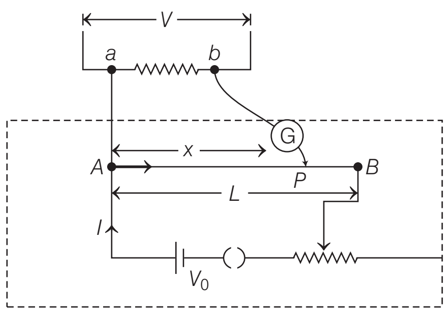
$\therefore$ Magnetic field at the axial point,

$$B = \frac{\mu_0 i R^2 N}{2(R^2 + r^2)^{3/2}}$$

$$\Rightarrow \quad B = \frac{4\pi \times 10^{-7} \times (4/\pi) \times 0.1 \times 0.1 \times 100}{2[(0.1)^2 + (0.2\sqrt{3})^2]^{3/2}}$$

$$= 1.7 \times 10^{-5}\text{T}$$

34. According to question, the functioning of potentiometer can be understood by the following diagram



Balancing length x is given by

$$\frac{x}{L} = \frac{V}{V_0}$$

$$\Rightarrow \quad x = \frac{V \times L}{V_0}$$

where, V = potential to be measured,
V_0 = potential difference across potentiometer wire
and L = length of potentiometer wire.

Since, $x \propto L$

So, if length of potentiometer wire is increased without changing the cell, the balancing length also increases.

35. As, initially, charge is maximum.

$$q = q_0 \cos\omega t$$

$$\Rightarrow \quad i = \frac{dq}{dt} = -\omega q_0 \sin \omega t$$

Given, $U_B = U_E$

$$\Rightarrow \quad \frac{1}{2} Li^2 = \frac{q^2}{2C}$$

$$\Rightarrow \quad \frac{1}{2} L(-\omega q_0 \sin \omega t)^2 = \frac{(q_0 \cos \omega t)^2}{2\,C}$$

$$\Rightarrow \quad \frac{\sin\omega t}{\cos\omega t} = \frac{1}{\sqrt{LC}\,\omega}$$

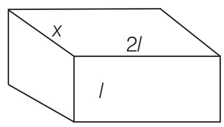
As, $\omega = \dfrac{1}{\sqrt{LC}}$

$$\therefore \quad \tan \omega t = 1$$

$$\Rightarrow \quad \tan \omega t = \tan \frac{\pi}{4}$$

$$\Rightarrow \quad t = \frac{\pi}{4\omega} = \frac{\pi}{4}\sqrt{LC}$$

36. Let the lengths of various edges in increasing order be l, x and 2l, respectively.



Maximum resistance, $R_{\max} = \dfrac{\rho 2l}{xl} = \dfrac{2\rho}{x}$

and minimum resistance,

$$R_{\min} = \frac{\rho l}{2\,lx} = \frac{\rho}{2x}$$

$$\therefore \quad \frac{R_{\max}}{R_{\min}} = \frac{2}{1/2} = 4$$

37. Gauss' theorem states that, the net electric flux through any closed surface is equal to the net charge inside the surface divided by ε_0.

i.e. $\quad \phi_{\text{total}} = \dfrac{q}{\varepsilon_0}$

Let electric flux linked with surfaces A, B and C be ϕ_A, ϕ_B and ϕ_C respectively. i.e.

$$\phi_{\text{total}} = \phi_A + \phi_B + \phi_C$$

Since, $\quad \phi_C = \phi_A$

$$\therefore \quad 2\phi_A + \phi_B = \phi_{\text{total}} = \frac{q}{\varepsilon_0}$$

or $\quad \phi_A = \dfrac{1}{2}\left(\dfrac{q}{\varepsilon_0} - \phi_B\right)$

But $\quad \phi_B = \phi \quad$ (given)

Hence, $\quad \phi_A = \dfrac{1}{2}\left(\dfrac{q}{\varepsilon_0} - \phi\right)$

38. Resistance of wire, $R = \rho l / A = 10\Omega$,

New length, $l_1 = l + l/10 = 11l/10$

$\therefore$ New area, $A_1 = Al/l_1 = \dfrac{10\,A}{11}$

$\therefore$ New resistance,

$$R_1 = \rho l_1 / A_1 = \rho\,(11l/10)\,/\,(10/11)\,A$$

$$= \frac{121\,\rho l}{100\,A} = \frac{121}{100} \times 10 \simeq 12\ \Omega$$

39. We know that, $e = NBA\,\omega \sin \omega t$

where, N = number of loops (= 1)

$$B = \frac{\mu_0 I}{2b}\,T$$

and $\quad A = \pi a^2\ \text{m}^2$

$$\therefore \quad e = \frac{\mu_0 I}{2b}(\pi a^2)\,\omega \sin \omega t$$

$$\Rightarrow \quad e = \frac{\pi a^2 \mu_0 I}{2b} \cdot \omega \sin \omega t$$

40. Potential energy, $U = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r}$

or $\quad U \propto \dfrac{1}{r}$

When r decreases, U increases and *vice-versa*. Moreover, potential energy as well as force are positive, if there is repulsion between the particles and negative, if there is attraction.

Hence, for proton-electron system, if r is decreased, then U will also decrease.

41. Here, $\varepsilon = 200$ V, $B = 0.5$ T

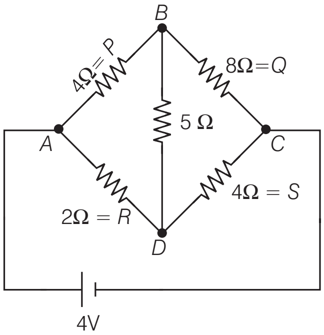
$l = 2$ m

EMF developed between centre and the ring,

$$\varepsilon = Blv = \frac{1}{2}\omega B l^2$$

or $\quad \omega = \dfrac{2\varepsilon}{Bl^2} = \dfrac{2 \times 200}{0.5 \times (2)^2} \Rightarrow \omega = 200\ \text{rad s}^{-1}$

42. Rearrangement of circuit diagram is as shown below



It forms a Wheatstone's bridge.

$$\therefore \quad \frac{P}{Q} = \frac{R}{S} \Rightarrow \frac{4}{8} = \frac{2}{4} = \frac{1}{2}$$

So, there is no current flow through BD due to balanced condition of Wheatstone bridge.

$\therefore$ Net resistance,

$$\frac{1}{R_{\text{net}}} = \frac{1}{P+R} + \frac{1}{Q+S}$$

$$\frac{1}{R_{\text{net}}} = \frac{1}{6} + \frac{1}{12} \Rightarrow R_{\text{net}} = 4\Omega$$

$$\Rightarrow \quad i = \frac{V}{R_{\text{net}}} = \frac{4}{4} = 1\text{ A}$$

43. In steady state, no current will pass through the capacitor.

In loop $AEDBA$,

Current, $I = \frac{V}{R} = \frac{12-6}{1+2} = 2\text{ A}$

Also, $V_{ED} = V_{FC}$

$$V_E - V_D = V_F - V_C$$

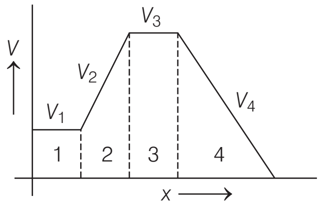
$$\Rightarrow 6 - 2 \times 1 = 6 - V_C$$

$$\Rightarrow \quad V_C = 2\text{ V}$$

Charge on capacitor, $Q = CV_C$

$$\Rightarrow \quad C = \frac{Q}{V_C} = \frac{10}{2} = 5\,\mu\text{F}$$

44. Various voltages in four regions are shown below



Electric field, $E = -\frac{dV}{dx}$

For I region, V_1 = constant

$$\therefore \quad \frac{dV_1}{dx} = 0$$

$$\therefore \quad E_1 = 0$$

For II region, $V_2 = + f(x)$

$$\therefore \quad E_2 = -\frac{dV_2}{dx} = -\text{ ve}$$

For III region, V_3 = constant

$$\therefore \quad \frac{dV_3}{dx} = 0 \Rightarrow E_3 = 0$$

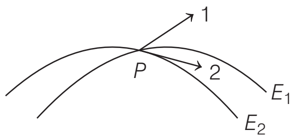
For IV region, $V_1 = - f(x)$

$$\therefore \quad E_4 = -\frac{dV_4}{dx} = +\text{ ve}$$

From these values, we have

$$E_4 > E_1 = E_3 > E_2$$

45. When two electric lines of force intersect each other, then at the point of intersection, if tangent is drawn, it gives two different directions of electric field as shown below, which is not possible.



Therefore, both A and R are true and R is the correct explanation of A.

46. The transmission of AC is done at high voltage to reduce current flowing through the wire is reduced. Due to this, corresponding dissipation of energy is also reduced.

If the transmission is done at low voltage, then we have to use thick wire in order to reduce the dissipation of energy which is practically not feasible.

Therefore, A is false and R is also false.

47. When current is flowing lines through a straight wire, the magnetic field lines is produced around it, is in the form of concentric circles.

According to Fleming's left hand rule, thumb points in the direction of force (F) which is perpendicular to both the direction of magnetic field and the direction of current.

Therefore, A is true, but R is false.

48. According to Gauss's law, the surface integral of the electric field intensity over any closed surface (Gaussian surface) in free space is equal to $\frac{1}{\varepsilon_0}$ times the net charge enclosed within the surface. This law is applicable for any closed surface, no matter what its shape or size be.

Electric field due to long straight charged wire at a distance r is

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

$$\Rightarrow \quad E \propto \frac{1}{r}$$

Therefore, A is true, but R is false.

49. In the case of DC, the frequency is zero and the net impedence is equal to the resistance. In the case of AC, the impedance of the AC circuit is given by

$$Z = \sqrt{R^2 + \omega^2 L^2}$$

where, R = resistance, ω = angular frequency and L = inductance.

As, $Z > R$, so the heat ($H \propto R$) produced in case of AC source is greater.

Therefore, both A and R are true and R is the correct explanation of A.

50. At $t = 0$, inductor behaves like an infinite resistance.

So, at $t = 0$, $\quad i = \dfrac{V}{R_2}$

and at $t = \infty$, inductor behaves like a conducting wire.

$$\therefore \quad i = \frac{V}{R_{eq}} = \frac{V(R_1 + R_2)}{R_1 R_2}$$

51. Since, magnetic field passing through the closed loop is increasing, therefore from Lenz's law, induced current will be produced in such a direction which opposes the cause of effect.

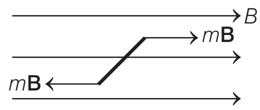
Hence, induced current will be anti-clockwise.

So, the induced magnetic field will be out of the plane of the figure.

Thus, I_1 is in the direction of ab and I_2 is in the direction of dc.

52. Net force on a dipole in uniform field will always be zero.

i.e. $\quad F = mB - mB = 0$



53. Magnetic field lines do not intersect each other. Because if they intersect, then the direction of the magnetic field would not be unique at the intersection which is impossible .

Hence, both statements I and II are incorrect.

54. Since, magnetic monopoles, i.e. separately north and south-poles do not exist, but they always exist in a pair. So, a pair of magnetic poles, i.e. north and south-poles separated by a distance in any magnet is called dipole.

Thus, the ultimate individual unit of magnetism in any magnet is dipole.

55. If a magnet is cut along the axis of length l, then new pole strength,

$$m' = \frac{m}{2}$$

$\therefore$ New magnetic moment,

$$M' = \frac{m}{2} \times 2l = \frac{m2l}{2} = \frac{M}{2}$$

SAMPLE PAPER 7

PHYSICS

A Highly Simulated Practice Questions Paper
*for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. Considering a spherical gaussian surface enclosing a point charge. If the radius of the surface becomes double, then the electric flux will

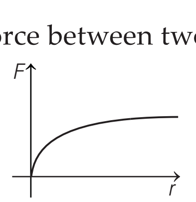
(a) get increased (b) remain the same (c) get decreased (d) Both (a) and (c)

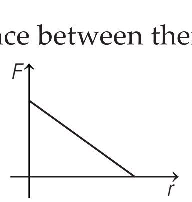
2. When a torque acting on an electric dipole kept in an uniform electric field is zero, then the orientation of dipole is

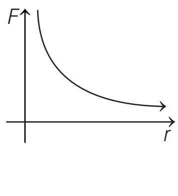
(a) $\frac{\pi}{2}$, for unstable equilibrium (b) zero, for stable equilibrium

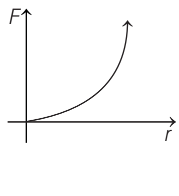
(c) $\frac{\pi}{3}$, for stable equilibrium (d) Cannot be determined

3. Force between two charges varies with distance between them as

(a)


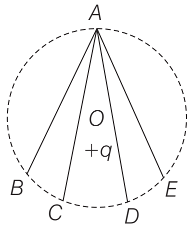
(b)


(c)


(d)


4. The electric field in a certain region is acting radially outward and is given by $E = Aa$. A charge contained in a sphere of radius a centred at the origin of the field will be
(a) $4\pi\varepsilon_0 Aa^2$ (b) $A\varepsilon_0 a^2$ (c) $4\pi\varepsilon_0 Aa^3$ (d) $\varepsilon_0 Aa^3$

5. In the electric field of a point charge q, a certain charge is carried from point A to B, C, D and E. Then, the work done



(a) is least along the path AB
(b) is least along the path AD
(c) is zero along all the paths AB, AC, AD and AE
(d) is least along AE

6. Kinetic energy of an electron accelerated in a potential difference of 100 V is
(a) 1.6×10^{-17} J (b) 1.6×10^{21} J (c) 1.6×10^{-29} J (d) 1.6×10^{-34} J

7. If there are n capacitors in parallel connected to V volt source, then the energy stored is equal to
(a) nCV^2 (b) $\frac{1}{2}nCV^2$
(c) $\frac{CV^2}{n}$ (d) $\frac{1}{2n}CV^2$

8. Dielectric constant of pure water is 81. Its permittivity will be
(a) 7.16×10^{-10} MKS units (b) 8.86×10^{-12} MKS units
(c) 1.02×10^{13} MKS units (d) Cannot be calculated

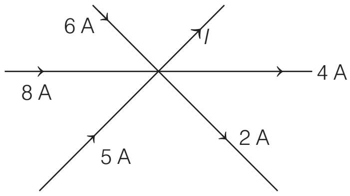
9. Across a metallic conductor of non-uniform cross-section, a constant potential difference is applied. The quantity which remains constant along the conductor is
(a) current density (b) current
(c) drift velocity (d) electric field

10. When a wire is stretched uniformly 8 times its original length, the new resistance is 640 Ω. The value of initial resistance is
(a) 10 Ω (b) 100 Ω (c) 1Ω (d) 0 Ω

11. Three identical cells each of emf 9V and internal resistance 1Ω are connected in series to the resistor of 6Ω. The value of current in the circuit is
(a) 1 A (b) 2 A (c) 3 A (d) 0 A

12. Choose the correct option for which Ohm's law is valid.
(a) For metallic conductors at low temperature
(b) For metallic conductors at high temperature
(c) For electrolytes when current passes through them
(d) All of the above

13. In the figure given below, the value of current I will be



(a) 3 A (b) 10 A (c) 13 A (d) 5 A

14. Which of the following statement (s) is/are correct?

(a) Moving charges or currents produce a magnetic field in the surrounding space.
(b) The electric field can convey energy and momentum and is established instantaneously.
(c) The magnetic field of several sources is the arithmetic addition of magnetic field of each individual source.
(d) The Lorentz force depends on q, **v** and **B**. Force on a negative charge is same as that on a positive charge.

15. A current loop in a magnetic field

(a) experiences a torque, whether the field is uniform or non-uniform in all orientations
(b) can be in equilibrium in one orientation
(c) can be equilibrium in two orientations, both the equilibrium states are unstable
(d) can be in equilibrium in two orientations, one stable, while the other is unstable

16. The angle of dip at a certain place is 45°, then the ratio of horizontal and vertical components of earth's magnetic field is

(a) 1:1 (b) 1:2 (c) 2:1 (d) 3:2

17. The net magnetic flux passing through a hypothetical closed surface enclosing a bar magnet is (in magnitude only)

(a) 1 (b) less than 1 (c) greater than 1 (d) zero

18. The induced emf in a coil of 10 H inductance in which current varies from 9 A to 4 A in 0.2 s is

(a) 200 V (b) 250 V (c) 300 V (d) 350 V

19. Oscillating metallic pendulum directed perpendicular to the plane of oscillation slows down due to

(a) eddy currents in a uniform magnetic field
(b) induced current in a uniform electric field
(c) electric current in a uniform electric field
(d) None of the above

20. The mutual inductance between the two coils X and Y is 0.4 H. If the change in magnetic flux occuring in coil Y is 1.2 Wb, then the change in current occuring in coil X is

(a) 3A (b) 2A (c) 1A (d) 0A

21. Electrical energy is transmitted over large distances at high alternating voltages. Which of the following statement(s) is/are incorrect?

(a) For a given power level, there is a lower current.
(b) Lower current implies less power loss.
(c) Transmission lines can be made thinner.
(d) It is easy to reduce the voltage at the receiving end, using step-down transformers.

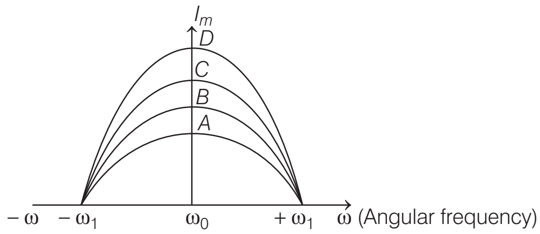
22. An AC generator consists of coil of 100 turns and cross-sectional area of $3 m^2$. It rotates with a constant angular speed of 60 rad s^{-1} in a uniform magnetic field 0.04 T. The maximum emf produced in the coil will be

(a) 700 V (b) 720 V (c) 600 V (d) 72 V

23. An alternating voltage is given by $V = 140 \sin 314t$ is connected across a resistor. If the rms value of current through the resistor is 1.98 A, the value of resistance will be

(a) 5Ω (b) 500Ω (c) 10Ω (d) 50Ω

24. The graphs shown below, depict the variation of current I_m *versus* angular frequency ω for four different *L-C-R* circuits. The graph which has maximum quality factor is



(a) *A* (b) *B*
(c) *C* (d) *D*

25. Which of the following statement(s) is/are incorrect?

(a) If the resonance is less sharp, the tuning of the circuit will not be good.
(b) Less sharp the resonance, less is the selectivity of the circuit or *vice-versa.*
(c) If quality factor is large, i.e. *R* is low or *L* is large, the circuit is more selective.
(d) Larger the value of *Q*, the larger is the value of $2\Delta\omega$ or the bandwidth and sharper is the resonance.

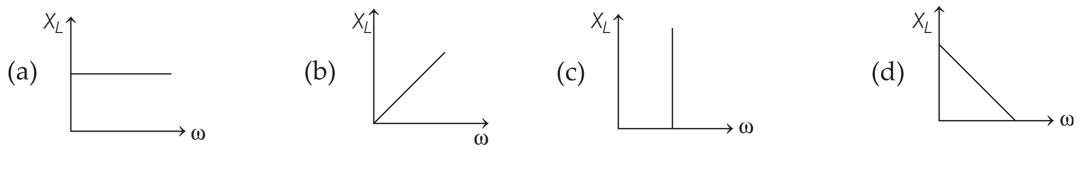
Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

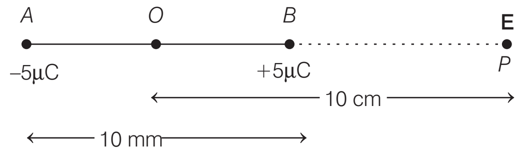
26. Which of the following statement(s) is/are incorrect?

(a) The vector product makes the force due to magnetic field vanish (become zero), if velocity and magnetic field are parallel or anti-parallel.
(b) The magnetic force is zero, if charge is not moving (as then $|v| = 0$).
(c) The magnitude of magnetic field **B** is 1 SI unit, when the force acting on a unit charge (1 C) moving parallel to **B** with a speed of 1 m/s is one newton.
(d) In the presence of an external magnetic field **B**, the force on mobile charge carriers is $F = (n/A)qv_d \times B$.

27. Which of the following graphs represents the correct variation of inductive reactance X_L with angular frequency ω?



28. In the figure given below, two charges +5μC and –5μC are kept at 10 mm apart. The electric field at point *P*, on the axis of the dipole, 10 cm away from its centre *O* on the side of positive charge is

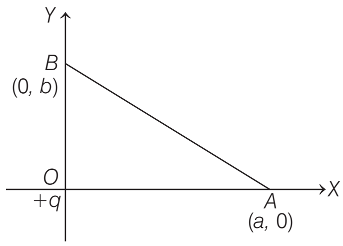


(a) 3×10^5 N/C (b) 8×10^5 N/C (c) 9×10^5 N/C (d) 4×10^5 N/C

29. A 60 W load is connected to the secondary coil of an ideal transformer whose primary coil draws line voltage. If the current in the primary coil is 0.27 A, then the current in the load will be (Take, $V_s = 111$ V and $V_p = 220$ V)

(a) 0.2 A (b) 0.3 A (c) 0.6 A (d) 0.54 A

30. A charge $+q$ is placed at origin *O* in *XY*-plane. The net work done in taking a charge *Q* from *B* to *A* along the straight line *AB* (as shown) is

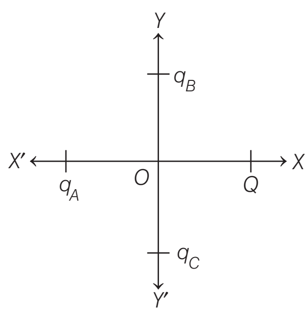


(a) $\frac{Qq}{4\pi\varepsilon_0}\left(\frac{b-a}{ab}\right)$ (b) $\frac{Qq}{4\pi\varepsilon_0}\left(\frac{a-b}{ab}\right)$ (c) $\frac{Qq}{4\pi\varepsilon_0}\left(\frac{ab}{b-a}\right)$ (d) zero

31. An electron in a H-atom circles around the proton with a speed of 2.18×10^6 m/s. If the radius of orbit is 5.3×10^{-11} m, then equivalent current will be

(a) 0.5×10^{-3} A (b) 1.1×10^{-3} A
(c) 2.1×10^{-3} A (d) 4×10^{-3} A

32. In the given figure, two positive charges q_B and q_C fixed along the *Y*-axis, exert a net electric force on a charge q_A fixed along *X*-axis in the $+x$-direction. The net force on q_A will



(a) increase, if a positive charge *Q* is added at $(x, 0)$
(b) increase, if a negative charge $-Q$ is added at $(x, 0)$
(c) does not increase, if a positive charge is added on *X*-axis
(d) remains the same, if any charge is added

33. The area of coil changes from 201 cm^2 to 200 cm^2 in a magnetic field of 0.05 T. If the amount of charge that flows through the coil is 2.5×10^{-6} C, then the resistance is

(a) 2 Ω (b) 4.5 Ω (c) 4 Ω (d) 2.5 Ω

34. A parallel plate air capacitor of capacitance C_0 is first connected to a cell of emf V and then disconnected from it. A dielectric slab of dielectric constant K, which can just fill the air gap of the capacitor, is now inserted in it.

Which of the following statement is incorrect about the result?

(a) The potential difference between the plates decreases K times.

(b) The energy stored in the capacitor decreases K times.

(c) The change in energy is $\frac{1}{2} C_0 V^2 (K-1)$.

(d) The change in energy is $\frac{1}{2} C_0 V^2 \left(\frac{1}{K} - 1\right)$.

35. Two long conductors separated by a distance d, carrying currents I_1 and I_2 in same direction. They exert a force F on each other. The current in one of them is three times the other and its direction is reversed. If the distance is increased to $3d$, the new force between the two conductors will be

(a) $-\frac{F}{2}$ (b) $\frac{-F}{3}$ (c) $-F$ (d) zero

36. A deuteron of kinetic energy 50 keV is moving in a circular orbit of radius 0.5 m. It is in a plane perpendicular to the magnetic field **B**. The kinetic energy of the proton follows a circular orbit of

(a) same radius and same **B** inside, is 125 keV

(b) different radius and same **B** inside, is 10 keV

(c) same radius and same **B** inside, is 100 keV

(d) different radius and different **B** outside, is zero

37. Which of the following statement(s) is/are incorrect?

(a) A transformer using the principle of mutual induction, change (or transform) an alternating voltage from one to another of greater or smaller value.

(b) If the transformer is assumed to be 100% efficient (no energy losses), the power input is less than the power output.

(c) If $N_s > N_p$ the voltage is stepped up ($V_s \geq V_p$). This type of arrangement is called a step-up transformer. However, $I_s < I_p$.

(d) If $N_s < N_p$, we have a step-down transformer. In this case, $V_s < V_p$ and $I_s > I_p$.

38. A uniform electric field having a magnitude E_0 and direction along the positive X-axis exists. If the potential V is zero at $x = 0$, then its value at $X = +x$ will be

(a) $+xE_0$ (b) $-xE_0$

(c) $+x^2 E_0$ (d) $-x^2 E_0$

39. A coil of self-inductance L is connected in series with a bulb B and an AC source. Brightness of the bulb decreases, when

(a) frequency of the AC source is decreased

(b) number of turns in the coil is reduced

(c) a capacitance of reactance $X_C = X_L$ is included in the same circuit

(d) an iron rod is inserted in the coil

40. An AC source is connected with a resistance R and an uncharged capacitance C in series. The potential difference across the resistor is in phase with the initial potential difference across the capacitor for the first time at the instant (assume that, at $t = 0$, emf is zero)

(a) $\frac{\pi}{4\omega}$ (b) $\frac{2\pi}{\omega}$

(c) $\frac{\pi}{2\omega}$ (d) $\frac{3\pi}{2\omega}$

41. Charge passing through a conductor of cross-section area $A = 0.3\ m^2$ is given by $q = 3t^2 + 5t + 2$ in coulomb, where t is in second. What is the value of drift velocity at $t = 2$ s? (Take, $n = 2 \times 10^{25}/m^3$)

(a) 0.77×10^{-5} m/s (b) 1.77×10^{-5} m/s

(c) 2.08×10^{5} m/s (d) 0.57×10^{5} m/s

42. An ionised gas contains both positive and negative ions. If it is subjected simultaneously to an electric field along the $+x$-direction and a magnetic field along the $+z$-direction, then

(a) positive ions deflect towards $+y$-direction and negative ions towards $-y$-direction

(b) all ions deflect towards $+y$-direction

(c) all ions deflect towards $-y$-direction

(d) positive ions deflect towards $-y$-direction and negative ions towards $+y$-direction

43. Two bulbs consume same energy operating at 200 V and 300 V respectively, when these are connected in series across a DC source of 500 V. Then, which of the following statement is correct?

(a) Ratio of potential difference across them is 3/2.

(b) Ratio of potential difference across them is 4/9.

(c) Ratio of power produced in them is 2/3.

(d) Ratio of power produced in them is 1/3.

44. A 100 Ω resistance and a capacitor of 100 Ω reactance are connected in series across a 220 V source. When the capacitor is 50% charged, the peak value of the current is

(a) 2.2 A (b) 11 A

(c) 4.4 A (d) $11\sqrt{2}$ A

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

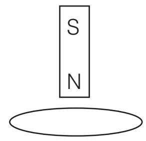
(c) A is true, but R is false.

(d) A is false and R is also false.

45. Assertion Considering a system of three charges, the force of attraction or repulsion between the two charges is independent of third charge.

Reason Force on a point charge is the vector sum of all the forces acting by other charges on that particular charge.

46. **Assertion** A magnet is dropped along the axis of a circular conducting loop as shown in figure, then acceleration of magnet is always less than g.



Reason When magnet is above the loop, then it will repel the magnet and when it is below the loop, then it will attract the magnet.

47. **Assertion** In potentiometer experiment, null point cannot be obtained if emf of unknown battery is more than the emf of known battery.

Reason By increasing the emf of known battery, null point length increases.

48. **Assertion** The induced emf and current will be same in two identical loops of copper and aluminium, when rotated with same speed in the same magnetic field.

Reason Induced emf is inversely proportional to rate of change of magnetic field while induced current depends on resistance of wire.

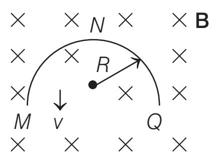
49. **Assertion** A ring of radius R carries a uniformly distributed charge $+Q$. A point charge $-q$ is placed on the axis of the ring at a distance $2R$ from the centre of the ring and released from rest. The particle will then execute SHM.

Reason When $2R$ is very large, then only the particle will execute SHM.

Section C

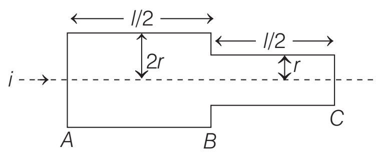
This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. A thin semi-circular conducting ring of radius R is falling with its plane vertical in a horizontal magnetic induction **B** as shown in figure. At the position MNQ, the speed of the ring is v. The potential difference developed across the ring is



(a) zero
(b) $\frac{1}{2} Bv\pi R^2$, M is at a higher potential
(c) πRBv, Q is at a higher potential
(d) $2RBv$, Q is at a higher potential

51. Two bars of radii r and $2r$ are kept in contact as shown. An electric current i is passed through the bars. Which of the following statement(s) is/are correct?



SAMPLE PAPER 7

I. Heat produced in bar BC is 4 times the heat produced in bar AB.

II. Electric field in both halves is equal.

III. Current density across AB is double that of across BC.

(a) Only I
(b) Only II
(c) Both I and II
(d) None of these

Case Study

Read the following paragraph and answer the questions.

Biot-Savart's Law

In Physics, Biot-Savart law illustrates the generation of magnetic field by a stable electric current. This law is very basic to magnetostatics and plays a key role with the Coulomb's law in electrostatics. It can be used for calculating magnetic reactions at the atomic or molecular level. It is also used in explaining the theoretical concepts of aerodynamics for the calculation of velocity.

According to Biot-Savart's law, the magnitude of magnetic field produced at a point is directly proportional to current, length of the element and inversely proportional to the square of the distance between element and the point.

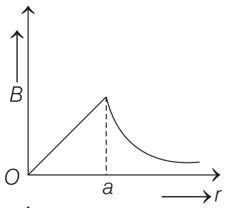
52. Which of the following gives the value of magnetic field due to a small current element according to Biot-Savart's law?

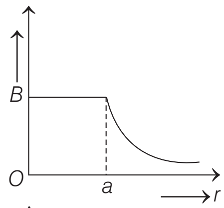
(a) $\frac{i\Delta l \sin\theta}{r^2}$
(b) $\frac{\mu_0}{4\pi}\frac{i\Delta l \sin\theta}{r}$
(c) $\frac{\mu_0}{4\pi}\frac{i\Delta l \sin\theta}{r^2}$
(d) $\frac{\mu_0}{4\pi}\frac{i\Delta l \sin\theta}{r^3}$

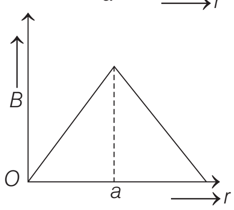
53. A current flows in a conductor from east to west. The direction of the magnetic field at a point above the conductor is

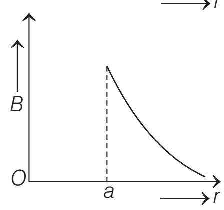
(a) towards north
(b) towards south
(c) towards east
(d) towards west

54. The variation in magnetic field due to a straight conductor of uniform cross-section of radius a and carrying a steady current is represented by

(a) 

(b) 

(c) 

(d) 

55. The magnetic field at the centre of a tightly wound coil with 150 turns is 15.7×10^{-4} T. If the radius of coil is 12 cm, then the value of current flowing through it is

(a) 6 A
(b) 5 A
(c) 2 A
(d) 8 A

OMR SHEET

SP 7

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

Correct | Incorrect | Incorrect | Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	20	a	b	c	d	38	a	b	c	d
2	a	b	c	d	21	a	b	c	d	39	a	b	c	d
3	a	b	c	d	22	a	b	c	d	40	a	b	c	d
4	a	b	c	d	23	a	b	c	d	41	a	b	c	d
5	a	b	c	d	24	a	b	c	d	42	a	b	c	d
6	a	b	c	d	25	a	b	c	d	43	a	b	c	d
7	a	b	c	d	26	a	b	c	d	44	a	b	c	d
8	a	b	c	d	27	a	b	c	d	45	a	b	c	d
9	a	b	c	d	28	a	b	c	d	46	a	b	c	d
10	a	b	c	d	29	a	b	c	d	47	a	b	c	d
11	a	b	c	d	30	a	b	c	d	48	a	b	c	d
12	a	b	c	d	31	a	b	c	d	49	a	b	c	d
13	a	b	c	d	32	a	b	c	d	50	a	b	c	d
14	a	b	c	d	33	a	b	c	d	51	a	b	c	d
15	a	b	c	d	34	a	b	c	d	52	a	b	c	d
16	a	b	c	d	35	a	b	c	d	53	a	b	c	d
17	a	b	c	d	36	a	b	c	d	54	a	b	c	d
18	a	b	c	d	37	a	b	c	d	55	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

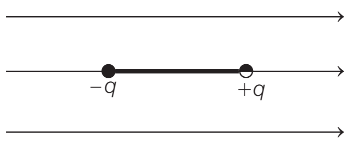
1. (b)	**2.** (b)	**3.** (c)	**4.** (c)	**5.** (c)	**6.** (a)	**7.** (b)	**8.** (a)	**9.** (b)	**10.** (a)
11. (c)	**12.** (a)	**13.** (c)	**14.** (a)	**15.** (d)	**16.** (a)	**17.** (d)	**18.** (b)	**19.** (a)	**20.** (a)
21. (c)	**22.** (b)	**23.** (d)	**24.** (d)	**25.** (d)	**26.** (c)	**27.** (b)	**28.** (c)	**29.** (d)	**30.** (a)
31. (b)	**32.** (a)	**33.** (a)	**34.** (c)	**35.** (c)	**36.** (c)	**37.** (b)	**38.** (b)	**39.** (d)	**40.** (d)
41. (b)	**42.** (c)	**43.** (b)	**44.** (a)	**45.** (b)	**46.** (a)	**47.** (c)	**48.** (d)	**49.** (c)	**50.** (d)
51. (a)	**52.** (c)	**53.** (a)	**54.** (a)	**55.** (c)					

SOLUTIONS

1. According to Gauss's theorem, $\phi = \frac{q_{enc}}{\varepsilon_0}$.

As, the radius of a spherical surface is increased, but the charge enclosed by the gaussian surface remains the same. So, the flux also remains same.

2. Here, electric dipole is placed in an uniform electric field E.



As, torque, $\tau = pE\sin\theta° = 0$

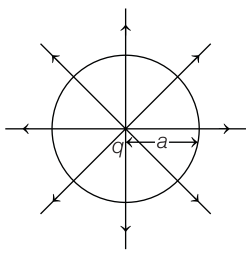
$\Rightarrow \quad \sin\theta = 0 \Rightarrow \theta = 0°$

So, for stable equilibrium, the orientation or angle θ should be zero.

3. According to Coulomb's law, force between two point charges, varies with distance as $F \propto \frac{1}{r^2}$. Therefore, the graph between F and r will be as shown in graph.(c).

4. Given, electric field, $E = Aa$ ...(i)

A charge q contained in a sphere of radius a centred at the origin is as shown below



Here, radius , $r = a$

$\therefore$ Electric field, $E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{a^2}$ ...(ii)

From Eqs. (i) and (ii), we get

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{a^2} = Aa \Rightarrow q = 4\pi\varepsilon_0 Aa^3$$

5. A, B, C, D and E all lie on equipotential surface because on the surface of a sphere due to point charge, potential is same. So,

$W_{AB} = W_{AC} = W_{AD} = W_{AE} = q(V_f - V_i) =$ zero.

6. By using $KE = qV \Rightarrow KE = 1.6 \times 10^{-19} \times 100$

$= 1.6 \times 10^{-17}$ J

7. The energy stored in a parallel plate capacitor,

$$U = \frac{1}{2}CV^2$$

The energy stored, for n capacitors connected in parallel, $U = \frac{1}{2}(nC)V^2$

8. Dielectric constant,

$$K = \frac{\text{Permittivity of medium}}{\text{Permittivity of free space}}$$

$$\Rightarrow \quad K = \frac{\varepsilon}{\varepsilon_0}$$

$\therefore$ Permittivity of medium, $\varepsilon = K\varepsilon_0$

$= 81 \times 8.85 \times 10^{-12}$

$= 7.16 \times 10^{-10}$ MKS units

9. The area of cross-section of conductor is non-uniform, so current density will be different, but the numbers of flow of electron will be same, so current will be constant.

10. Resistance of a material, $R = \rho\frac{l}{A}$ ...(i)

where, ρ = resistivity of wire,

l = length of wire

and A = area of wire.

When it is stretched, length (l') increases 8 times and the cross-sectional area (A') decreases 8 times of initial area.

So, $l' = 8l$ and $A' = \frac{A}{8}$

New resistance, $R' = \frac{\rho(8l)}{\frac{A}{8}} = 64\rho\left(\frac{l}{A}\right)$

$\Rightarrow \quad 640 = 64R$ [using Eq. (i)]

$\Rightarrow \quad R = 10\Omega$

11. Total emf, $E = 3 \times 9 = 27$ V

Total resistance, $R = 6 + 3r = 6 + 3 = 9\Omega$

Using Ohm's law,

$$I = \frac{E}{R} = \frac{27}{9}$$

$\Rightarrow \quad I = 3\text{A}$

12. The statement given in option (a) is correct but rest are incorrect and these can be corrected as,

Ohm's law is valid for metallic conductors at low temperature but not valid at high temperature.

When current passes through the electrolyte, it violates Ohm's law.

13. From Kirchhoff's first law, in an electric circuit, the algebraic sum of the currents meeting at any junction is zero. i.e. $\Sigma I = 0$.

Taking inward direction of current as positive and outward as negative, we have

$$6 + 5 + 8 - 2 - 4 - I = 0$$

$\Rightarrow \quad I = 13\text{A}$

14. Statement given in option (a) is correct while rest are incorrect and these can be corrected as,

The electric field can convey energy and momentum and is not established instantaneously but takes finite time to propagate.

The magnetic field of several sources is the vector addition of magnetic field of each individual source.

The Lorentz force depends on q, **v** and **B**. Force on a negative charge is opposite to that on a positive charge.

15. A current loop in a magnetic field can have two equilibrium for two orientations.

For parallel magnetic field configuration, the current loop is stable and for anti-parallel it is unstable.

16. Angle of dip is given as

$$\tan\delta = \frac{B_V}{B_H}$$

$$\tan 45° = \frac{B_V}{B_H} \Rightarrow B_H = B_V \qquad (\because \tan 45° = 1)$$

$\therefore \quad B_H : B_V = 1:1$

17. Net magnetic flux passing through a hypothetical closed surface enclosing a bar magnet (dipole) is zero because bar magnet has two poles (north and south-poles), hence number of magnetic field lines leaving the surface is balanced by the number of magnetic field lines entering it.

18. Given, $L = 10$ H, $I_1 = 9$ A, $I_2 = 4$ A and $\Delta t = 0.2$ s

Induced emf,

$$\varepsilon = -L\frac{dI}{dt} = -L\frac{(I_2 - I_1)}{\Delta t} = \frac{-10 \times (4-9)}{0.2}$$

$$= \frac{50}{0.2} = 250 \text{ V}$$

19. The currents induced in the bulk of conductors, when the magnetic flux linked with the conductor changes are known as eddy currents. Due to these currents, the oscillatory metallic pendulum slows down when placed perpendicular to the plane of oscillation.

20. Given, $M = 0.4$ H, $d\phi = 1.2$ Wb

We know that ,

$$\phi = MI$$

$\therefore \quad d\phi = MdI$

$\Rightarrow \quad dI = \frac{d\phi}{M} = \frac{1.2}{0.4}$

$\Rightarrow \quad dI = 3$ A

21. We have to transmit energy (power) over large distances at high alternating voltages, so current flowing through the wires will be low, for a given constant power (P).

For this, the transmission lines are made thicker.

As, $\quad P = E_{\text{rms}} i_{\text{rms}}$

i_{rms} is low, when E_{rms} is high.

So, power loss $= i_{\text{rms}}^2 R =$ low $\qquad (\because i_{\text{rms}}$ is low)

Now, at the receiving end high voltage is reduced by using step-down transformers.

Hence, statement given in option (c) is incorrect and rest are correct.

22. Given, $N = 100$, $A = 3\text{m}^2$, $\omega = 60 \text{ rad s}^{-1}$, $B = 0.04$ T

Maximum emf produced in the coil,

$$e_0 = NBA\omega = 100 \times 0.04 \times 3 \times 60$$

$$= 720 \text{ V}$$

23. Given, $V_0 = 140$ V, $I_{\text{rms}} = 1.98$ A

As, $\quad I_{\text{rms}} = \frac{V_{\text{rms}}}{R}$

$$\Rightarrow \quad R = \frac{V_{\text{rms}}}{I_{\text{rms}}} = \frac{0.707 V_0}{I_{\text{rms}}}$$

$$= \frac{0.707 \times 140}{1.98}$$

$$= 50\Omega$$

24. As the resonance peak is sharper for circuit D, so it has maximum Q-factor or quality factor.

25. The sharpness of resonance is given by

$$\frac{\omega_0}{2\Delta\omega} = \frac{\omega_0 L}{R}$$

The ratio $\frac{\omega_0 L}{R}$ is also called the quality factor (Q) of the circuit. i.e. $Q = \frac{\omega_0 L}{R}$

$\Rightarrow 2\Delta\omega = \frac{\omega_0}{Q}$, so larger the value of Q, the smaller is the value of $2\Delta\omega$ or the bandwidth and sharper is the resonance.

Thus, statement given in option (d) is incorrect and rest are correct.

26. Statement given in option (c) is incorrect and it can be corrected as

The magnitude of magnetic field **B** is 1 SI unit, when the force acting on a unit charge (1 C) moving perpendicular to **B** with a speed of 1 m/s is one newton.

Rest statements are correct.

27. Inductive reactance, $X_L = \omega L \quad \Rightarrow X_L \propto \omega$

Hence, inductive reactance increases linearly with angular frequency as shown in graph (b).

28. Given, $q = \pm 5\mu C = \pm 5 \times 10^{-6} C$

$$2a = 10 \text{ mm} = 10 \times 10^{-3} \text{ m}$$

$$r = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$$

$$\therefore \quad |\mathbf{p}| = |q| \times 2a = 5 \times 10^{-6} \times 10 \times 10^{-3},$$

$$= 5 \times 10^{-8} \text{ m}$$

The electric field along BP will be

$$\mathbf{E} = \frac{2|\mathbf{p}|r}{4\pi\varepsilon_0 (r^2 - a^2)^2}$$

As, $r >> a$

$$\mathbf{E} = \frac{2|\mathbf{p}|}{4\pi\varepsilon_0 r^3} = \frac{2 \times 5 \times 10^{-8} \times 9 \times 10^9}{(10 \times 10^{-2})^3}$$

$$= 9 \times 10^5 \text{ N/C}$$

29. Given, $P_s = 60\text{W}$, $I_p = 0.27\text{A}$, $V_p = 220$ V and $V_s = 110$ V

For an ideal transformer,

$$\frac{V_s}{V_p} = \frac{I_p}{I_s}$$

$$\Rightarrow \quad I_s = \frac{I_p}{V_s} \times V_p = \frac{0.27 \times 220}{111}$$

$$\Rightarrow \quad I_s = 0.54\text{A}$$

30. Potential at point A due to charge $+q$,

$$V_A = \frac{1}{4\pi\varepsilon_0}\frac{q}{a}$$

Potential at point B due to charge $+q$,

$$V_B = \frac{1}{4\pi\varepsilon_0}\frac{q}{b}$$

Work done in taking a charge Q from B to A,

$$W = Q(V_A - V_B) = \frac{Qq}{4\pi\varepsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$$

$$= \frac{Qq}{4\pi\varepsilon_0}\left(\frac{b-a}{ab}\right)$$

31. Given, $v = 2.18 \times 10^6$ m/s, $r = 5.3 \times 10^{-11}$ m

$$e = 1.6 \times 10^{-19} \text{ C}$$

Time period of revolution of electron,

$$T = \frac{2\pi r}{v} = \frac{2\pi \times 5.3 \times 10^{-11}}{2.18 \times 10^6}$$

$$= 1.528 \times 10^{-16} \text{ s}$$

Equivalent current, $I = \frac{\text{Charge}}{\text{Time}} = \frac{e}{T}$

$$I = \frac{1.6 \times 10^{-19}}{1.528 \times 10^{-16}}$$

$$= 1.05 \times 10^{-3} \text{ A} \simeq 1.1 \times 10^{-3} \text{ A}$$

32. Here, positive charges q_B and q_C exert a net force on charge q_A fixed along X-axis in $+x$-direction. So, the charge q_A should be negative in nature. Hence, due to addition of a positive charge Q at $(x, 0)$, the force on q_A shall increase along the positive X-axis.

33. Magnetic flux, $\phi = B \cdot A$

Change in flux, $\Delta\phi = B \cdot \Delta A$

$$= 0.05(201 - 200) \times 10^{-4}$$

$$= 5 \times 10^{-6} \text{ Wb}$$

$\therefore$ Change in charge, $\Delta Q = \frac{\Delta\phi}{R}$

$$\Rightarrow \quad R = \frac{\Delta\phi}{\Delta Q} = \frac{5 \times 10^{-6}}{2.5 \times 10^{-6}}$$

$$R = 2\Omega$$

34. Initial energy, $U_i = \frac{1}{2} C_0 V^2$

When dielectric slab is introduced the capacitance increases K times and potential difference decreases K times.

$\therefore$ Final energy, $U_f = \frac{1}{2}(KC_0)(V/K)^2$

or $$U_f = \frac{1}{K}\left(\frac{1}{2} C_0 V^2\right)$$

So, energy stored in the capacitor decreases K times.

$\therefore$ Change in energy $= U_f - U_i$

$$= \frac{1}{2} C_0 V^2 (1/K - 1)$$

Thus, the statement given in option (c) is incorrect but rest are correct.

35. Initially, force between the two conductors,

$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} l$$

Finally, $F' = \frac{\mu_0}{2\pi}\frac{(3I_1)(I_2)}{3d} l$

$F' = -F$ (direction is reversed)

36. Kinetic energy is given as $\text{KE} = \frac{q^2 B^2 r^2}{2m}$

$$\Rightarrow \quad \text{KE} \propto \frac{1}{m}$$

$$\Rightarrow \quad \frac{(\text{KE})_d}{(\text{KE})_p} = \frac{m_p}{m_d}$$

$$(\text{KE})_p = \frac{m_d}{m_p} \times (\text{KE})_d$$

$$\Rightarrow \quad (\text{KE})_p = \frac{2m_p}{m_p} \times 50 \qquad (\because m_d = 2m_p)$$

$\Rightarrow$ $(\text{KE})_p = 100\text{keV}$, having same radius and same **B** inside.

37. The statement given in option (b) is incorrect and it can be corrected as,

If the transformer is assumed to be 100% efficient (no energy losses), the power input is equal to the power output, i.e.

Power at primary coil = Power at secondary coil

$$I_p V_p = I_s V_s$$

Rest statements are correct.

38. We have, $E_0 = -\frac{dV}{dx}$ or $dV = -E_0\, dx$

On integrating both sides, we get

$$\int dV = -\int E_0\, dx \Rightarrow V_x = -xE_0$$

39. Current in the *R*-*L* circuit is given by

$I = \frac{E}{\sqrt{\omega^2 L^2 + R^2}}$, where E is the voltage of an AC source.

As, $L = \frac{\mu_0 \mu_r N^2 A}{l} \Rightarrow L \propto \mu_r$

When iron rod is inserted, L increases, therefore current I decreases and brightness of bulb also decreases.

40. AC source voltage,

$$V = V_0 \sin\omega t \qquad (\text{as, } V = 0 \text{ at } t = 0)$$

$$\Rightarrow \quad V_R = V_0 \sin\omega t$$

and $V_C = V_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

V and V_R are in same phase. While V_C lags V(or V_R) by 90°. Now, V_R is in same phase with initial potential difference across the capacitor for the first time, when

$$\omega t = -\frac{\pi}{2} + 2\pi = \frac{3\pi}{2}$$

$$\Rightarrow \quad t = \frac{3\pi}{2\omega}$$

41. Given, $A = 0.3\ \mathbf{m}^2$, $n = 2 \times 10^{25}/\text{m}^3$, $q = (3t^2 + 5t + 2)\,\text{C}$

$$\therefore \ I = \frac{dq}{dt} = \frac{d}{dt}(3t^2 + 5t + 2) = 6t + 5$$

At $t = 2\,s$, $I = 6 \times 2 + 5 = 17$ A

$\therefore$ Drift velocity, $v_d = \frac{I}{neA}$

$$= \frac{17}{2 \times 10^{25} \times 1.6 \times 10^{-19} \times 0.3}$$

$$= \frac{17}{0.96 \times 10^{-6}} = 1.77 \times 10^{-5}\ \text{m/s}$$

42. For an ionised gas, as the electric field is switched ON along + x -direction, positive ion will start to move along positive x-direction and negative ion along negative x-direction. Current associated with motion of both types of ions is along positive x-direction.

According to Fleming's left hand rule, force on both types of ions will be along negative y-direction ($-y$-direction).

43. As, power of a bulb, $P = \frac{V^2}{R}$

$$\Rightarrow \quad R = \frac{V^2}{P} \quad \text{or} \quad R \propto V^2$$

i.e. $\frac{R_1}{R_2} = \left(\frac{200}{300}\right)^2 = \frac{4}{9}$

When connected in series, potential drop is in the ratio of their resistance.

So, $\frac{V_1}{V_2} = \frac{R_1}{R_2} = \frac{4}{9}$

Now, $P = I^2 R$

or $P \propto R$ (in series I is same)

$$\Rightarrow \quad \frac{P_1}{P_2} = \frac{R_1}{R_2} = \frac{4}{9}$$

$\therefore$ The statement given in option (b) is correct.

44. Impedance of the *R*-*C* circuit,

$$Z = \sqrt{R^2 + X_C^2}$$

where, $R = 100\ \Omega$ and $X_C = 100\ \Omega$

$$\Rightarrow \quad Z = \sqrt{(100)^2 + (100)^2} = 100\sqrt{2}\ \Omega$$

Also, $V_0 = 220$ V

$\Rightarrow$ $V_{\text{rms}} = 220\sqrt{2}$ V

Peak value of the current,

$$I_{\max} = \frac{V_{\max}}{Z} = \frac{220\sqrt{2}}{100\sqrt{2}} = 2.2\ \text{A}$$

45. Net force on a charge due to the presence of other charges is the vector sum of forces due to all other charges, taken one at a time. The individual forces are unaffected due to the presence of other charges. This is known as the superposition principle. So, the force between any two charges is independent of any other charge.
Therefore, both A and R are true but R is not the correct explanation of A.

46. This is in accordance with Lenz's law. When magnet is above the loop, then north-pole is formed and hence will be repeled and when it is below the loop, then it will attract the magnet.

So, the acceleration of the magnet is always less than g.
Therefore, both A and R are true and R is the correct explanation of A.

47. If we increase emf of known battery, potential gradient increases, so smaller length will be required to equalise emf of unknown battery. So, null point length will decrease.

Therefore, A is true but R is false.

48. Since, both the loops are identical (same area and number of turns) and moving with a same speed in same magnetic field. Hence, same emf is induced in both the coils because it is directly proportional to the rate of change of magnetic field. But the induced current will be more in the copper loop as its resistance be lesser as compared to that of the aluminium loop.

Therefore, A is false and R is also false.

49. When charge is at $2R$, the motion will be simple harmonic only when charge $-q$ is not very far from the centre of ring on its axis. Otherwise motion is periodic, but not simple harmonic in nature.

Therefore, A is true but R is false.

50. The emf induced in a conductor does not depend on its shape, but only on its end points, M and Q in this case. Thus, the conductor is equivalent to an imaginary straight conductor of length, $l = MQ = 2R$. Therefore, potential difference developed across the ring $= Blv = B(2R)v$ and the direction of induced current is from Q to M. Therefore, Q is at higher potential.

51. Current flowing through both the bars is equal. Now, the heat produced is given by

$$H = I^2 Rt$$

$$\Rightarrow \quad H \propto R$$

$$\Rightarrow \quad \frac{H_{AB}}{H_{BC}} = \frac{R_{AB}}{R_{BC}} = \frac{(1/2r)^2}{(1/r)^2} \quad \left(\because R \propto \frac{1}{A} \propto \frac{1}{r^2}\right)$$

$$= \frac{1}{4}$$

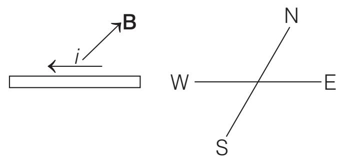
$$\therefore \quad H_{BC} = 4H_{AB}$$

As, $E \propto \frac{1}{r}$, so $E_{AB} < E_{BC}$.

52. According to Biot-Savart's law, magnetic field due to a small current carrying element is

$$dB = \frac{\mu_0}{4\pi} \frac{i\Delta l \sin\theta}{r^2}$$

53. The direction of current is shown in the figure



According to Fleming's left-hand rule, direction of magnetic field produced will be towards north.

54. The magnetic field at a point outside the straight conductor is given by

$$B = \frac{\mu_0 I}{2\pi r}$$

It means $B \propto \frac{1}{r}$ (if, $r > a$)

Its graph is a hyperbola.

The magnetic field at a point inside the conductor is

$$B = \frac{\mu_0 I \times r}{2\pi a^2}$$

or $B \propto r$ (if, $r < a$)

Its graph is a straight line.

These variations are correctly shown in graph of option (a).

55. Given, $N = 150$, $R = 12$ cm $= 12 \times 10^{-2}$ m

$$B = 15.7 \times 10^{-4} \text{ T}$$

$\therefore$ Magnetic field at the centre,

$$B = \frac{\mu_0 NI}{2R}$$

$$15.7 \times 10^{-4} = \frac{4\pi \times 10^{-7} \times 150 \times I}{2 \times 12 \times 10^{-2}}$$

$$\Rightarrow \quad I = \frac{15.7 \times 10^{-4} \times 24 \times 10^{-2}}{4\pi \times 10^{-7} \times 150}$$

$$I \simeq 2 \text{ A}$$

SAMPLE PAPER 8

PHYSICS

*A Highly Simulated Practice Questions Paper for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. An electric dipole of dipole moment 20×10^6 C-m is enclosed by a closed surface. The net electric flux (in N-m^{2}C^{-1}) through the surface is

(a) 10×10^{-3} (b) 20×10^{-6} (c) 100×10^{-8} (d) zero

2. If 10^9 electrons transfer from one body to another every second, then in 198 yr the amount of charge that is accumulated will be

(a) 1 C (b) 2 C (c) 4 C (d) zero

3. The electric field in a region is given by $\mathbf{E} = a\hat{\mathbf{i}} + b\hat{\mathbf{j}}$, here a and b are constants. The net flux passing through a square area of side l parallel to YZ-plane is

(a) $a^2 l^2$ (b) al^2 (c) $b^2 l^2$ (d) bl^2

4. Pick out the statement which is incorrect.

(a) A negative test charge experiences a force opposite to the direction of the field.
(b) The tangent drawn to a line of force represents the direction of electric field.
(c) Field lines never intersect.
(d) The electric field lines forms closed loop.

5. Choose the correct explanation for the following statement.
"Electric force acting on a proton and an electron moving in a uniform electric field is same, where acceleration of electron is 1836 times that of a proton".

(a) Electron is heavier than proton.
(b) Electron is lighter than proton.
(c) Velocity of electron is much higher than proton.
(d) None of the above

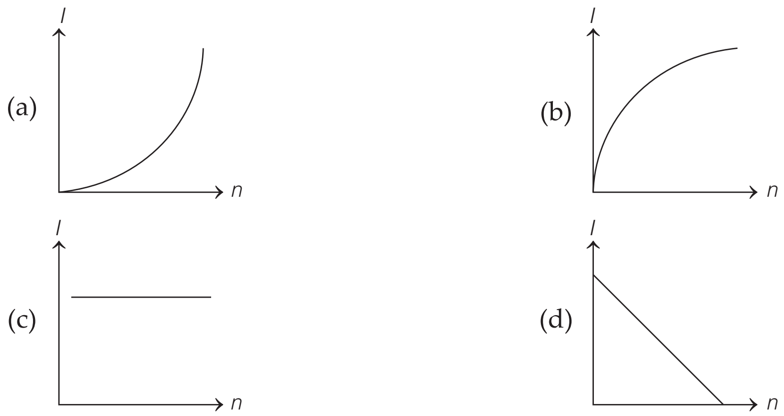
6. Energies stored in capacitor and dissipated during charging a capacitor is in the ratio
(a) 1 : 1 (b) 1 : 2
(c) $1:\sqrt{2}$ (d) 2 : 1

7. A parallel plate capacitor is connected to a battery. A metal sheet of negligible thickness is placed between the plates. Which of the following statement(s) is/are correct?
(a) Equal and opposite charges will appear in the forces of metal sheet.
(b) Capacity remains same.
(c) Potential difference between the plates will increase.
(d) Battery supplies more charge.

8. The ratio of power dissipated by two resistors is 5 : 9, then the value of two resistors are in the ratio of
(a) 5 : 9 (b) 4 : 3 (c) 6 : 9 (d) 9 : 5

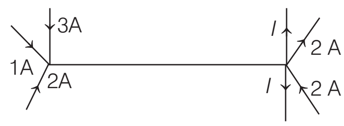
9. The resistance will be least in a wire with length and cross-section area respectively, as
(a) $L/2$ and $2A$ (b) $2L$ and A (c) L and A (d) L and $2A$

10. A battery consists of a variable number (n) of identical cells, each having an internal resistance r connected in series. The terminals of the battery are short-circuited. A graph of current (I) in the circuit *versus* the number of cells (n) will be as shown in figure



11. The energy dissipated by a wire in 0.5 h is 72 kJ. If 2A current flows in the wire, then the value of resistance is
(a) 50 Ω (b) 100 Ω (c) 10 Ω (d) zero

12. The given figure represents currents in the part of an electric circuit, then the value of current I will be

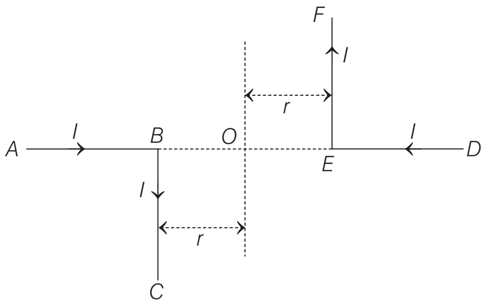


(a) 1 A (b) 2 A (c) 3 A (d) 4 A

13. A current carrying wire in the form of a circular loop of single turn, changes into a coil of 2 turns. If its new value of magnetic induction at the centre is *B*, then the original value of magnetic induction is

(a) $\frac{B}{4}$ (b) $\frac{B}{8}$ (c) $\frac{B}{2}$ (d) B

14. Two long thin wires *ABC* and *DEF* are arranged as shown in the figure. The magnitude of the magnetic field at *O* is



(a) $\frac{\mu_0 I}{4\pi r}$ (b) $\frac{\mu_0 I}{2\pi r}$ (c) $\frac{\mu_0 I}{2\sqrt{2}\pi r}$ (d) zero

15. An ammeter has resistance R_0 and range *I*. What resistance should be connected in parallel with it to increase its range by *nI*?

(a) $R_0/(n-1)$ (b) $R_0/(n+1)$ (c) R_0/n (d) None of these

16. The length of a magnetised steel wire is *l* and the magnetic moment is *m*. It is bent into the shape of *L* with two equal sides. The magnetic moment now will be

(a) $m/2$ (b) $2m$ (c) $\sqrt{2}\,m$ (d) $m/\sqrt{2}$

17. The magnetic moment of an electron orbiting in a circular orbit of radius *r* with a speed *v* is

(a) evr (b) $evr/2$ (c) $er/2v$ (d) $evr^2/2$

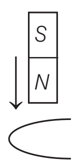
18. A wire of length 50 cm moves with a velocity of 300 m/min, perpendicular to the magnetic field. If the magnitude of magnetic field is 0.8 T, then the induced emf is

(a) 1 V (b) 2 V (c) 3 V (d) 4 V

19. Choose the correct statement for Faraday's law of electromagnetic induction.

(a) Induced emf e must be zero, if magnetic flux $\phi = 0$ or changing.
(b) Induced emf $e \neq 0$ and magnetic flux $\phi = 0$.
(c) Induced emf $e \neq 0$, if magnetic flux is changing.
(d) Induced emf $e = 0$, then magnetic flux must be zero.

20. A copper ring having a cut such that it does not form a complete loop is held horizontally. A bar magnet is dropped through the ring with its length along the axis of the ring shown in the figure. The acceleration of the falling magnet is



(a) g (b) less than g (c) more than g (d) zero

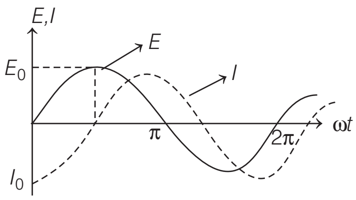
21. Two coils A and B having 200 and 400 turns, respectively. A current of 1 A in coil A causes a flux per turn of 10^{-3} Wb to link with A and a flux per turn of 0.8×10^{-3} Wb through B. The ratio of mutual inductance of A and B is

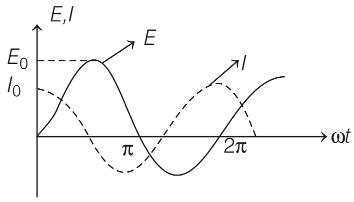
(a) 0.625 (b) 1.25
(c) 1.5 (d) 1.625

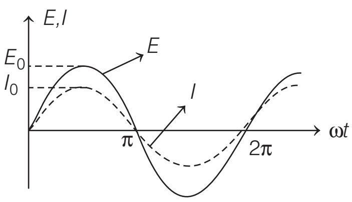
22. In series R-L-C circuit, $L = 1.00$ mH, $C = 1.00$ nF and $R = 200\,\Omega$. When the source with peak voltage 100 V is applied across it, the resonant frequency will be

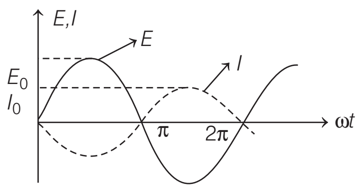
(a) 1×10^3 rad/s (b) 1×10^6 rad/s
(c) 1.56×10^6 rad/s (d) 1.75×10^3 rad/s

23. The phase relationship between current and voltage in a pure inductive circuit, is best represented by

(a)


(b)


(c)


(d)


24 In series L-C-R circuit voltage drop across resistance is 8 V, across inductor is 6 V and across capacitor is 12 V. Then,

(a) current of the source will be leading in the circuit
(b) voltage drop across each element will be less than the applied voltage
(c) reactance of inductor is greater than that of capacitor
(d) None of the above

25. If both the resistance and the inductance in an L-R AC series circuit are doubled, the new impedance will be

(a) halved (b) fourfold
(c) doubled (d) quadrupled

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. A direct current I flows along the length of an infinitely long straight thin walled pipe, then the magnetic field is

(a) uniform throughout the pipe but not zero
(b) zero only along the axis of the pipe
(c) zero at any point inside the pipe
(d) maximum at the centre and minimum at the edge

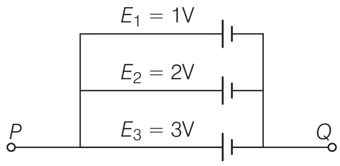
27. If a transformer of an audio amplifier has output impedance 8000 Ω and the speaker has input impedance of 8 Ω. The secondary and primary turns of this transformer connected between the output of amplifier and to loudspeaker should have the ratio

(a) 1000 : 1 (b) 100 : 1 (c) 1 : 32 (d) 32 : 1

28. Two parallel plate air capacitors have their plate areas 100 and 500 cm^2, respectively. If they have the same charge & potential and the distance between the plates of the first capacitor is 0.5 mm, what is the distance between the plates of the second capacitor?

(a) 0.25 cm (b) 0.52 cm (c) 0.75 cm (d) 1 cm

29. A circuit consists of three batteries of emf $E_1 = 1$ V, $E_2 = 2$V and $E_3 = 2$V and internal resistances 1 Ω, 2 Ω and 1 Ω respectively, which are connected in parallel as shown in the figure. The potential difference between points P and Q is

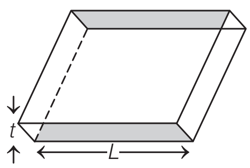


(a) 1.0 V (b) 2.0 V (c) 2.2 V (d) 3.0 V

30. An inductor is connected to 220 V, 50 Hz AC supply. The rms value of current in the circuit is 16 A, then the value of inductance is

(a) 40 mH (b) 45 mH (c) 44 mH (d) 50 mH

31. Consider a thin square sheet of side L, thickness t and made of a material of resistivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is



(a) directly proportional to L (b) directly proportional to t
(c) independent of L (d) independent of t

32. Two point charges of magnitudes 1 μC and 0.5 μC are located at 30 cm apart. The potential at mid-point along the line joining the two charges is

(a) 9×10^8 V (b) 10×10^8 V (c) 5×10^{10} V (d) 9×10^4 V

33. An inductor L, a capacitor of 20 μF and a resistor of 10 Ω are connected in series with an AC source of frequency 50 Hz. If the current is in phase with the voltage, then the inductance of the inductor is

(a) 2.00 H (b) 0.51 H (c) 1.5 H (d) 0.99 H

34. A charged particle P leaves the origin with speed $v = v_0$, at some inclination with the X-axis. There is a uniform magnetic field B along the X-axis and P strikes a fixed target T on the X-axis for a minimum value of $B = B_0$. P will also strike T, if

(a) $B = 2B_0, v = 2v_0$ (b) $B = 2B_0, v = v_0$
(c) Both (a) and (b) (d) $B = \frac{B_0}{2}, v = 2v_0$

35. Wires A and B have resistivities ρ_A and ρ_B, $(\rho_B = 2\rho_A)$ and have lengths l_A and l_B. If the diameter of the wire B is twice that of A and the two wires have same resistance, then $\frac{l_B}{l_A}$ is

(a) 2 (b) 1 (c) $\frac{1}{2}$ (d) $\frac{1}{4}$

36. According to phenomenon of mutual inductance,

(a) the mutual inductance does not depend on the geometry of the two coils involved
(b) the mutual inductance depends on the intrinsic magnetic property like relative permeability of the material
(c) the mutual inductance is independent of the magnetic property of the material
(d) ratio of magnetic flux produced by the coil 1 at the place of the coil 2 and the current in the coil 2 will be different from that of the ratio defined by interchanging the coils

37. A 3.0 cm wire carrying a current of 10 A is placed inside a solenoid perpendicular to its axis. The magnetic field inside the solenoid is given to be 0.27 T. The magnetic force on the wire is

(a) 8.1×10^{-2} N, inwards (b) 9.1×10^{-2} N, outwards
(c) 8.6×10^{-2} N, outwards (d) 6.6×10^{-2} N, inwards

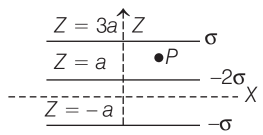
38. A long solenoid with 10 turns/cm has a small loop placed normal to the axis of solenoid. The current carried by the solenoid changes steadily from 2A to 4A in 0.2s and the induced voltage is 3.8×10^{-6} V. The area of the small loop will be

(a) 9 cm^2 (b) 30 cm^2
(c) 3 cm^2 (d) 30 m^2

39. Two poles one of which is 5 times as strong as the other, exert on each other a force equal to 0.8×10^{-3} kg-wt, when placed 10 cm apart in air. The strength of stronger pole will be

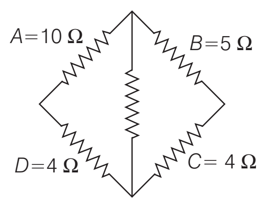
(a) 62.6 A-m (b) 6.26 A-m (c) 66 A-m (d) 0.626 A-m

40. Three infinitely charged sheets are kept parallel to XY-plane having charge densities as shown, then the value of electric field at P is



(a) $\frac{-4\sigma}{\varepsilon_0}\hat{\mathbf{k}}$ (b) $\frac{4\sigma}{\varepsilon_0}\hat{\mathbf{k}}$ (c) $\frac{-2\sigma}{\varepsilon_0}\hat{\mathbf{k}}$ (d) $\frac{2\sigma}{\varepsilon_0}\hat{\mathbf{k}}$

41. In a typical Wheatstone network, the resistances in cyclic order are $A = 10\,\Omega$, $B = 5\,\Omega$, $C = 4\,\Omega$ and $D = 4\,\Omega$. For the bridge to be balanced,



SAMPLE PAPER 8

(a) 10 Ω should be connected in parallel with A
(b) 10 Ω should be connected in series with A
(c) 5 Ω should be connected in series with B
(d) 5 Ω should be connected in parallel with B

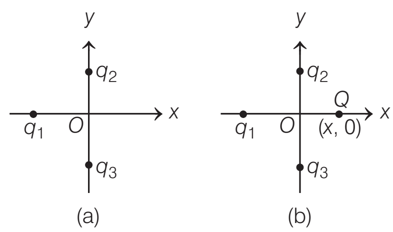
42. A coil is rotating in a magnetic field and produces an induced emf. The phase difference between the flux linked with a coil is

(a) $\frac{\pi}{2}$, uniform magnetic field
(b) $\frac{\pi}{4}$, non-uniform magnetic field
(c) $\frac{-\pi}{6}$, uniform magnetic field
(d) π, non-uniform magnetic field

43. A cylindrical rod is reformed to half of its original length, keeping volume constant. Its resistance after reformation is R, then the original resistance is

(a) R (b) $2R$ (c) $4R$ (d) $8R$

44. In figure two positive charges q_2 and q_3 fixed along the Y-axis, exert a net electric force in the $+x$-direction on a charge q_1 fixed along the X-axis. If a positive charge Q is added at $(x, 0)$, the force on q_1 will be



(a) increase along the positive X-axis
(b) decrease along the positive X-axis
(c) point along the negative X-axis
(d) increase but the direction changes, because of the intersection of Q with q_2 and q_3

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** Coulomb's law relates the two point charges and distance between them.
Reason Coulomb's force increases with the increase in magnitude of two charges.

46. **Assertion** The dimensions of resistance and reactance are similar in nature.
Reason In a capacitor, the value of instantaneous alternating current is sinusoidal in nature.

47. **Assertion** When a conductor is subjected to electric field, the field is zero inside the conductor.

Reason Inside the conductor, potential is constant.

48. **Assertion** Internal resistance is constant for a cell and does not change with the passage of time.

Reason Internal resistance is independent of distance between the plates of cell.

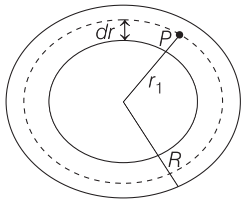
49. **Assertion** Convection currents are the main reason behind the earth's magnetic field.

Reason Magnetic element is related to the earth's magnetic field.

Section C

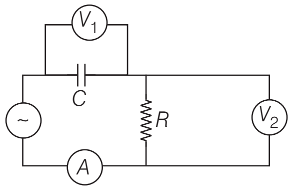
This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. Let $\rho(r) = \frac{Q}{\pi R^4} r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point P inside the sphere at distance r_1 from the centre of the sphere, the magnitude of electric field is



(a) zero (b) $\frac{Q}{4\pi\varepsilon_0 r_1^2}$ (c) $\frac{Qr_1^2}{4\pi\varepsilon_0 R^4}$ (d) $\frac{Qr_1^2}{3\pi\varepsilon_0 R^4}$

51. The diagram shows a capacitor C and a resistor R connected in series to an AC source V_1 and V_2 are voltmeters and A is an ammeter.



Consider the following statements

I. Readings in A and V_2 are always in phase.

II. Reading in V_1 is ahead in phase with reading in V_2.

III. Readings in A and V_1 are always in phase.

Which of these statement(s) is/are correct?

(a) Only I (b) Only II (c) Both I and II (d) Both II and III

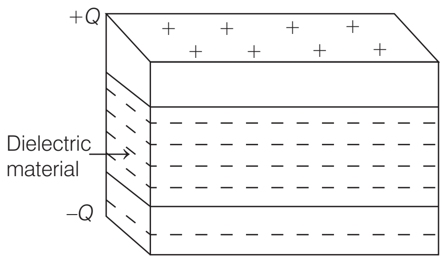
Case Study

Read the following paragraph and answer the questions.

Dielectric Materials

Dielectric material are insulating materials, which are poor conductor of electricity. But it can be used to store charge by making it polarised with the application of electric field. Just like an ideal capacitor, it stores and dissipates the electric charge.

These materials are of two types; polar and non-polar. They are widely used in applications such as OLED, LED, LCD, etc.
Under the effect of an external field, a net dipole moment is induced in the dielectric.



52. In the presence of large external electric field, non-polar dielectric will behave as
(a) polar dielectric (b) point charges
(c) electric dipole (d) semiconductor

53. The value of electric field is reduced in a dielectric slab due to
(a) magnetisation (b) polarisation
(c) conductivity (d) Both (a) and (c)

54. Electric field inside the capacitor is 100 V/m and its dielectric constant is 5.5. The polarisation of capacitor will be
(a) $45\ C/m^2$ (b) $450\ C/m^2$ (c) $4.5\ C/m^2$ (d) $5.5\ C/m^2$

55. Which of the following material can be used as a dielectric?
(a) Ceramics (b) Copper
(c) Aluminium (d) Iron

OMR SHEET

SP 8

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

●	✔	✗	◓
Correct	Incorrect	Incorrect	Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	20	a	b	c	d	38	a	b	c	d
2	a	b	c	d	21	a	b	c	d	39	a	b	c	d
3	a	b	c	d	22	a	b	c	d	40	a	b	c	d
4	a	b	c	d	23	a	b	c	d	41	a	b	c	d
5	a	b	c	d	24	a	b	c	d	42	a	b	c	d
6	a	b	c	d	25	a	b	c	d	43	a	b	c	d
7	a	b	c	d	26	a	b	c	d	44	a	b	c	d
8	a	b	c	d	27	a	b	c	d	45	a	b	c	d
9	a	b	c	d	28	a	b	c	d	46	a	b	c	d
10	a	b	c	d	29	a	b	c	d	47	a	b	c	d
11	a	b	c	d	30	a	b	c	d	48	a	b	c	d
12	a	b	c	d	31	a	b	c	d	49	a	b	c	d
13	a	b	c	d	32	a	b	c	d	50	a	b	c	d
14	a	b	c	d	33	a	b	c	d	51	a	b	c	d
15	a	b	c	d	34	a	b	c	d	52	a	b	c	d
16	a	b	c	d	35	a	b	c	d	53	a	b	c	d
17	a	b	c	d	36	a	b	c	d	54	a	b	c	d
18	a	b	c	d	37	a	b	c	d	55	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (d)	**2.** (a)	**3.** (b)	**4.** (d)	**5.** (b)	**6.** (d)	**7.** (b)	**8.** (d)	**9.** (a)	**10.** (c)
11. (c)	**12.** (c)	**13.** (a)	**14.** (b)	**15.** (c)	**16.** (d)	**17.** (b)	**18.** (b)	**19.** (c)	**20.** (a)
21. (a)	**22.** (b)	**23.** (a)	**24.** (a)	**25.** (c)	**26.** (c)	**27.** (a)	**28.** (a)	**29.** (b)	**30.** (c)
31. (c)	**32.** (d)	**33.** (b)	**34.** (c)	**35.** (a)	**36.** (b)	**37.** (a)	**38.** (c)	**39** (a)	**40** (c)
41. (a)	**42.** (a)	**43.** (c)	**44.** (a)	**45.** (b)	**46.** (b)	**47.** (a)	**48.** (d)	**49** (b)	**50** (c)
51. (b)	**52.** (a)	**53.** (b)	**54.** (b)	**55.** (a)					

SOLUTIONS

1. According to Gauss's theorem,

$\phi = \frac{q}{\varepsilon_0}$, where q is the total charge enclosed within the surface and ϕ is the net flux.

We know that, a dipole have both negative as well as positive charge of equal magnitude.

So, total charge for a dipole is zero.

$$\Rightarrow \qquad \phi = \frac{0}{\varepsilon_0} = 0$$

$\therefore$ There will be no flux through the surface.

2. Charge moving out in 1 s

$$q = ne = 1.6 \times 10^{-19} \times 10^9$$
$$= 1.6 \times 10^{-10}\,\text{C}$$

In 198 yr, the total accumulated charge

= total time period × charge flows per second

$= 198\,\text{yr} \times 1.6 \times 10^{-10}\,\text{C}$

$= 6.25 \times 10^9\,\text{s} \times 1.6 \times 10^{-10}\,\text{C}$

$= 1\,\text{C}$

3. A square area of side l parallel to YZ-plane in vector form can be written as $\mathbf{S} = l^2\hat{\mathbf{i}}$

Given, $\mathbf{E} = a\hat{\mathbf{i}} + b\hat{\mathbf{j}}$

$\therefore$ Electric flux passing through the given area will be

$$\phi_E = \mathbf{E}\cdot\mathbf{S} = (a\hat{\mathbf{i}} + b\hat{\mathbf{j}})\cdot(l^2\hat{\mathbf{i}}) = al^2$$

4. Electric field lines does not form closed loop, as field line can never start and end on the same charge. So, the option (d) is incorrect.

5. Force on a charge particle, $F = qE$

As, charge q on electron and proton are equal in magnitude. Hence, force F acting on both of them is equal.

Also, acceleration of charge $(a) = F/m$

Since, F is same for electron and proton.

$$\Rightarrow \qquad a \propto \frac{1}{m}$$

As, acceleration of electron is 1836 times that of a proton, so electron is lighter than proton.

6. Since, half of the energy is dissipated during charging of a capacitor.

Hence,

$$\frac{\text{Energy stored in a capacitor}}{\text{Energy dissipated during charging a capacitor}}$$

$= \frac{1}{1/2}$ or $2:1$

7. As, a metal sheet is placed between two plates of capacitor and the permittivity of metal sheet is one. So, the capacity remains same.

8. Power is given as $P = \frac{V^2}{R}$

$$\Rightarrow \qquad \frac{P_1}{P_2} = \frac{\frac{V^2}{R_1}}{\frac{V^2}{R_2}}$$

$$\Rightarrow \qquad \frac{P_1}{P_2} = \frac{R_2}{R_1}$$

$$\Rightarrow \qquad \frac{R_2}{R_1} = \frac{5}{9} \qquad \text{(given, } P_1/P_2 = 5/9\text{)}$$

or $R_1 : R_2 = 9:5$

9. Resistance, $R = \rho l/A$ or $R \propto l/A$

($\because \rho$ is constant)

So, checking optionwise, we get

$$R_a \propto \frac{L}{4A}, R_b \propto \frac{2L}{A}, R_c \propto \frac{L}{A}$$

and $\quad R_d \propto \frac{L}{2A}$

Thus, resistance is least in a wire of length $L/2$ and area of cross-section is $2A$.

10. For n identical cells connected in series, current is given as $I = \frac{nE}{nr} = \frac{E}{R}$, where E is the emf of each cell.

So, current in the circuit does not depend on number of cells in the battery.

Hence, the graph is correctly depicted in option (c).

11. Given, $I = 2\,A$, $H = 72\text{ kJ} = 72 \times 10^3$ J

and $t = 0.5\text{ h} = (0.5 \times 3600)$ s

Energy dissipated is given as

$$H = I^2Rt$$

$$72 \times 1000 = (2)^2 \times R \times (0.5 \times 3600)$$

$$\Rightarrow \frac{72 \times 1000}{4 \times 0.5 \times 3600} = R$$

$$R = 10\ \Omega$$

12. By applying Kirchhoff's first law, i.e. $\Sigma I = 0$, we get

$$1 + 3 + 2 + 2 - I - I - 2 = 0$$

$$2I = 6$$

$$I = 3\text{A}$$

13. Magnetic induction, $B_0 = \frac{\mu_0 NI}{2r} = \frac{\mu_0 I}{2r}$ ... (i)

(given, $N = 1$)

New magnetic induction,

$$B = \frac{\mu_0 NI}{2\,(r/2)} = \frac{\mu_0 2I}{2(r/2)} \quad \text{(given, } N = 2)$$

$$B = \frac{4\mu_0 I}{2r}$$

$$B_0 = \frac{B}{4} \quad \text{[using Eq. (i)]}$$

14. B due to AB and DE will be zero at O.

Magnetic field due to semi-infinite wire at distance d,

$$B = \frac{\mu_0 I}{4\pi d}$$

Here, magnetic field at O due to BC,

$$B_{BC} = \frac{\mu_0 I}{4\pi r}$$

Magnetic field at O due to EF,

$$B_{EF} = \frac{\mu_0 I}{4\pi r}$$

Net magnetic field at O,

$$B_{\text{Total}} = B_{BC} + B_{EF} = \frac{\mu_0 I}{2\pi r}$$

15. Given, $I_g = I$ and $G = R_0$

For parallel combination,

$$I = nI + I = (n+1)I$$

$$\therefore \text{ Shunt, } S = \frac{I_g G}{I - I_g} = \frac{IR_0}{(n+1)I - I} = \frac{R_0}{n}$$

16. If q_m is the strength of each pole and l is the length of steel wire, then magnetic moment

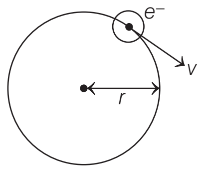
$$m = q_m \times l \quad \text{... (i)}$$

When the wire is bent into L-shape, effective distance between the poles

$$l' = \sqrt{(l/2)^2 + (l/2)^2} = l/\sqrt{2}$$

$$\therefore \quad m' = q_m \times \frac{l}{\sqrt{2}} = \frac{m}{\sqrt{2}} \quad [\because \text{ from Eq. (i)}]$$

17. An electron orbiting in a circular orbit of radius r with speed v is as shown below



Magnetic moment, $M = NiA$

where, N = number of turns of the current loop,

i = current

and A = area of loop.

Since, the orbiting electron behaves as a current loop of current i, we can write

$$i = \frac{e}{T} = \frac{e}{\frac{2\pi r}{v}} = \frac{ev}{2\pi r}$$

$$\Rightarrow \quad M = NiA = (1)\left(\frac{ev}{2\pi r}\right)(\pi r^2) = \frac{evr}{2}$$

18. Given, $l = 50\text{ cm} = 0.5$ m, $B = 0.8$ T

and $v = 300$ m/min

$$= \frac{300}{60} = 5 \text{ m/s} \quad (\because 1 \text{ min} = 60 \text{ s})$$

$\therefore$ Induced emf, $\varepsilon = Blv = 0.8 \times 0.5 \times 5 = 2$ V

19. We know that, according to Faraday's law

$$e = \frac{-d\phi}{dt}$$

$\Rightarrow e = 0$ only, if $\frac{d\phi}{dt} = 0$

If $e = 0$, then ϕ is constant.

If $e \neq 0$, then ϕ is changing.

20. In accordance with Faraday's law, an emf is induced in the copper ring due to the movement of magnet. But there will be no induced current because of cut in the ring. Hence, nothing opposes the free fall of the magnet.

Therefore, acceleration $a = g$.

21. From, $\phi = Mi \Rightarrow M = \frac{\phi}{i}$

where, M is coefficient of mutual inductances and ϕ = flux per turn.

Here, $\phi_A = 10^{-3}$ Wb, $N_A = 200$,

$$\phi_B = 0.8 \times 10^{-3} \text{ Wb and } N_B = 400$$

$$\therefore \quad \frac{M_A}{M_B} = \frac{\phi_A N_A}{\phi_B N_B}$$

$$= \frac{10^{-3} \times 200}{0.8 \times 10^{-3} \times 400} = \frac{10}{16} = 0.625$$

22. Given, $L = 1\,\text{mH} = 1 \times 10^{-3}$ H

and $\quad C = 1\,\text{nF} = 1 \times 10^{-9}$ F

Resonant frequency of R-L-C series circuit,

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1 \times 10^{-3} \times 1 \times 10^{-9}}}$$

$$\omega_0 = 1 \times 10^6 \text{ rad/s}$$

23. In the pure inductive circuit, the current lags behind the voltage by a phase angle of $(\pi/2)$ rad (90°). Voltage is ahead of current only in graph (a). So, the correct graph is (a).

24. Since, $V_C > V_L$

$\therefore \quad X_C > X_L$

Hence, current will lead the voltage and voltage drop,

$$V = \sqrt{V_R^2 + (V_C - V_L)^2} = 10 \text{ V} \Rightarrow V < V_C$$

25. For L-R circuit, $Z = \sqrt{R^2 + X_L^2}$

Here, $\quad Z_1 = \sqrt{(R_1)^2 + (X_{L_1})^2}$

and $\quad Z_2 = \sqrt{(R_2)^2 + (X_{L_2})^2}$

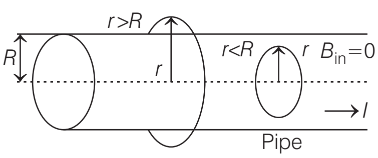
Given, $R_2 = 2R$ and $X_{L_2} = 2X_L$

$$\Rightarrow \quad Z_2 = \sqrt{(2R)^2 + (2X_L)^2} = 2Z_1$$

26. According to Ampere's circuital law,

$$B_{\text{outside}} = \frac{\mu_0}{4\pi}\frac{2I}{r}$$

Required arrangement is shown in figure below



For an internal point, $r < R$

$$B_{\text{internal}} = \frac{\mu_0(0)}{2\pi r} = 0 \quad (\because I_{\text{inside}} = 0)$$

For a point on pipe, $r = R$

$$B = \frac{\mu_0 I}{2\pi R}$$

For an external point, $r > R$

$$B_{\text{external}} = \frac{\mu_0 I}{2\pi r}$$

Hence, magnetic field is zero only inside the pipe at any point.

27. From Faraday's law, the induced emfs across primary and secondary,

$$e_p = -N_p \frac{\Delta\phi}{\Delta t}$$

and $$e_s = -N_s \frac{\Delta\phi}{\Delta t}$$

Also, $e = iR$

$$\therefore \quad \frac{R_p}{R_s} = \frac{N_p}{N_s}$$

Given, $R_s = 8000\,\Omega$ and $R_p = 8\,\Omega$

$$\therefore \quad \frac{N_s}{N_p} = \frac{R_s}{R_p} = \frac{8000}{8} = \frac{1000}{1}$$

28. Let A_1 and d_1 be the area of plates and distance between the plates of first capacitor, A_2 and d_2 be corresponding values in case of second capacitor. If C_1 and C_2 are the capacitances of two capacitors, then

$$C_1 = \frac{\varepsilon_0 A_1}{d_1} \text{ and } C_2 = \frac{\varepsilon_0 A_2}{d_2}$$

We know that, $C = \dfrac{q}{V}$

Since, the two capacitors have same charge and potential, their capacitances must be equal, i.e.

$$C_1 = C_2$$

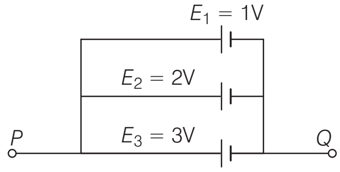
or $$\frac{\varepsilon_0 A_1}{d_1} = \frac{\varepsilon_0 A_2}{d_2}$$

or $$d_2 = \frac{A_2}{A_1} d_1$$

Here, $A_1 = 100\text{ cm}^2$, $A_2 = 500\text{ cm}^2$ and $d_1 = 0.5\text{ mm} = 0.05\text{ cm}$

$$\therefore \; d_2 = \frac{500 \times 0.05}{100} = 0.25 \text{ cm}$$

29. Cells with resistors $1\Omega, 2\,\Omega$ and 1Ω are in parallel.



So, the required internal resistance,

$$\frac{1}{r} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

$$\Rightarrow \quad \frac{1}{r} = \frac{1}{1} + \frac{1}{2} + \frac{1}{1}$$

$$\frac{1}{r} = \frac{2+1+2}{2}$$

$\Rightarrow \quad r = \frac{2}{5}\Omega$

The potential difference between points P and Q,

$$E = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2} + \frac{E_3}{r_3}}{1/r} = \frac{\frac{1}{1} + \frac{2}{2} + \frac{3}{1}}{5/2}$$

$$= \frac{\frac{2+2+6}{2}}{5/2} = \frac{10/2}{5/2} = \frac{5}{5} \times 2 = 2\text{ V}$$

30. Given, $V_{rms} = 220$ V, $I_{rms} = 16$ A and $\nu = 50$ Hz

$\therefore \quad I_{rms} = \frac{V_{rms}}{X_L}$

or $\quad X_L = \frac{V_{rms}}{I_{rms}} = \frac{220}{16} = 13.75\ \Omega$

Inductive reactance,

$$X_L = \omega L = 2\pi\nu L$$

$$13.75 = 2 \times 3.14 \times 50 \times L$$

$$L = 43.7 \times 10^{-3}\text{H} \simeq 44\text{ mH}$$

31. Resistance between two opposite faces of square sheet of given shaded areas is

$$R = \frac{\rho(L)}{A} = \frac{\rho L}{tL} = \frac{\rho}{t}$$

(for shaded area, $A = t \times L$)

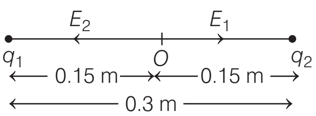
i.e. R is independent of L.

32. Given, $q_1 = 1\,\mu\text{C} = 1 \times 10^{-6}$ C

and $\quad q_2 = 0.5\,\mu\text{C} = 0.5 \times 10^{-6}$ C

Distance between the two charges

$= 30$ cm $= 0.3$ m



At the mid-point, $r_1 = r_2 = \frac{0.3}{2}$ m $= 0.15$ m

Net potential at O,

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$$

$$= 9 \times 10^9\left(\frac{1}{0.15} + \frac{0.5}{0.15}\right) \times 10^{-6}$$

$$= 9 \times 10^3 \times \frac{1.5}{0.15}$$

$$= 9 \times 10^4\text{ V}$$

33. In an L-C-R circuit, the current and the voltage are in phase ($\phi = 0$), so

$$\tan\phi = \frac{X_L - X_C}{R} = \frac{\omega L - \frac{1}{\omega C}}{R} = 0$$

or $\quad \omega L = \frac{1}{\omega C}$

or $\quad L = \frac{1}{\omega^2 C}$

Here, $\quad \omega = 2\pi f = 2 \times 3.14 \times 50 = 314\text{ s}^{-1}$

and $\quad C = 20\mu\text{F} = 20 \times 10^{-6}$ F

$\therefore \quad L = \frac{1}{(314)^2 \times (20 \times 10^{-6})} = 0.51$ H

34. For minimum value of B, charged particle is colliding after one pitch. It will collide the target again, if the pitch is halved or remains same, as

$$P = (v\cos\theta)\left(\frac{2\pi m}{Bq}\right)$$

or $\quad P \propto \frac{v}{B}$

$\therefore$ Both the options (a) and (b) are correct.

35. Given, $\rho_B = 2\rho_A$ and $R_A = R_B = R$

Let $\quad r_A = r \Rightarrow r_B = 2r$

According to formula,

$$R_A = \rho_A \cdot \frac{l_A}{\pi r_A^2} \quad \ldots\text{(i)}$$

and $\quad R_B = \rho_B \cdot \frac{l_B}{\pi r_B^2} \quad \ldots$(ii)

$\because \quad R_A = R_B \Rightarrow \rho_A \cdot \frac{l_A}{\pi r_A^2} = \rho_B \cdot \frac{l_B}{\pi r_B^2}$

[from Eqs. (i) and (ii)]

or $\quad \frac{l_B}{l_A} = \frac{r_B^2}{r_A^2} \cdot \frac{\rho_A}{\rho_B} = \frac{(2r)^2}{r^2} \cdot \frac{\rho_A}{\rho_B}$

$$= \frac{4r^2}{r^2} \cdot \frac{\rho_A}{2\rho_A} = \frac{4}{2} = 2$$

36. The mutual inductance depends on the relative permeability of medium between the coils (μ_r) or nature of material on which two coils are wound.

37. Here, the angle between the magnetic field and direction of flow of current is 90°.

Given, $\quad l = 3$ cm $= 3 \times 10^{-2}$ m,

$I = 10$ A and $B = 0.27$ T

Magnitude of force on wire,

$$F = IlB\sin 90°$$

$$= 10 \times 3 \times 10^{-2} \times 0.27 \times \sin 90°$$

$$= 8.1 \times 10^{-2}\text{ N} \quad (\because \sin 90° = 1)$$

According to right-hand rule, the direction of magnetic force is perpendicular to paper, i.e. inwards.

38. Given, $\frac{N}{l} = 10$ turns/cm $= 1000$ turns/m

$$\frac{dI}{dt} = \frac{4-2}{0.2} = 10\ \text{As}^{-1}$$

$$|\varepsilon| = 3.8 \times 10^{-6}\ \text{V}$$

As, $|\varepsilon| = \frac{d\phi}{dt} = \frac{d}{dt}(BA) = A\frac{d}{dt}\left(\mu_0 \frac{N}{l} I\right)$

$\Rightarrow \quad \varepsilon = A\mu_0\left(\frac{N}{l}\right)\frac{dI}{dt}$

Now, substituting the given values, we get

$$3.8 \times 10^{-6} = A \times 4\pi \times 10^{-7} \times 1000 \times 10$$

$\therefore$ Area, $A = 3 \times 10^{-4}\ \text{m} = 3\ \text{cm}^2$

39. Let m and $5\,m$ be the pole strength of the two poles.

Here, $F = 0.8 \times 10^{-3}$ kg-wt
$= 0.8 \times 10^{-3} \times 9.8$ N
$r = 10$ cm $= 0.1$ m

$\therefore \quad F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$

$\Rightarrow \quad 0.8 \times 10^{-3} \times 9.8 = \frac{10^{-7} \times m \times 5m}{(0.1)^2}$

$\Rightarrow \quad m = 12.52$ A-m

and $5m = 5 \times 12.52$ A-m $= 62.6$ A-m

40. Electric field due to infinite sheet is given by

$$E = \frac{\sigma}{2\varepsilon_0}$$

So, the equation can be written as

$$\mathbf{E}_P = \frac{\sigma}{2\varepsilon_0}(-\hat{\mathbf{k}}) + \frac{(-2\sigma)}{2\varepsilon_0}(\hat{\mathbf{k}}) + \frac{(-\sigma)}{2\varepsilon_0}(\hat{\mathbf{k}}) = \frac{-2\sigma}{\varepsilon_0}\hat{\mathbf{k}}$$

41. Resistance in upper arms, $A = 10\,\Omega$ and $B = 5\,\Omega$

Resistance in lower arms, $C = 4\,\Omega$ and $D = 4\,\Omega$

The condition required to form a balanced Wheatstone bridge is given by $\frac{A}{B} = \frac{D}{C}$

which does not satisfy this case, i.e. $\frac{10}{5} \neq \frac{4}{4}$

If a $10\,\Omega$ resistance is connected in parallel with A [as per option (a)], the relation for a new resistance is given by

$$\frac{1}{A'} = \frac{1}{10} + \frac{1}{10} = \frac{2}{10} = \frac{4}{4} = \frac{1}{5}$$

$\Rightarrow \quad A' = 5\,\Omega$

Now, the network satisfies the condition of balanced Wheatstone bridge. i.e.

$$\frac{5}{5} = \frac{4}{4}$$

42. We know that, flux linked with a coil,

$$\phi = BA\cos\theta$$

Induced emf, $\varepsilon = \frac{-d\phi}{dt} = \frac{-d(BA\cos\theta)}{dt}$

$$= BA\sin\theta = BA\cos\left(\frac{\pi}{2} + \theta\right)$$

$\therefore$ Phase difference $= \frac{\pi}{2} + \theta - \theta = \frac{\pi}{2}$

So, the magnetic field will be uniform.

43. Original resistance of the rod,

$$R_1 = \frac{\rho l_1}{\pi r_1^2} \qquad \left(\because R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}\right)$$

Now, the rod is changed such that, $l_2 = \frac{l_1}{2}$

As, volume remains constant.

$\therefore \quad \pi r_1^2 l_1 = \pi r_2^2 l_2$

or $\quad \frac{r_1^2}{r_2^2} = \frac{l_2}{l_1}$

Now, the resistance of rod after reformation

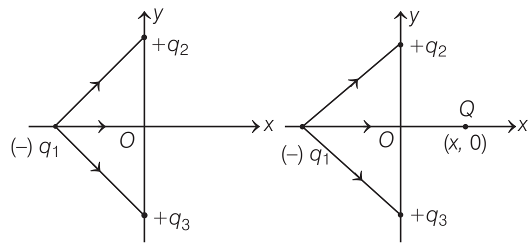
$$R_2 = \frac{\rho l_2}{\pi r_2^2} = R$$

$\therefore \quad \frac{R_1}{R} = \frac{\rho l_1}{\pi r_1^2} \times \frac{\pi r_2^2}{\rho l_2} = \frac{l_1}{l_2} \times \frac{r_2^2}{r_1^2}$

$\Rightarrow \quad \frac{R_1}{R} = \frac{l_1}{l_2} \times \frac{l_1}{l_2} = \left(\frac{l_1}{l_2}\right)^2 = (2)^2$

$$R_1 = 4R$$

44. As, q_2, q_3 are positive charges and net force on q_1 is along $+\,x$-direction, therefore q_1 must be negative as shown in Fig. (a).



(a) (b)

When a positive charge Q is added at $(x, 0)$, it will attract $(-\,q_1)$ along $+\,x$-direction as shown is in Fig. (b). Therefore, force on q_1 will increase along the positive X-axis.

45. Coulomb's law measures the force between two point charges.

According to this law, force between two point charges is directly proportional to the product of magnitude of two charges and inversely proportional to the square of the distance between them, i.e. $F \propto q_1 q_2$.

So, F increases with the increase in magnitude of charges keeping r constant.

Therefore, both A and R are true but R is not the correct explanation of A.

46. The instantaneous value of alternating current through a capacitor, $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

Hence, the current is sinusoidal in nature. The SI unit of capacitive reactance is ohm (Ω) and is similar to that of resistance.

Therefore, both A and R are true but R is not the correct explanation of A.

47. Conductors are the materials through which electric charge can flow easily.

Electrostatic potential is constant throughout the volume of the conductor and has same value on its surface. Thus, inside a conductor, the electrostatic field is zero.

Therefore, both A and R are true and R is the correct explanation of A.

48. Internal resistance of a cell is defined as, the resistance offered by the electrolyte of the cell to the flow of charges passing through it. Its value is finite and increases with the passage of time.

Internal resistance is directly proportional to the separation between the two plates of the cell.

Therefore, A is false and R is also false.

49. The core of the earth is hot and molten (consisting of iron and nickel). The magnetic field of earth arises due to electrical currents produced by convective motion of metallic fluids in the outer core of earth.

So, the convection currents are the main reason behined the earth's magnetic field.

However, the physical quantities that determines the intensity of the earth's total magnetic field completely are the magnetic elements.

So, magnetic element is related to the earth's magnetic field.

Therefore, both A and R are true but R is not the correct explanation of A.

50. According to Gauss' theorem,

$$\phi = \frac{q_{\text{enclosed}}}{\varepsilon_0}$$

$$\Rightarrow \quad EA = E(4\pi r_1^2) = \frac{\int_0^{r_1} \rho(r) S dr}{\varepsilon_0}$$

$$= \frac{\int_0^{r_1} \frac{Q}{\pi R^4} r 4\pi r^2\, dr}{\varepsilon_0} \quad (\because S = 4\pi r^2)$$

$$= \frac{Q \times 4}{\varepsilon_0 R^4} \int_0^{r_1} r^3 dr = \frac{4Q}{\varepsilon_{04} R^4} \left(\frac{r^4}{4}\right)_0^{r_1}$$

$$\Rightarrow \quad E = \frac{Q r_1^2}{4\pi\varepsilon_0 R^4}$$

51. In R-C series circuit voltage across the capacitor leads the voltage across the resistance by $\frac{\pi}{2}$ or reading in V_1 is ahead in phase with reading in V_2.

52. If a non-polar dielectric is kept in a large external field, then it will behave as polar dielectric. This is due to the presence of the induced charges which produce a field opposing the external field.

53. The main reason in the reduction of electric field is due to the presence of dipole aligned in the direction opposite to the applied external field of polarisation.

54. As, $\varepsilon_r = 1 + \chi$, where χ is electric susceptibility.

$$\chi = 5.5 - 1 = 4.5$$

Polarisation, $P = \chi E$

where, E is the applied electric field.

$$\Rightarrow \quad P = 4.5 \times 100$$

$$P = 450 \text{ C/m}^2$$

55. We know that, only non-conducting substances can be used as a dielectric. So, ceramics is used as a dielectric.

SAMPLE PAPER 9

PHYSICS

A Highly Simulated Practice Questions Paper
*for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

Roll No. | | | | | | | |

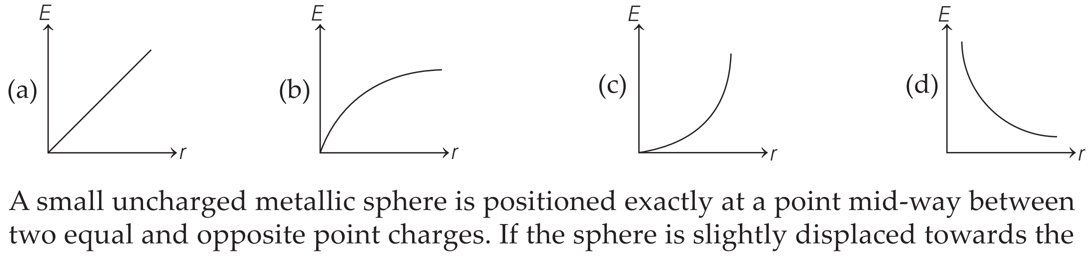
Maximum Marks : 35
Time allowed : 90 min

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

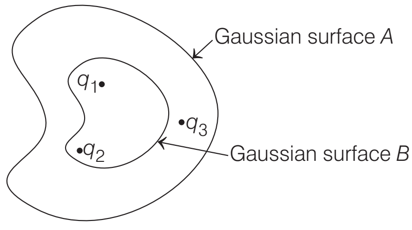
1. Study the following statements and choose the correct option.
(a) Electric field lines never form closed loops.
(b) Field lines intersect each other.
(c) A negative charge experiences a force in the direction of the field.
(d) Tangent drawn to a line of force does not represent the direction of electric field.

2. The graph which correctly represents the variation of electric field with distance r from the centre of the short dipole along its axial line will be



3. A small uncharged metallic sphere is positioned exactly at a point mid-way between two equal and opposite point charges. If the sphere is slightly displaced towards the positive charge and released, then
(a) it will oscillate about its original position
(b) it will move further towards the positive charge
(c) it will move further towards the negative charge
(d) it will not move

4. The electric flux for Gaussian surface A that enclose the charged particles in free space is (Given, $q_1 = -14$ nC, $q_2 = 78.85$ nC, $q_3 = -56$ nC)



(a) 10^4 Nm^2 C^{-1} (b) 10^3 Nm^{2}C^{-1} (c) 6.32×10^3 Nm^{2}C^{-1} (d) zero

5. A ball of mass 1 kg carrying a charge 10^{-8} C moves from a point A at potential 600 V to a point B at zero potential. The change in its kinetic energy is

(a) -6×10^{-6} erg (b) -6×10^{-6} J
(c) 6×10^{-6} J (d) 6×10^{-6} erg

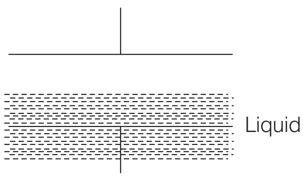
6. The work done in carrying an electron from point A to B in an electric field is 10 μJ. Then, the potential difference $(V_B - V_A)$ is

(a) + 2 kV (b) – 2MV
(c) + 20V (d) None of these

7. Equal charge is given to two metallic spheres of different radii. The potential will be

(a) more on the smaller sphere
(b) more on the bigger sphere
(c) equal on both the spheres
(d) depend on the nature of the materials of the spheres

8. A parallel plate capacitor is located horizontally such that one of the plates is submerged in a liquid while the other is above the liquid surface. When plates are charged, the level of liquid



(a) rises
(b) falls
(c) remains unchanged
(d) may rise or fall depending on the amount of charge

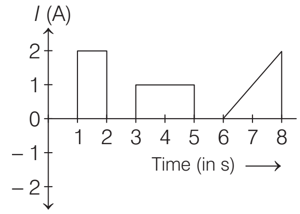
9. From the following situations choose the correct one, for which the heat generated by a coil connected to a battery is maximum?

(a) When the coil is directly connected to the battery as such.
(b) When the coil is divided into two equal parts and both parts are connected to the battery in parallel.
(c) When the coil is divided into four equal parts which are connected to the battery in parallel.
(d) When only half of the coil is connected to the battery.

10. In a potentiometer, null point were obtained at 120 cm and 160 cm with cell of emf 2.1 V and one unknown emf x V. The value of x is

(a) 2.4 (b) 1.1 (c) 2.8 (d) 2.1

11. The plot represents the flow of current through a wire at three different times. The ratio of charges flowing through the wire at different times, is (see figure)



(a) 2 : 1 : 2 (b) 1 : 3 : 3 (c) 1 : 1 : 1 (d) 2 : 3 : 4

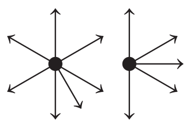
12. The number of dry cells each of emf 1.5 V and internal resistance 0.5 Ω that must be joined in series with a resistance of 20 Ω, so as to send a current of 0.6 A through the circuit, is

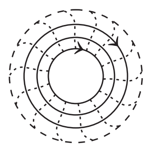
(a) 2 (b) 8 (c) 10 (d) 12

13. Which amongst the following options correctly depicts the magnetic field lines?

(a) 

(b) 

(c) 

(d) 

14. In order to decrease the current sensitivity of a moving coil galvanometer, the physical quantity that should be increased is

(a) strength of its magnet
(b) torsional constant of its suspension
(c) number of turns of its coil
(d) area of its coil

15. Deuterium and helium are subjected to an accelerating field simultaneously. Then, which of the following statements is/are correct?

(a) Both the particles will acquire same energy.
(b) Deuterium accelerates faster, than helium.
(c) Helium accelerates faster than deuterium.
(d) Neither of them have acceleration in any field.

16. A wire of length 4 cm carrying current 2A is bent to form a circlular coil. The magnetic moment of the coil (in A-m^2) is

(a) $\frac{1}{\pi}$ (b) π (c) $\frac{\pi}{2}$ (d) $\frac{8}{\pi}$

17. The primary origin(s) of magnetism lies in

(a) atomic currents (b) Pauli exclusion principle
(c) polar nature of molecules (d) None of these

18. If the magnetic field on the earth be modelled by the of a point magnetic dipole at the centre of the earth. The angle of dip at a point on the geographical equator

(a) is always zero
(b) is unbounded
(c) can be positive or negative
(d) None of these

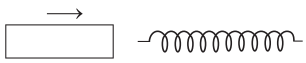
19. A long solenoid has 200 turns. When a current of 2A flows through it, the magnetic flux linked with each turn of the solenoid is 2×10^{-3} Wb. The self-inductance of solenoid is

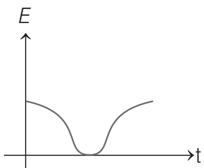
(a) 1 H
(b) 0.1 H
(c) 2 H
(d) 0.2 H

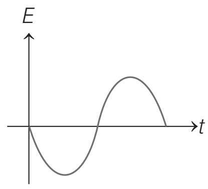
20. A squared shaped coil of area A is placed in a magnetic field that changes from B to $3B$ in time interval t. The emf induced in the coil will be

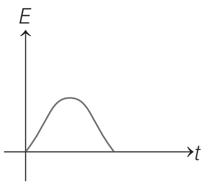
(a) $2BA/t$
(b) $4BA/t$
(c) $3B/At$
(d) $4B/At$

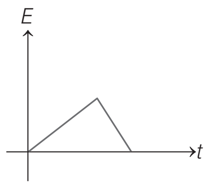
21. The variation of induced emf (E) with time (t) in a coil, if a short bar magnet is moved along its axis with a constant velocity is best represented as



(a)


(b)


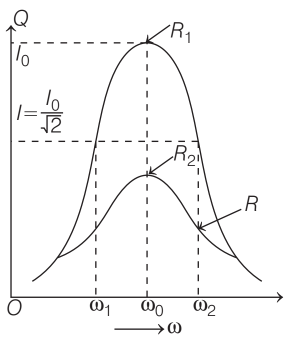
(c)


(d)


22. A bulb is connected first with AC and then with DC of same voltage. It will shine brightly

(a) in DC
(b) in AC
(c) in the ratio of brightness 1 : 4
(d) equal in both the circuits

23. The graph shown below, depicts the variation of Q-factor with angular frequency ω of an L-C-R series circuit for two resistances R_1 and R_2. So, the relation between R_1 and R_2 will be



(a) $R_1 = R_2$
(b) $R_1 > R_2$
(c) $R_1 < R_2$
(d) Information is insufficient

24. Average value of current/voltage in which of the following option(s) is non-zero?

(a) $I = 4 + 3\cos\omega t$
(b) $V = 5\sin\omega t + 3\cos\omega t$
(c) $I = \sin\omega t + 2\sin 2\omega t + 3\sin 3\omega t$
(d) Both (b) and (c)

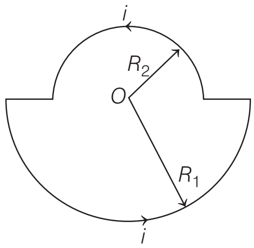
25. In step-up transformer, relation between number of turns in primary (N_p) and number of turns in secondary (N_s) coils is

(a) $N_s > N_p$
(b) $N_p > N_s$
(c) $N_s = N_p$
(d) $N_p = 2N_s$

Section B

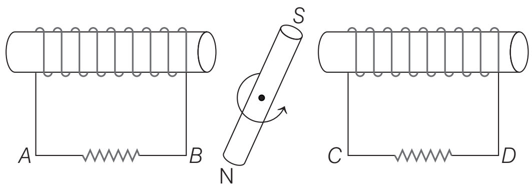
This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. Magnitude and direction of magnetic field at point O in the following figure, is



(a) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, $\otimes$
(b) $\frac{\mu_0 i}{3R}\left(\frac{1}{\pi} + \frac{3}{2}\right)$, $\odot$
(c) $\frac{\mu_0 i}{4R}\left(\frac{2}{\pi} + 1\right)$, $\otimes$
(d) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$, $\odot$

27. The magnet in figure rotates a shown on a pivot through its centre. At the instant shown, what are the directions of the induced currents?

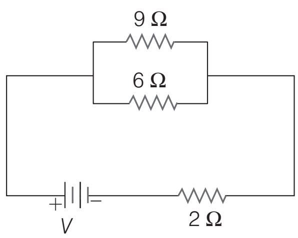


(a) A to B and C to D
(b) B to A and C to D
(c) A to B and D to C
(d) B to A and D to C

28. The excess (equal in number) of electrons that must be placed on each of two small spheres spaced 3 cm apart, with force of repulsion between the spheres to be 10^{-19}N, is

(a) 25
(b) 225
(c) 625
(d) 1250

29. If power dissipated in the 9 Ω resistor in the circuit shown is 36W, the potential difference across the 2 Ω resistor is

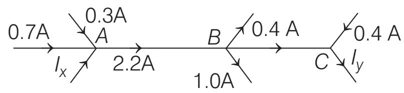


(a) 8 V
(b) 10 V
(c) 2 V
(d) 4 V

30. A toroid of n turns, mean radius R and cross-sectional radius a carries current I. It is placed on a horizontal table taken as XY-plane. Its magnetic moment m
(a) is non-zero and points in the z-direction by symmetry
(b) points along the axis of the toroid
(c) is zero, otherwise there would be a field falling as $\frac{1}{r^3}$ at large distances outside the toroid
(d) is pointing radially outwards

31. A 60 μF capacitor is connected to a 110 V, 60Hz AC supply. The rms value of the current in the circuit will be
(a) 2.5 A (b) 2.1 A (c) 3.1 A (d) 3.5 A

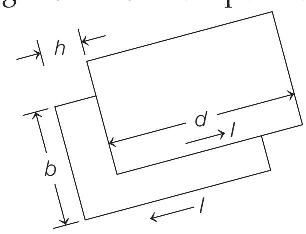
32. In the following figure, values of I_x and I_y are respectively



(a) 1 A, 1A (b) 1.2 A, 1.2 A (c) 0.8 A, 0.8 A (d) 1 A, 1.2 A

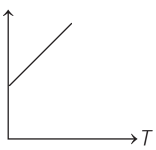
33. A spherical conductor carrying a charge q. If the electric field of conductor with radii 5 cm, 10 cm and 15 cm at the centre of conductor is E_1, E_2 and E_3 respectively, then
(a) $E_1 < E_2 < E_3$ (b) $E_1 = E_2 = E_3$
(c) $E_1 > E_2 > E_3$ (d) $E_1 = E_2 > E_3$

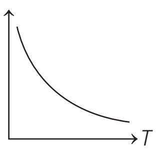
34. The inductance per unit length of a double tape line as shown in the figure, is

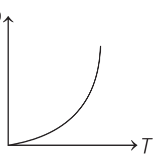


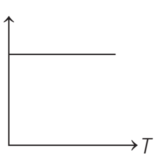
(a) $\frac{\mu_0 h}{b}$ (b) $\frac{b}{\mu_0 h}$ (c) $\frac{\mu_0 b}{h}$ (d) $\frac{hb}{\mu_0}$

35. The correct variation of resistivity with temperature for manganin is depicted in which of the following option?

(a) 

(b) 

(c) 

(d) 

36. A charge $q = 1\,\mu C$ is placed at point Q(1m, 2m, 4m). The electric field (in N/C) at point P(0m, – 4m, 3m) is
(a) $-38.42\hat{\mathbf{i}} - 230.52\,\hat{\mathbf{j}} - 38.42\,\hat{\mathbf{k}}$ (b) $4\hat{\mathbf{i}} - 3\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$
(c) $230\hat{\mathbf{i}} - 38.4\,\hat{\mathbf{j}} - 382\,\hat{\mathbf{k}}$ (d) $9\hat{\mathbf{i}} - 2\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$

37. The horizontal component of the earth's magnetic field is 0.22 G and the total magnetic field is 0.4 G. The angle of dip is

(a) $\tan^{-1}(\infty)$ (b) $\tan^{-1}(1.518)$

(c) $\tan^{-1}(\pi)$ (d) $\tan^{-1}(1)$

38. Two charged spherical conductors of radii R_1 and R_2 are connected by a wire, then the ratio of volume charge densities of the sphere ρ_1/ρ_2 is

(a) $\frac{R_1}{R_2}$ (b) $\frac{R_1^2}{R_2^2}$ (c) $\frac{R_2^2}{R_1^2}$ (d) $\frac{R_2}{R_1}$

39. A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant, uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement(s) from the following.

(a) The entire rod is at the same electric potential.
(b) There is an electric field in the rod.
(c) The electric potential is highest at the centre of the rod and decreases towards its ends.
(d) The electric potential is lowest at the centre of the rod and increases towards its ends.

40. Mean free path of electrons in a copper wire at room temperature is
(Take, resistivity of copper $= 1.7 \times 10^{-8}\ \Omega$-m, density of electrons in copper wire $= 8.5 \times 10^{28}\ \text{m}^{-3}$, charge on an electron $= 1.6 \times 10^{-19}$ C, mass of an electron $= 9.1 \times 10^{-31}$ kg and drift velocity of free electrons $= 1.6 \times 10^{-4}\ \text{ms}^{-1}$)

(a) 5×10^{-10} m (b) 4×10^{-18} m

(c) 2×10^{-18} m (d) 9×10^{-18} m

41. A deuteron and α-particles are shot into a magnetic field at right angles to the field with same kinetic energy, then the ratio of their radii is

(a) $\sqrt{2}:1$ (b) 1 : 2 (c) 1 : 1 (d) $1:\sqrt{2}$

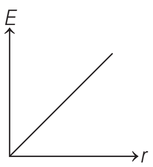
42. Three point charges $q_1 = 1\mu\text{C}$, $q_2 = -1\mu\text{C}$ and $q_3 = 2\mu\text{C}$ are placed at (1m, 0, 0), (0, 1m, 0) and (0, 0, 2m), respectively. The electric potential at origin will be

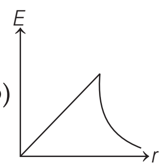
(a) 8×10^4 V (b) 4×10^2 V (c) 6×10^4 V (d) 9×10^3 V

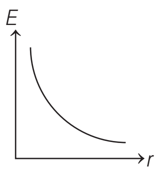
43. A charged particle is projected with some initial velocity in a region of electric and magnetic fields, such that $\mathbf{E} = 0$, $\mathbf{B} \neq 0$, $\mathbf{E} \neq \mathbf{B}$. Initial velocity of the particle makes an angle θ with $\mathbf{B}$, where $\theta \neq 90°$. The probable path traversed by the particle will be

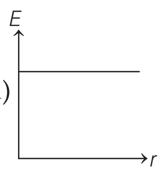
(a) straight line (b) circular (c) helical (d) Both (b) and (c)

44. For a conducting plate with uniform surface charge density σ, the electric field is plotted as a function of distance from the centre. The graph which depicts *E versus r* will be

(a) 

(b) 

(c) 

(d) 

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) *Both A and R are true and R is the correct explanation of A.*
(b) *Both A and R are true, but R is not the correct explanation of A.*
(c) *A is true, but R is false.*
(d) *A is false and R is also false.*

45. **Assertion** When glass rod is rubbed with silk cloth, rod gets positively charged and silk gets negatively charged.

Reason Some of the electrons from the rod are transferred to silk cloth.

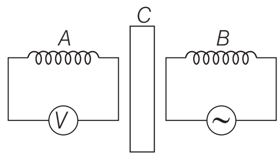
46. **Assertion** When a choke coil is connected in series with a lamp to a DC line, the lamp is seen to shine brightly.

Reason Insertion of the iron core in the choke causes, no change in the brightness of the lamp.

47. **Assertion** For a charged particle moving from point P to point Q, the net work done by an electrostatic field on the particle is independent of the path connecting point P to point Q.

Reason The net work done by a conservative force on an object moving along a closed loop is zero.

48. **Assertion** A coil A is connected to a voltmeter V and the other coil B is connected to an alternating current source. If a large copper sheet C is placed between the two coils, the induced emf in the coil A is reduced.



Reason Copper sheet between the coils, has no effect on the induced emf in coil A.

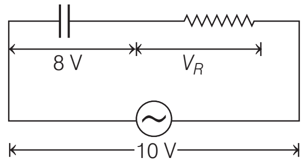
49. **Assertion** Two identical heaters are connected to two different sources, i.e. one with DC and other with AC having same potential difference across their terminals.The heat produced in heater supplied with AC source is greater.

Reason The net impedance of an AC source is greater than resistance offered by a DC source.

Section C

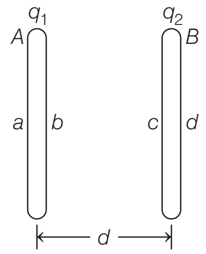
This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

50. In a series R-C circuit shown in figure, the applied voltage is 10 V and the voltage across capacitor is found to be 8V. Then, the voltage across R will be



(a) 6V with phase difference of $\tan^{-1}\left(\frac{4}{3}\right)$
(b) 3V with phase difference of $\tan^{-1}\left(\frac{3}{4}\right)$
(c) 6V with phase difference of $\tan^{-1}\left(\frac{5}{3}\right)$
(d) 4V with phase difference of $\tan^{-1}\left(\frac{5}{3}\right)$

51. Consider that, the charges given to the two plates A and B of a parallel plate capacitor are different, i.e. q_1 and q_2 as shown in figure below



With the help of the information given above, which of the following statement is correct?

I. The charge on the surfaces a and b of the plate A are $\frac{q_1 + q_2}{2}$ and $\frac{q_1 - q_2}{2}$.

II. The charges on the surfaces c and d of the plate B are $\frac{q_1 - q_2}{2}$ and $\frac{q_1 + q_2}{2}$.

III. The electric field between the two plates A and B is $\frac{q_1 - q_2}{2\varepsilon_0 A}$.

(a) Both I and II
(b) Both II and III
(c) Both I and III
(d) I, II and III

Case Study

Read the following paragraph and answers the questions.

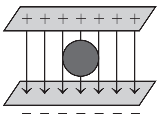
Electrostatic Shielding

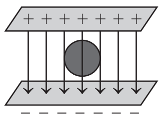
Electrostatic shielding is the phenomenon that is observed when a Faraday cage operates to block the effects of an electric field. Such a cage can block the effects of an external field on its internal contents or the effects of an internal field on the outside environment. This happens because no electric field exist inside a hollow conductor, even if there are charges present outside. Thus, the conductor acts like an electrostatic shield. This is only true, if the conductor is kept at a constant potential.

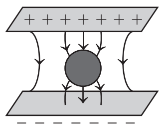
52. For a Faraday's cage, the charge given to any conductor resides on its outer surface, because the free charge tends to be in its

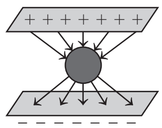
(a) minimum potential energy state
(b) minimum kinetic energy state
(c) maximum potential energy state
(d) maximum kinetic energy state

53. An uncharged sphere of conductor is placed in between two charged plates as shown. The correct option representing lines of force will be

(a) 

(b) 

(c) 

(d) 

54. Which of the following statement is incorrect for a perfect conductor?

(a) The surface of the conductor is an equipotential surface.
(b) The electric field just outside the surface of a conductor is perpendicular to the surface.
(c) The charge carried by a conductor is always uniformly distributed over the surface of the conductor.
(d) None of the above

55. The potential of a spherical conductor of radius 3 m is 6 V. The potential as its centre is

(a) zero (b) 2 V (c) 6 V (d) 18 V

OMR SHEET

SP 9

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

● Correct ✔ Incorrect ✗ Incorrect ◓ Incorrect

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	a	b	c	d	**20**	a	b	c	d	**38**	a	b	c	d
2	a	b	c	d	**21**	a	b	c	d	**39**	a	b	c	d
3	a	b	c	d	**22**	a	b	c	d	**40**	a	b	c	d
4	a	b	c	d	**23**	a	b	c	d	**41**	a	b	c	d
5	a	b	c	d	**24**	a	b	c	d	**42**	a	b	c	d
6	a	b	c	d	**25**	a	b	c	d	**43**	a	b	c	d
7	a	b	c	d	**26**	a	b	c	d	**44**	a	b	c	d
8	a	b	c	d	**27**	a	b	c	d	**45**	a	b	c	d
9	a	b	c	d	**28**	a	b	c	d	**46**	a	b	c	d
10	a	b	c	d	**29**	a	b	c	d	**47**	a	b	c	d
11	a	b	c	d	**30**	a	b	c	d	**48**	a	b	c	d
12	a	b	c	d	**31**	a	b	c	d	**49**	a	b	c	d
13	a	b	c	d	**32**	a	b	c	d	**50**	a	b	c	d
14	a	b	c	d	**33**	a	b	c	d	**51**	a	b	c	d
15	a	b	c	d	**34**	a	b	c	d	**52**	a	b	c	d
16	a	b	c	d	**35**	a	b	c	d	**53**	a	b	c	d
17	a	b	c	d	**36**	a	b	c	d	**54**	a	b	c	d
18	a	b	c	d	**37**	a	b	c	d	**55**	a	b	c	d
19	a	b	c	d										

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (a)	**2.** (d)	**3.** (b)	**4.** (b)	**5.** (c)	**6.** (d)	**7.** (a)	**8.** (a)	**9.** (c)	**10.** (c)
11. (c)	**12.** (c)	**13.** (d)	**14.** (b)	**15.** (d)	**16.** (d)	**17.** (a)	**18.** (c)	**19.** (d)	**20.** (a)
21. (b)	**22.** (d)	**23.** (c)	**24.** (a)	**25.** (a)	**26.** (d)	**27.** (a)	**28.** (c)	**29.** (b)	**30.** (c)
31. (a)	**32.** (b)	**33.** (b)	**34.** (a)	**35.** (a)	**36.** (a)	**37.** (b)	**38.** (c)	**39.** (b)	**40.** (b)
41. (a)	**42.** (d)	**43.** (c)	**44.** (d)	**45.** (a)	**46.** (c)	**47.** (b)	**48.** (c)	**49.** (a)	**50.** (a)
51. (c)	**52.** (c)	**53.** (c)	**54.** (c)	**55.** (c)					

SOLUTIONS

1. Statement given in option (a) is correct, but rest are incorrect and these can be corrected as,
A negative test charge experiences a force opposite to the direction of the field.

The tangent drawn to a line of force represents the direction of electric field.

Field lines never intersect each other.

2. Electric field at a distance r from the centre of short dipole along its axial line is given as

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\frac{2\mathbf{p}}{r^3}$$

$$\Rightarrow \qquad E \propto \frac{1}{r^3}$$

So, the correct graph is depicted in option (d).

3. Initially, the force experienced by the sphere is equal in magnitude but opposite in direction due to both negative and positive charges.

$\therefore$ Net force $=0$

On displacing the sphere towards the positive charge, force on sphere due to positive charge will be more than due to the negative charge, because of its closeness. So, sphere will move further towards the positive charge.

4. Electric flux, $\phi = \dfrac{q}{\varepsilon_0}$

where, q is the net charge enclosed in the Gaussian surface.

$$= \frac{(-14 + 78.85 - 56)\times 10^9}{8.85\times 10^{-12}}$$

$$= \frac{8.85\times 10^{-9}}{8.85\times 10^{-12}} = 10^3 \text{ Nm}^2\text{C}^{-1}$$

5. As work is done by the field, kinetic energy (KE) of the body increased.

$$\therefore \qquad \Delta\text{KE} = W = q(V_A - V_B)$$
$$= 10^{-8}(600 - 0) = 6\times 10^{-6}\text{ J}$$
$$= 6\times 10^{-6}\times 10^7 \text{ erg}$$
$$= 60 \text{ erg}$$

6. Given, $W = 10\mu\text{J} = 10\times 10^6$ J

Since, $W = q\Delta V = e(V_B - V_A)$

$$\Rightarrow V_B - V_A = W/e = \frac{10\times 10^6}{1.6\times 10^{-19}} = 6.25\times 10^{25}\text{V}$$

7. Potential on a metallic sphere of radius R is given as, $V = \dfrac{kq}{R}$, i.e. $V \propto \dfrac{1}{R}$

($\because$ k and q are constants)

$\therefore$ Potential on smaller sphere will be more.

8. When plates of the capacitor are charged, then opposite charges are induced on water. So due to attractive force, water level will rise.

9. Since, battery supplies constant emf. So, heat generated in the coil, $H = \dfrac{V^2t}{R}$ or $H \propto \dfrac{1}{R}$.

So, R should be minimum to generate maximum heat. In option (c), resistance would be minimum, since four parts of the coil are connected in parallel. So, heat generated would be maximum.

10. As we know, in a potentiometer $E = \dfrac{V}{l}$

where, E is a constant.

$$\Rightarrow \quad \frac{V_1}{l_1} = \frac{V_2}{l_2}$$

$$\Rightarrow \quad \frac{2.1}{120} = \frac{V_2}{160}$$

$$\Rightarrow \quad V_2 = \frac{160\times 2.1}{120} = 2.8 \text{ V}$$

$$\therefore \quad x = 2.8$$

11. As we know, charge = Area under the current-time graph

For time interval 1 s to 2 s, $q_1 = 2\times 1 = 2$ C
for time interval 3 s to 5 s, $q_2 = 1\times 2 = 2$ C
and for time interval 6 s to 8 s,

$$q_3 = \frac{1}{2}\times 2\times 2 = 2 \text{ C}$$

$\therefore$ $q_1 : q_2 : q_3 = 2:2:2 = 1:1:1$

12. For n identical cells (series grouping),

$$I = \frac{nE}{nr + R}$$

$$\Rightarrow \quad \mathbf{0.6} = \frac{n \times 1.5}{n \times 0.5 + 20}$$

This gives, $n = 10$.

13. In option (d), magnetic field lines are completely confined within a toroid. Field lines are forming closed loops, since each loop encloses a region across which a current passes. Thus, it correctly depicts magnetic field lines.

But, magnetic field lines can never emanate from a point, as shown in options (a) and (c).

Magnetic field lines (like electric field lines) can never cross each other, otherwise the direction of field at the point of intersection is ambiguous. Thus, option (b) is also incorrect.

14. Sensitivity of a moving coil galvanometer, $S = \frac{NAB}{C}$

where, C is the torsional constant of its suspension.

$$\Rightarrow \quad S \propto \frac{1}{C}$$

($\because N$, A and B are constants)

So, in order to decrease the current sensitivity of a moving coil galvanometer the torsional constant of its suspension should increase.

15. Both deuterium and helium are neutral particles. So, they are not affected by electric or magnetic field. Hence, they will not be accelerated in any field.

16. Given, length of wire, $L = 2\pi R = 4$ cm

$$\Rightarrow \quad R = \frac{2}{\pi}\text{ m}$$

Magnetic moment of the coil,

$$M = iA = (i)(\pi R^2) = 2 \times \pi \times \frac{2}{\pi} \times \frac{2}{\pi} = \frac{8}{\pi}\text{ A-m}^2$$

17. The primary origin of magnetism lies in the fact that, the electrons are revolving and spinning about nucleus of an atom, which gives rise to current called atomic current.

18. If the total magnetic field of the earth is modelled by a point magnetic dipole at the centre, then it is in the same plane of magnetic equator. In the north, the B_V is upward, so angle of dip is negative and in the south B_V is downward. So, angle of dip is positive. Thus, the angle of dip at a point on the geographical equator is bounded in a range from positive to negative values.

19. As, flux linkage = flux through each turn $\times n$

$$\phi = 2 \times 10^{-3} \times 200 = 0.4\text{ Wb}$$

Also, $\phi = LI$, where L is the self-inductance of the solenoid.

$$\Rightarrow \quad L = \frac{\phi}{I} = \frac{0.4}{2} = 0.2\text{ H}$$

20. As, magnitude of induced emf,

$$|e| = \frac{\Delta\phi}{\Delta t} = \frac{3BA - BA}{t} = \frac{2BA}{t}$$

21. When a short bar magnet is moved along its axis with constant velocity, then in accordance with Faraday's law of electromagnetic induction, emf is induced.

The polarity of the emf induced will be opposite in the two cases, while the magnet enters the coil and while the magnet leaves the coil. This condition is satisfied only in the graph shown in option (b).

22. Since, brightness is related as $P_{\text{consumed}} \propto \frac{1}{R}$

Here, the voltage is same $V_{AC} = V_{DC}$.

For bulb, $R_{AC} = R_{DC}$

So, brightness will be equal in both the cases.

23. $$Q\text{-factor} = \frac{\text{Voltage across } L \text{ or } C}{\text{Voltage across } R}$$

$$= \frac{V_L \text{ or } V_C}{V_R} = \frac{\omega_0 L}{R} \text{ or } \frac{1}{\omega_0 RC}$$

($\therefore X_L = X_C$)

From the above relation, it is clear that as R increases (or current decreases), Q-factor of the circuit decreases.

So, $R_1 < R_2$.

24. Average value of a sinusoidal function is zero, so optionwise

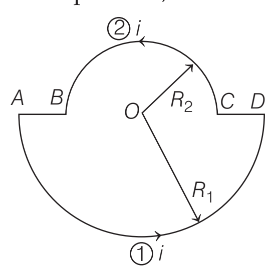
(a) average value of current, $I_{av} = I_0 = 4$ units

(b) average value of the voltage, $V_{av} = 0$

(c) average value of current, $I_{av} = 0$

25. In step-up transformer, the number of turns in secondary coil is greater than the number of turns in the primary coil, i.e. $N_S > N_P$. Because in this case, voltage is stepped up ($V_S > V_P$).

26. According to the question,



Magnetic field at O due to straight wires AB and CD is zero.

Magnetic fields due to semi-circular wires, i.e. BC and DA are

$$B_1 = \frac{\mu_0 i}{4R_1}, \odot \quad (\because i \text{ is clockwise})$$

and $$B_2 = \frac{\mu_0 i}{4R_2}, \odot$$

Magnetic field at the centre point O,

$$B_O = B_1 + B_2 = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} + \frac{1}{R_2}\right), \odot$$

27. In the rotation of magnet, N-pole moves closer to coil CD and S-pole moves closer to coil AB. As per Lenz's law, N-pole should develop at the end corresponding to C. Induced current flows from C to D. Again, S-pole should develop at the end corresponding to B. Therefore, induced current in the coil flows from A to B.

28. Coulomb's law is given by

$$F = K\frac{q_1 q_2}{r^2}$$

Substituting $q_1 = q_2 = ne$, we get

$$F = K\frac{(ne)(ne)}{r^2} = K\frac{n^2e^2}{r^2}$$

$$\Rightarrow \quad n^2 = \frac{Fr^2}{Ke^2}$$

On putting $F = 10^{-19}\,\mathbf{N}, r = 3\,\mathbf{cm} = 3 \times 10^{-2}\text{m}$, $K = 9 \times 10^9\ \text{N}\mathbf{m^2}\ \text{C}^{\mathbf{-2}}$, $e = 1.6 \times 10^{-19}$ C, we get

$$n^2 = \frac{10^{-19} \times (3 \times 10^{-2})^2}{9 \times 10^9 \times (1.6 \times 10^{-19})^2}$$

$$\Rightarrow \quad n = 625$$

29. Electric power, $P = i^2R$

$\therefore$ Current, $i = \sqrt{\frac{P}{R}}$

For resistance of 9 Ω,

$$i_1 = \sqrt{\frac{36}{9}} = \sqrt{4} = 2 \text{ A}$$

and $$i_2 = \frac{i_1 \times R}{6} = \frac{2 \times 9}{6} = 3 \text{ A}$$

$\because \quad I = i_1 + i_2 = 2 + 3 = 5$ A

So, $V_2 = IR_2 = 5 \times 2 = 10$ V

30. In case of toroid, the magnetic field is only confined inside its coils and its magnetic lines of force is in the form of concentric circles. However, there is no magnetic field outside the body of toroid. This is because, the loop outside encloses no current. Thus, the magnetic moment of toroid is zero.

In general, if we take r as a large distance outside the toroid, then $m \propto \frac{1}{r^3}$. As, m is zero, so it has no direciton.

31. Given, capacitance of the capacitor, $C = 60\ \mu\text{F}$

$$= 60 \times 10^{-6} \text{ F}$$

$$V_{\text{rms}} = 110 \text{ V}$$

Frequency of AC supply, $f = 60$ Hz

Capacitive reactance,

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2 \times 3.14 \times 60 \times 60 \times 10^{-6}}$$

$$= 44.23\ \Omega$$

The rms value of the current in the circuit,

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{X_C}$$

$$= \frac{110}{44.23} = 2.49 \approx 2.5 \text{ A}$$

32. Applying Kirchhoff's first law, i.e. $\Sigma I = 0$, at the nodes A, B and C, we get

at the node A, $I_x + 0.7 + 0.3 = 2.2$

i.e. $\quad I_x = 1.2$ A

at the node B, $2.2 - (1.0 + 0.4) = 0.8$ **A**

Then, at the node C, $\mathbf{0.8} + \mathbf{0.4} = I_y$

i.e. $\quad I_y = \mathbf{1.2\ A}$

33. Since, spherical conductor is a equipotential surface.

So, $E_{\text{inside}} = 0 \Rightarrow E_1 = E_2 = E_3$

34. Neglecting end effects of magnetic field, we have

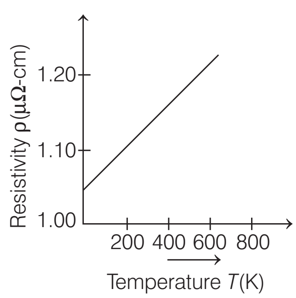
$$B = \frac{\mu_0 I}{b}$$

Flux per unit length of the plates,

$$\phi = B \times A = \frac{\mu_0 I}{b} \times h \times 1 = \frac{\mu_0 hI}{b}$$

Also, $\phi = LI \Rightarrow L = \frac{\mu_0 h}{b}$

35. Some materials like nichrome, manganin, etc., exhibit a very weak dependence of resistivity with temperature as shown



36. Given, $\mathbf{r}_Q = \hat{\mathbf{i}} + 2\hat{\mathbf{j}} + 4\hat{\mathbf{k}}$

and $\mathbf{r}_P = -4\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$

$\therefore \mathbf{r}_P - \mathbf{r}_Q = -\hat{\mathbf{i}} - 6\hat{\mathbf{j}} - \hat{\mathbf{k}}$

or $|\mathbf{r}_P - \mathbf{r}_Q| = \sqrt{(-1)^2 + (-6)^2 + (-1)^2} = \sqrt{38}$ m

Now, electric field,

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{|\mathbf{r}_P - \mathbf{r}_Q|^3} (\mathbf{r}_P - \mathbf{r}_Q)$$

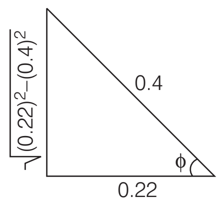
Substituting the values, we have

$$\mathbf{E} = \frac{(9.0 \times 10^9)(1.0 \times 10^{-6})}{(38)^{3/2}} (-\hat{\mathbf{i}} - 6\hat{\mathbf{j}} - \hat{\mathbf{k}})$$

$$\mathbf{E} = (-38.42\hat{\mathbf{i}} - 230.52\,\hat{\mathbf{j}} - 38.42\,\hat{\mathbf{k}})\text{ N/C}$$

37. As we know, $B_H = B\cos\phi$

$$\Rightarrow \quad \cos\phi = \frac{B_H}{B} = \frac{0.22}{0.4}$$



$$\Rightarrow \quad \tan\phi = \frac{\sqrt{(0.4)^2 - (0.22)^2}}{0.22}$$

$$\Rightarrow \quad \phi = \tan^{-1}(1.518)$$

38. Potential at the surface of spherical conductor of radius R carrying charge Q,

$$V_S = \frac{Q}{4\pi\varepsilon_0 R}$$

Let Q_1 and Q_2 are the charges on two spherical conductors of radii R_1 and R_2, respectively.

When these two charged spherical conductors are connected by a wire, the potential at their surfaces becomes equal.

$$\therefore \quad V_{S_1} = V_{S_2}$$

$$\frac{Q_1}{4\pi\varepsilon_0 R_1} = \frac{Q_2}{4\pi\varepsilon_0 R_2} \Rightarrow \frac{Q_1}{Q_2} = \frac{R_1}{R_2} \quad \dots \text{(i)}$$

Volume charge density, $\sigma = \dfrac{\text{Charge}}{\text{Volume}}$

$$\therefore \quad \frac{\sigma_1}{\sigma_2} = \frac{\left(\dfrac{Q_1}{\frac{4}{3}\pi R_1^3}\right)}{\left(\dfrac{Q_2}{\frac{4}{3}\pi R_2^3}\right)} = \frac{Q_1}{Q_2} \times \frac{R_2^3}{R_1^3} = \frac{R_1}{R_2} \times \frac{R_2^3}{R_1^3}$$

[from Eq. (i)]

$$= \frac{R_2^2}{R_1^2}$$

39. According to Faraday's law, an induced emf is set up on the rod, whose magnitude is Blv. Thus, an electric field is generated in the rod. The electric potential varies uniformly along the rod.

40. We know that, $\rho = \dfrac{m_e}{ne^2\tau}$

$\therefore$ Relaxation time,

$$\tau = \frac{m_e}{e^2 n\rho} = \frac{9.1 \times 10^{-31}}{(1.6 \times 10^{-19})^2 \times 8.5 \times 10^{28} \times 1.7 \times 10^{-8}}$$

$$\simeq 2.5 \times 10^{-14}\text{s}$$

Mean free path of electron (distance covered between two collisions)

$$= v_d\tau = 1.6 \times 10^{-4} \times 2.5 \times 10^{-14}$$

$$\cong 4 \times 10^{-18}\text{ m}$$

41. The radius of the circular path of a charged particle in magnetic field,

$$r = \frac{mv}{qB} = \frac{\sqrt{2mE}}{qB}$$

Here, kinetic energy (E) for deuteron and α-particle is same and both are moving in the same magnetic field.

$$\therefore \quad r \propto \frac{\sqrt{m}}{q}$$

So, $$\frac{r_d}{r_\alpha} = \frac{\dfrac{\sqrt{m_d}}{q_d}}{\dfrac{\sqrt{m_\alpha}}{q_\alpha}} = \sqrt{\frac{m_d}{m_\alpha}} \times \frac{q_\alpha}{q_d}$$

$$= \sqrt{\frac{2m}{4m}} \cdot \frac{2q}{q}$$

$$= \frac{2}{\sqrt{2}} = \sqrt{2} \text{ or } \sqrt{2} : 1$$

42. The net electric potential at origin,

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3}\right)$$

Substituting the values, we have

$$V = (9.0 \times 10^9)\left(\frac{1}{1.0} - \frac{1}{1.0} + \frac{2}{2.0}\right) \times 10^{-6}$$

$$= 9.0 \times 10^3\text{ V}$$

43. Since, $\mathbf{E} = 0$; $\mathbf{B} \neq 0$ and $\mathbf{E} \neq \mathbf{B}$, i.e. only the magnetic force acts on it. So, the path traversed by the particle will be helical (with uniform pitch), if $\mathbf{v}$ is at any angle to $\mathbf{B}(\theta \neq 90^\circ)$.

44. Electric field near a charged conducting plate/surface of any shape is given by $E = \frac{\sigma}{\varepsilon_0}$, where σ is the surface charge density.

i.e. E is independent of the distance from the centre of the plate.

Thus, the correct graph is shown in option (d).

45. When we rub a glass rod with silk, some of the electrons from the rod are transferred to the silk cloth.

Thus, rod gets positively charged and silk gets negatively charged.

Only less tightly bound electrons in rod are transferred to silk by rubbing.

Therefore, both A and R are true and R is the correct explanation of A.

46. A choke has no impedance, if it is connected to DC line. Therefore, lamp shines brightly and has no effect on inserting iron core in the choke.

But choke offers impedance, if it is connected to AC line. As, when an iron core is inserted in the choke, the impedance to AC increases. Hence, the brightness of the bulb decreases.

Therefore, A is true, but R is false.

47. Work done by conservative force does not depend on the path but depends only on end points. So, for a closed path it is zero.

As electrostatic force is a conservative force.

So, when a charged particle moves from point P to Q, then the work done by an electrostatic field on the particle is independent of the path connecting point P to Q.

Therefore, both A and R are true but R is not the correct explanation of A.

48. In the absence of the copper sheet, induced emf will be produced in the coil A due to the mutual induction between the coils A and B. As a result, voltmeter will show deflection depending on the magnitude of the induced emf.

When the copper sheet is placed between the two coils, eddy currents will be set-up in the coil. Since, the eddy currents have an opposing effect, the magnetic flux linked with A due to eddy current will always be opposite to that due to the alternating current through B. Thus, induced current will be reduced.

Therefore, A is true, but R is false.

49. In the case of DC source, the frequency is zero and the net impedance is equal to the resistance.

However, in the case of AC source, the impedance of the circuit is given by

$$Z = \sqrt{R^2 + \omega^2 L^2}$$

where, R = resistance,

ω = angular frequency

and L = inductance.

Also, heat generated by the coil, $H \propto Z$

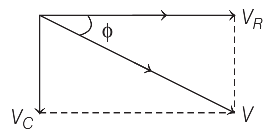
So, for the given heaters, the heat produced in heater supplied with AC source is greater.

Therefore, both A and R are true and R is the correct explanation of A.

50. We know that, for series R-C circuit,

$$V^2 = V_C^2 + V_R^2$$

Given, $V = 10$ V and $V_C = 8$ V



$$100 = 64 + V_R^2$$

$$\Rightarrow \quad V_R^2 = 36 \Rightarrow V_R = \sqrt{36} = 6 \text{ V}$$

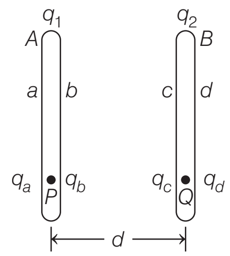
Also, $\tan\phi = \frac{V_C}{V_R} \Rightarrow \tan\phi = \frac{8}{6}$

$$\tan\phi = \frac{4}{3}$$

$$\therefore \quad \phi = \tan^{-1}\left(\frac{4}{3}\right)$$

51. At the point P, the electric field due to charge q_a is towards right, whereas it will be towards left due to charges q_b, q_c and q_d.

Since, the resultant electric field at a point inside a conductor is zero, i.e.



$$\frac{q_a}{2\varepsilon_0 A} - \frac{q_b}{2\varepsilon_0 A} - \frac{q_c}{2\varepsilon_0 A} - \frac{q_d}{2\varepsilon_0 A} = 0$$

or $\quad q_a = q_b + q_c + q_d$

$= (q_1 - q_a) + (q_2 - q_d) + q_d$

$= q_1 - q_a + q_2$

$$\Rightarrow \quad q_a = \frac{q_1 + q_2}{2}$$

and $q_b = q_1 - q_a = q_1 - \frac{q_1 + q_2}{2} = \frac{q_1 - q_2}{2}$

Similarly, the electric field at Q is zero.

$$\frac{q_a}{2\varepsilon_0 A} + \frac{q_b}{2\varepsilon_0 A} + \frac{q_c}{2\varepsilon_0 A} - \frac{q_d}{2\varepsilon_0 A} = 0$$

$$\Rightarrow \quad q_d = q_a + q_b + q_c$$

$$= (q_1 - q_b) + q_b + (q_2 - q_d)$$

$$q_d = q_1 + q_2 - q_d$$

$$\Rightarrow \quad q_d = \frac{q_1 + q_2}{2} \quad \text{and} \quad q_c = q_2 - q_d$$

$$\therefore \quad q_c = \frac{q_2 - q_1}{2}$$

The charges on the inner surfaces (q_b, q_c) which are equal and opposite are responsible for creating the electric field between the plates of the capacitor.

Thus, $E = \frac{\sigma}{\varepsilon_0} = \frac{q_1 - q_2}{2\varepsilon_0 A}$

So, statements I and III are correct but II is incorrect.

52. In a conductor, the free charges tends to be in maximum potential energy state.

53. Electric lines of force never intersects the conductor. They are perpendicular and slightly curved near the surface of conductor.

So, the correct representation of force is given by option (c).

54. The charge carried by a conductor is not always uniformly distributed over the surface of the conductor.

55. Electric potential inside a charged sphere is same everywhere as that on the surface.

$$\Rightarrow \quad V_{\text{surface}} = V_{\text{centre}} = 6\,\text{V}$$

SAMPLE PAPER 10

PHYSICS

A Highly Simulated Practice Questions Paper
*for CBSE **Class XII** (Term I) Examination*

Instructions

1. This question paper is divided into three sections.
*2. **Section - A** contains 25 questions. Attempt **any 20** questions.*
*3. **Section - B** contains 24 questions. Attempt **any 20** questions.*
*4. **Section - C** contains 6 questions. Attempt **any 5** questions.*
5. Each question carries 0.77 mark.
*6. There is **no** negative marking.*

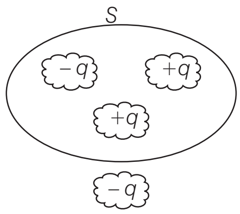
Roll No. | | | | | | | |

Maximum Marks : 35
Time allowed : 90 min

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

1. The figure given below shows a distribution of charges. The flux of electric field due to these charges through the surface *S* is



(a) q/ε_0 (b) $4q/\varepsilon_0$ (c) zero (d) $2q/\varepsilon_0$

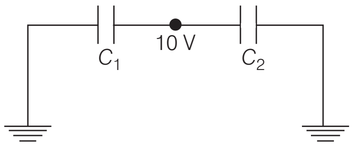
2. "All charges on a conductor must reside on its outer surface". This statement is true for
(a) hollow spheres (b) solid and hollow spheres both
(c) conductors with smooth edges (d) All of these

3. An electric dipole of dipole moment **p** is placed in a uniform external electric field **E**, then
(a) torque experienced by the dipole is $\mathbf{E} \cdot \mathbf{p}$
(b) torque is zero, if **p** is perpendicular to **E**
(c) torque is maximum, if **p** is perpendicular to **E**
(d) potential energy is maximum, if **p** is parallel to **E**

4. Two spherical conductors, each of capacity C are charged to potential V and $-V$ respectively. These are then connected by means of a fine wire. The loss of energy is

(a) $(1/2)\,CV^2$ (b) CV^2 (c) $2CV^2$ (d) zero

5. In the circuit shown below, $C_1 = 2\mu F$. The charge stored in the capacitor C_2 is (Here, $C_2 = 2C_1$)



(a) zero (b) 90 μC
(c) 20 μC (d) 40 μC

6. A hollow metal sphere of radius 5 cm is charged such that, the potential on its surface becomes 60 V. The potential at the centre of the sphere is

(a) 20 V (b) zero (c) 12 V (d) 6 V

7. The electric potential V is given as a function of distance x (metre) by

$$V = (2x^2 + 5x - 4)\text{V}$$

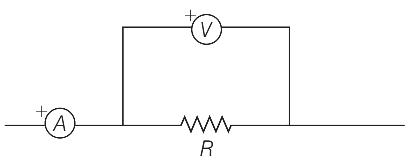
The ratio of magnitude of electric field at $x = 2$ and $x = 3$ is

(a) 20/39 (b) 6/7
(c) 13/17 (d) 23/27

8. Two point charges $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(d, 0)$ respectively of a X, Y-coordinate system, then which of the following statement(s) is/are correct?

(a) The electric field **E** at all points on the X-axis has the same direction.
(b) **E** at all points on the Y-axis is along $\hat{\mathbf{i}}$.
(c) **E** at all points on Y-axis is along $-\hat{\mathbf{i}}$.
(d) The dipole moment is $2\,qd$ directed along $\hat{\mathbf{i}}$.

9. An ammeter A, an ideal voltmeter V and a resistance R are connected as shown in figure. If the reading of voltmeter is 2.4 V and the reading of ammeter is 0.6 A, then R is



(a) equal to 4 Ω (b) greater than 4 Ω
(c) less than 4 Ω (d) between 2 Ω and 3 Ω

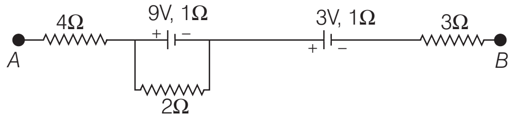
10. The slope of the graph showing the variation of potential difference on X-axis and current on Y-axis gives conductor's

(a) resistivity (b) resistance
(c) reciprocal of resistance (d) conductivity

11. A metallic resistor is connected across a battery. If the number of collisions of the free electrons with the lattice is somehow decreased in the resistor (for example by cooling it), then the current will

(a) remains constant (b) increase
(c) decrease (d) become zero

12. The potential difference between the points A and B in the circuit shown below is 16 V. Which of the following statement(s) is/are correct?



(a) The current through the 2Ω resistor is 3.5 A.
(b) The current through the 4Ω resistor is 2.5 A.
(c) The current through the 3Ω resistor is 1.5 A.
(d) The potential difference between the terminals of the 9 V battery is 8 V.

13. A moving coil galvanometer has 200 turns and each turn has an area of $1\,cm^2$. The magnetic field produced by the magnet is 0.01 T. The deflection in the galvanometer coil is 0.2 rad, when a current of 2mA is passed through it. The torsional constant (in N-m rad^{-1}) of the spiral spring will be

(a) 4×10^{-5} (b) 2×10^{5} (c) 6×10^{-6} (d) 2×10^{-6}

14. Two parallel beams of positive charges moving in the same direction will
(a) repel each other
(b) attract each other
(c) not interact with each other
(d) deflect each other making an angle of 90° between them

15. The smallest value of B that can be set-up at the equator to permit a proton of speed $10^5\ ms^{-1}$ to circulate around the earth is
(Take, $R = 6.4 \times 10^6$ m and mass of proton, $m = 1.67 \times 10^{-27}$ kg)

(a) 1.63×10^{-10} T (b) 4.2×10^{-7} T (c) 1.6×10^{-8} T (d) 9.2×10^{-10} T

16. Magnetic field produced inside a solenoid of infinite length, is
(a) directly proportional to current flowing through it
(b) directly proportional to number of turns
(c) inversely proportional to number of turns
(d) Both (a) and (b)

17. The ultimate individual unit of magnetism in any magnet is a

(a) north-pole (b) south-pole (c) dipole (d) quadrupole

18. Magnetic field lines due to a bar magnet is same as the magnetic field lines produced by a

(a) toroid (b) coil carrying current (c) solenoid (d) Both (a) and (c)

19. Faraday's law is expressed by the following formula (Here, e = induced emf, ϕ = magnetic flux in one turn and N = number of turns)

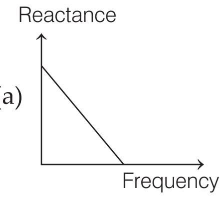
(a) $e = -\phi \dfrac{dN}{dt}$ (b) $e = -N\dfrac{d\phi}{dt}$ (c) $e = -\dfrac{d}{dt}\left(\dfrac{\phi}{N}\right)$ (d) $e = N\dfrac{d\phi}{dt}$

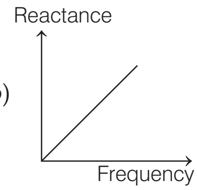
20. A circular coil expands radially in a region of magnetic field and no electromotive force is produced in the coil. Choose the correct statement for the specified result.
(a) The magnetic field is constant.
(b) The magnetic field is in the same plane as the circular coil and it may or may not vary.
(c) The magnetic field has a perpendicular (to the plane of the coil) component whose magnitude is increasing suitably.
(d) There is constant magnetic field in the perpendicular (to the plane of the coil) direction.

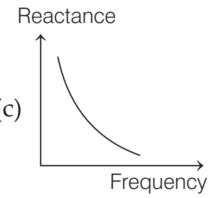
21. Choose the correct option regarding the energy stored in L and C components of an LC-circuit.

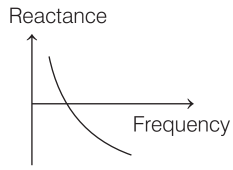
(a) $L \rightarrow$ Magnetic energy; $C \rightarrow$ Magnetic energy
(b) $L \rightarrow$ Magnetic energy; $C \rightarrow$ Electrical energy
(c) $L \rightarrow$ Electrical energy; $C \rightarrow$ Magnetic energy
(d) $L \rightarrow$ Electrical energy; $C \rightarrow$ Electrical energy

22. The graph that correctly represents the variation of reactance with angular frequency for a series L-C combination is

(a)


(b)


(c)


(d)


23. An AC voltage is applied to a resistance R and an inductor L in series. If R and the inductive reactance both are equal to 3Ω, the phase difference between the applied voltage and the current in the circuit is

(a) $\frac{\pi}{4}$ rad (b) $\frac{\pi}{2}$ rad (c) zero (d) $\frac{\pi}{6}$ rad

24. To reduce the resonant frequency in an L-C-R series circuit with a generator, which of the following statement(s) is/are correct?

(a) The generator frequency should be reduced.
(b) Another capacitor should be added in parallel to the first.
(c) The iron core of the inductor should be removed.
(d) Dielectric in the capacitor should be removed.

25. A small signal voltage $V(t) = V_0 \sin \omega t$ is applied across an ideal capacitor C. Then, which of the following is the correct result of it?

(a) Over a full cycle the capacitor C does not consume any energy from the voltage source.
(b) Current $I(t)$ is in phase with voltage $V(t)$.
(c) Current $I(t)$ leads voltage $V(t)$ by 180.
(d) Current $I(t)$ lags voltage $V(t)$ by 90°.

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 will be considered for evaluation.

26. In a neon gas discharge tube, Ne^+ ions moving through a cross-section of the tube each second to the right is 2.9×10^{18}, while 1.2×10^{18} electrons move towards left in the same time. The electronic charge being 1.6×10^{-19} C, then the net electric current is

(a) 0.27 A, towards right (b) 0.66 A, towards right
(c) 0.66 A, towards left (d) zero

27. Which of the following statement(s) is/are incorrect about capacitor?

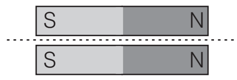
(a) The current in a capacitive circuit is $i = i_m \sin\left(\omega t - \frac{\pi}{2}\right)$, where the amplitude of the oscillating current is $i_m = \frac{V_m}{\omega C}$.

(b) For a purely capacitive circuit, $\left(\frac{1}{\omega C}\right)$ plays the role of resistance. It is called capacitive reactance and denoted by $X_C = \frac{1}{\omega C}$.

(c) The current reaches its maximum value earlier than the voltage by one-fourth of a period.

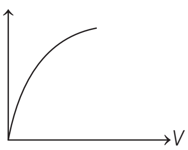
(d) In case of a capacitor, the average power, $P_c = \left\langle \frac{i_m V_m}{2} \sin(2\omega t) \right\rangle = 0$, since $< \sin(2\omega t) > = 0$ over a complete cycle.

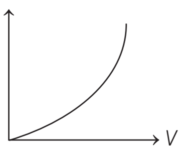
28. A magnet of magnetic moment M and pole strength m is divided in two equal parts shown below, then magnetic moment of each part will be

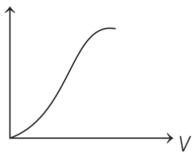


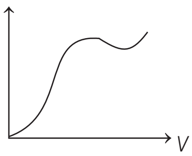
(a) M (b) $M/2$ (c) $M/4$ (d) $2M$

29. The variation between V and I for a heater filament is represented by

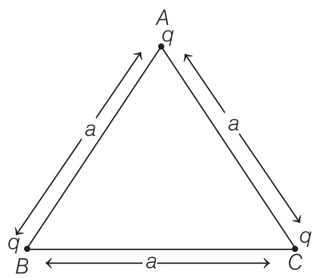
(a) 

(b) 

(c) 

(d) 

30. Three equal charges each of charge q are placed at the vertices of a triangle as shown in figure. The magnitude of electric field intensity at the point C is



(a) $\frac{q}{4\pi\varepsilon_0 a^2}$ (b) $\frac{\sqrt{2}\, q}{4\pi\varepsilon_0 a^2}$ (c) $\frac{\sqrt{3}\, q}{4\pi\varepsilon_0 a^2}$ (d) $\frac{2q}{4\pi\varepsilon_0 a^2}$

31. A circular ring of diameter 20 cm has a resistance of 0.01 Ω. The charge that will flow through the ring, if it is turned from a position perpendicular to a uniform magnetic field of 2.0 T to a position parallel to the field is about

(a) 63 C (b) 0.63 C
(c) 6.3 C (d) 0.063 C

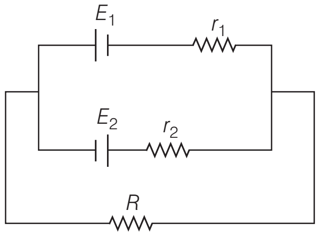
32. In a series L-C-R circuit, resistance is 20 Ω and impedance is 20 Ω. The phase difference between the current and the voltage is

(a) 0° (b) 30°
(c) 45° (d) 60°

33. A magnetic dipole which is an arrangement of two magnetic poles of equal and opposite strength separated by some distance is placed in a uniform magnetic field. The net magnetic force on the dipole

(a) is always zero
(b) depends on the orientation of the dipole
(c) can never be zero
(d) depends on the strength of the dipole

34. The current in the resistance R will be zero, if



(a) $E_1 r_1 = E_2 r_2$ (b) $\frac{E_1}{r_1} = \frac{E_2}{r_2}$ (c) $(E_1 + E_2) r_1 = E_1 r_2$ (d) $(E_1 - E_2) r_1 = E_2 r_1$

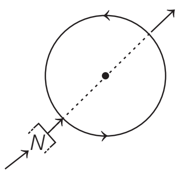
35. A wire of length a carries a current I along X-axis. A magnetic field exists around the wire which is given by $\mathbf{B} = B_0(2\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + \hat{\mathbf{k}})$ T. The magnitude of magnetic force on the wire is

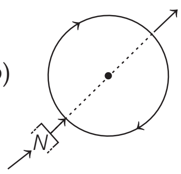
(a) $\sqrt{10}\ B_0 Ia$ (b) $2 B_0 Ia$ (c) $\sqrt{5} B_0 Ia$ (d) $4 B_0 Ia$

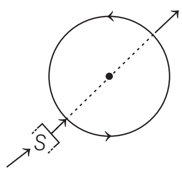
36. Initially the resistance of the wire is R. But when it is stretched to n times of its original length, its resistance becomes R'. Then, the ratio of $R' : R$ is

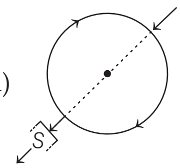
(a) $1 : n$ (b) $n^2 : 1$ (c) $1 : n^2$ (d) $n : 1$

37. Which of the following figure correctly depicts the Lenz's law? (Here, the straight arrows show the movement of the labelled pole of a bar magnet into a closed circular loop and the arrows on the circle show the direction of the induced current)

(a) 

(b) 

(c) 

(d) 

38. An electron is under the influence of coulomb force and has an acceleration of $5 \times 10^{22}\ \text{m/s}^2$. If the same force acts on the proton, then the acceleration of proton will be

(a) $2 \times 10^{19}\ \text{m/s}^2$ (b) $4 \times 10^{19}\ \text{m/s}^2$ (c) $2.7 \times 10^{19}\ \text{m/s}^2$ (d) $1 \times 10^{19}\ \text{m/s}^2$

39. Which of the following statement(s) is/are correct ?

(a) In a series L-C-R circuit, the AC current in each element is different at any time, having the different amplitude and phase.

(b) By analogy to the resistance in a circuit, we introduce the impedance Z in an R-L-C series circuit given by $Z = \sqrt{R^2 + (X_C - X_L)^2}$.

(c) The phasor $\mathbf{I}$ is always parallel to phasor $\mathbf{V}_R$; the phase angle ϕ is the angle between $\mathbf{V}_R$ and $\mathbf{V}$ and can be determined from $\tan\phi = \frac{V_L + V_C}{V_R}$, when $V_L > V_C$.

(d) The impedance triangle is a right triangle with Z as its base.

40. The electric current in a circuit is given by $I = 3t$, where t is in second and I is in ampere. The rms current for the period $t = 0$ to $t = 1$ s is

(a) 3 A (b) 9 A (c) $\sqrt{3}$ A (d) $3\sqrt{3}$ A

41. The radius of the earth is 6.4×10^6 m and the specific charge on proton is 9.6×10^7 C kg^{-1}. What should be the value of minimum magnetic field at the equator of earth, such that a proton moving with velocity $1.92 \times 10^7 \text{ ms}^{-1}$ may revolve round the earth ?

(a) 1.57×10^{-8} T (b) 3.12×10^{-8} T (c) 5.36×10^{-6} T (d) 7.83×10^{-6} T

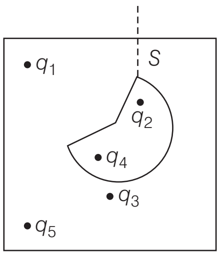
42. A resistance of 2Ω is to be made from a copper wire (specific resistance $= 1.7 \times 10^{-6}$ Ω- m) using a wire of length 50 cm. The radius of the wire is

(a) 0.0116 mm (b) 0.367 mm (c) 0.116 mm (d) 0.267 mm

43. If emf $E = 4 \cos 1000t$ volt is applied to an L-R circuit of inductance 3 mH and resistance 4 Ω, the amplitude of current in the circuit is

(a) $\frac{4}{\sqrt{7}}$ A (b) 1.0 A (c) $\frac{4}{7}$ A (d) 0.8 A

44. Five charges q_1, q_2, q_3, q_4 and q_5 are fixed at their positions as shown in figure. S is a Gaussian surface. The Gauss' law is given by $\oint \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$.



Which of the following statement(s) is/are correct?

(a) **E** on the LHS of the above equation will have a contribution from q_1, q_5 and q_3, while q on the RHS will have a contribution from q_2 and q_4 only.
(b) **E** on the LHS of the above equation will have a contribution from q_2 and q_3 only.
(c) **E** on the LHS of the above equation will have a contribution from all charges, while q on the RHS will have a contribution from q_2 and q_4 only.
(d) Both **E** on the LHS and q on the RHS will have contributions from q_2 and q_4 only.

ASSERTION-REASONING MCQs

Direction (Q. Nos. 45-49) *For given questions two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below*

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false and R is also false.

45. **Assertion** Connections between the resistors in a meter bridge is made of thick copper strips as it minimises the resistance of the connections.

Reason Resistance is inversely proportional to the cross-sectional area.

46. **Assertion** A bird perches on a bare high power line, still nothing happens to the bird.
Reason A man standing on the ground touches the same line and gets a fatal shock.

47. **Assertion** Both alternating current and direct current are measured in ampere.
Reason Ampere can never be used to define alternating currents, as its direction changes continuously w.r.t. time.

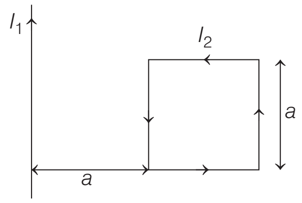
48. **Assertion** Magnetic field lines can be entirely confined within the core of a toroid, but not within a straight solenoid.
Reason In a straight solenoid, magnetic field lines can form closed loops within the solenoid.

49. **Assertion** A parallel plate capacitor is connected across a battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which it stores become K times.
Reason The surface density of charge on the plate remains constant or unchanged.

Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, only first 5 will be considered for evaluation.

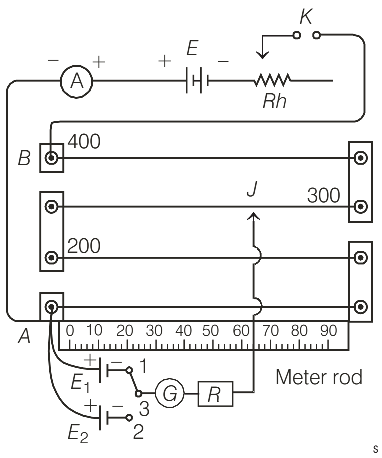
50. A rigid square loop of side a and carrying current I_2 is lying on a horizontal surface near a long current I_2 carrying wire in the same plane as shown in figure. The net force on the loop due to the wire will be



(a) repulsive and equal to $\frac{\mu_0 I_1 I_2}{2\pi}$ (b) attractive and equal to $\frac{\mu_0 I_1 I_2}{3\pi}$

(c) zero (d) repulsive and equal to $\frac{\mu_0 I_1 I_2}{4\pi}$

51. Two cells of emfs approximately $E_1 = 5$ V and $E_2 = 10$ V are to be accurately compared using a potentiometer of length 400 cm.



I. The battery that runs the potentiometer should have voltage of 8 V.
II. The battery of potentiometer can have a voltage of 15 V and R is adjusted, so that the potential drop across the wire slightly exceeds 10 V.
III. The first portion of 50 cm of wire itself should have a potential drop of 10 V.

Which of the following statement(s) is/are correct?
(a) Only I
(b) Only II
(c) Both I and III
(d) Both I and II

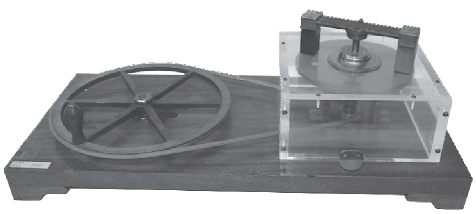
Case Study

Read the following paragraph and answer the questions.

Arago's Rotation

Arago's rotations is an observable magnetic phenomenon that involves the interactions between a magnetised needle and a moving metal disc. The effect was discovered by Francois Arago in 1824. At the time of their discovery, Arago's rotations were surprising effects that were difficult to explain.

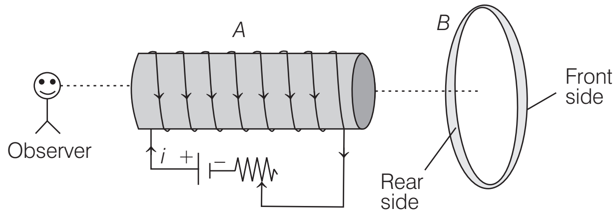
In 1831, Michael Faraday introduced the theory of electromagnetic induction, which explained how the effects happen in details. A magnetic needle is freely suspended on a pivot or string, a short distance above a copper disc. If the disc is stationary, the needle aligns itself with the earth's magnetic field. If the disc is rotated in its own plane, the needle rotates in the same direction as the disc. This was explained in accordance with Faraday's law of electromagnetic induction and Lenz law.



52. In Arago's rotation, a copper ring is moved quickly towards south-pole of a powerful stationary bar magnet, then
(a) current flows through the copper ring
(b) voltage in the magnet increases
(c) current flows in the magnet
(d) copper ring will get magnetised

53. Whenever a magnet is moved either towards or away from copper disc in Arago's rotation, an emf is induced. The magnitude of which is independent of the
(a) strength of the magnetic field
(b) speed with which the magnet is moved
(c) number of turns in the coil
(d) resistance of the coil

54. In Arago's rotations, if instead of copper disc an aluminium ring B is used which faces an electromagnet A. If the current I through A is altered, then which of the following is true?



(a) Whether I increases or decreases, B will not experience any force.
(b) If I decreases, A will repel B.
(c) If I increases, A will attract B.
(d) If I increases, A will repel B.

55. If a coil of 40 turns and area $4.0\ \text{cm}^2$ is suddenly removed from a magnetic field, then it is observed that a charge of 2.0×10^{-4} C flows into the coil. If the resistance of the coil is $80\ \Omega$, then the magnetic flux density (in Wb/m^2) is

(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0

OMR SHEET

SP 10

Roll No. | | | | | | | |

Student Name | | | | | | | | | | | | |

Sub Code. | | | |

Instructions

- Use black or blue ball point pens and avoid Gel & Fountain pens for filling the OMR sheet.
- Darken the bubbles completely. Don't put a tick mark or a cross mark, half-filled or over-filled bubbles will not be read by the software.

- Do not write anything on the OMR Sheet.
- Multiple markings are invalid.

1	ⓐ ⓑ ⓒ ⓓ		20	ⓐ ⓑ ⓒ ⓓ		38	ⓐ ⓑ ⓒ ⓓ						
2	ⓐ ⓑ ⓒ ⓓ		21	ⓐ ⓑ ⓒ ⓓ		39	ⓐ ⓑ ⓒ ⓓ						
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12	ⓐ ⓑ ⓒ ⓓ		31	ⓐ ⓑ ⓒ ⓓ		49	ⓐ ⓑ ⓒ ⓓ						
13	ⓐ ⓑ ⓒ ⓓ		32	ⓐ ⓑ ⓒ ⓓ		50	ⓐ ⓑ ⓒ ⓓ						
14	ⓐ ⓑ ⓒ ⓓ		33	ⓐ ⓑ ⓒ ⓓ		51	ⓐ ⓑ ⓒ ⓓ						
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16	ⓐ ⓑ ⓒ ⓓ		35	ⓐ ⓑ ⓒ ⓓ		53	ⓐ ⓑ ⓒ ⓓ						
17	ⓐ ⓑ ⓒ ⓓ		36	ⓐ ⓑ ⓒ ⓓ		54	ⓐ ⓑ ⓒ ⓓ						
18	ⓐ ⓑ ⓒ ⓓ		37	ⓐ ⓑ ⓒ ⓓ		55	ⓐ ⓑ ⓒ ⓓ						
19	ⓐ ⓑ ⓒ ⓓ												

Check Your Performance

Total Questions: ____________

Total Correct Questions: ____________

$$\text{Score Percentage} = \frac{\text{Total Correct Questions}}{\text{Total Questions}} \times 100$$

If Your Score is

- Less than 60% > **Average** (Revise the concepts again)
- Greater than 60% but less than 75% > **Good** (Do more practice)
- Above 75% > **Excellent** (Keep it on)

Answers

1. (a)	**2.** (d)	**3.** (c)	**4.** (b)	**5.** (d)	**6.** (b)	**7.** (c)	**8.** (b)	**9.** (a)	**10.** (c)
11. (b)	**12.** (a)	**13.** (d)	**14.** (b)	**15.** (a)	**16.** (d)	**17.** (c)	**18.** (c)	**19.** (b)	**20.** (b)
21. (b)	**22.** (d)	**23.** (a)	**24.** (b)	**25.** (a)	**26.** (b)	**27.** (a)	**28.** (b)	**29.** (a)	**30.** (c)
31. (c)	**32.** (a)	**33.** (a)	**34.** (b)	**35.** (a)	**36.** (b)	**37.** (a)	**38.** (c)	**39.** (b)	**40.** (c)
41. (b)	**42.** (b)	**43.** (d)	**44.** (c)	**45.** (a)	**46.** (b)	**47.** (c)	**48.** (c)	**49.** (c)	**50.** (d)
51. (b)	**52.** (a)	**53.** (d)	**54.** (d)	**55.** (b)					

SOLUTIONS

1. According to Gauss's law,

Flux of electric field, $\phi = \frac{1}{\varepsilon_0} \times Q_{\text{enclosed}}$

$$= \frac{1}{\varepsilon_0}(-q+q+q)$$

$$= \frac{q}{\varepsilon_0}$$

2. For conductors of any shape and size (solid or hollow), all the charges must reside on its outer surface.

3. Torque on dipole, $\tau = pE\sin\theta$

When $\theta = 0°$ or $180°$, i.e. E is parallel or anti-parallel to p, then τ is minimum.

When $\theta = 90°$, i.e. E is perpendicular to p, then τ is maximum.

4. Both spherical conductors carry equal and opposite charges. So, after connecting by a wire, there will be no charge in any conductor. Hence, all the stored energy will be destroyed.

$\therefore$ Loss of energy $= 2\left(\frac{1}{2}CV^2\right) = CV^2$

5. Potential difference across C_2 is 10 V.

$\therefore \quad q = C_2V = 2 \times 2 \times 10 = 40\,\mu\text{C}$

6. For a metal sphere, the electric potential at any point inside the sphere is zero as charge resides at its surface.

i.e. $\quad V_{\text{centre}} = 0$

7. We have, electric field,

$$E = -\frac{dV}{dx} = -\frac{d}{dx}(2x^2+5x-4) = (-4x-5)$$

$\therefore (E)_{x=2} = -4\times 2-5$

$= -8-5 = -13$ V/m

and $(E)_{x=3} = -4\times 3 - 5 = -17$ V/m

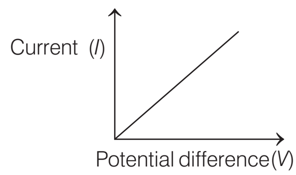
$\therefore \quad \frac{(E)_{x=2}}{(E)_{x=3}} = \frac{13}{17}$

8. The two charges given here form an electric dipole and for this dipole any point on Y-axis is at the equatorial line. Hence, **E** at all points on Y-axis will be in a direction opposite to **p**. As, **p** is along negative X-axis, so **E** is along positive X-axis, i.e. along $\hat{\mathbf{i}}$.

9. If voltmeter is ideal in nature, then R should be

$$R = \frac{V}{I} = \frac{2.4}{0.6} = 4\,\Omega$$

10. The given graph is depicted as,



$$\text{Slope} = \frac{Y\text{-axis coordinate}}{X\text{-axis coordinate}} = \frac{I}{V}$$

As, $\quad V = IR$

$\Rightarrow \quad \frac{I}{V} = \frac{1}{R}$

Hence, for the given graph the slope is reciprocal of resistance.

11. If number of collisions of the free electrons with the lattice is decreased, the time of relaxation of electrons will increase. Due to which, drift velocity of electrons will increase and hence current will increase.

12. Potential difference between the terminals of 9V battery $= V_{AB} - V_{\text{battery}} = 16-9 = 7$ V

Consequently, current in $2\,\Omega$ resistor

$$= \frac{7}{2} = 3.5 \text{ A}$$

13. Given, $N = 200$ turns, $A = 1\text{ cm}^2 = 1\times 10^{-4}\text{ m}^2$,

$B = 0.01$ T, $\theta = 0.2$ rad and $I = 2$ mA $= 2\times 10^{-3}$ A

We know that, $I = \frac{k}{NAB}\theta$

$\Rightarrow \quad k = \frac{NABI}{\theta}$

$$\Rightarrow \quad k = \frac{200 \times 1 \times 10^{-4} \times 0.01 \times 2 \times 10^{-3}}{0.2}$$

$$\therefore \quad = 2 \times 10^{-6} \text{ N-m rad}^{-1}$$

14. Two parallel beams of positive charges moving in the same directions set-up, two parallel currents flowing in the same direction. Hence, they will attract each other.

15. Given, $v = 10^5 \text{ ms}^{-1}$, $m = 1.67 \times 10^{-27}$ kg

and $\quad R = 6.4 \times 10^6$ m

The radius of circular path of a charged particle in a magnetic field is

$$R = \frac{mv}{Bq}$$

$$\Rightarrow \quad B = \frac{mv}{qR}$$

Substituting the given values, we get

$$B = \frac{1.67 \times 10^{-27} \times 10^5}{1.6 \times 10^{-19} \times 6.4 \times 10^6}$$

$$= 1.63 \times 10^{-10} \text{ T}$$

16. The magnetic field inside a solenoid of infinite length is given by

$$B_{\text{in}} = \mu_0 ni$$

where, n is the number of turns in the coil and i is the current flowing through it.

$\therefore \quad B \propto n$ and $B \propto i$

17. Since, magnetic monopoles, i.e. separate north and south-poles does not exist. They always exist in a pair. A pair of magnetic poles, i.e. north and south-poles separated by a distance in any magnet is called dipole.

Thus, the ultimate individual unit of magnetism in any magnet is dipole.

18. Magnetic field lines produced by a solenoid is same as that of bar magnet.

19. According to Faraday's law, an emf is induced in a circuit when magnetic flux linked with the circuit changes.

Faraday's law mathematically can be expressed as $e = -\dfrac{Nd\phi}{dt}$

20. In case of no emf induced, when circular coil expands radially in a region of magnetic field such that the magnetic field is in the same plane as the circular coil, then the dot product of area and field is zero or change in magnetic field is also zero, i.e. it may or may not vary.

And when the magnetic field has a perpendicular (to the plane of the coil) component whose magnitude is decreasing suitably in such a way that the cross product of magnetic field and surface area of plane of coil remain constant at every instant.

21. In an L-C circuit, the inductor stores the magnetic energy and the capacitor stores the electrical energy.

22. In an L-C combination, at resonance $X_L = X_C$.

As, impedance in L-C circuit is given by $Z = \omega L - \dfrac{1}{\omega C}$.

So, when $\omega \to 0$, $Z \to \infty$ (– ve) and when $\omega \to \infty$, $Z \to \infty$ (– ve) and at resonance $Z = 0$.

So, the correct graph is given in option (d).

23. As, we know, for an R-L circuit,

$$\tan \phi = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{3}{3} = 1$$

$$\Rightarrow \quad \phi = \tan^{-1}(1) = 45° = \frac{\pi}{4} \text{ rad}$$

24. Resonant frequency in an L-C-R series circuit,

$$\nu_r = \frac{1}{2\pi\sqrt{LC}}$$

To reduce ν_r, C can be increased, by adding another capacitor in parallel to the first.

25. For an AC circuit containing capacitor only, the phase difference between current and voltage will be $\dfrac{\pi}{2}$, i.e. current leads the voltage by 90°.

Hence, power in this case is given by

$$P = VI \cos \phi$$

where, ϕ = phase difference between voltage and current.

$$\therefore \quad P = VI \cos 90° = 0$$

26. Current, $i = (n_{\text{Ne}} + n_e)e$

$$\Rightarrow \quad i = (2.9 \times 10^{18} + 1.2 \times 10^{18}) \times 1.6 \times 10^{-19}$$

$= 0.66$ A (towards right)

($\because$ Ne^+ ions are moving to the right)

27. Statement given in option (a) is incorrect and it can be corrected as

The current in a capacitive circuit is $i = i_m \sin\left(\omega t + \dfrac{\pi}{2}\right)$ because current leads $\dfrac{\pi}{2}$ angle from voltage in a capacitive circuit.

where, the amplitude of the oscillating current is

$$i_m = \frac{V_m}{X_C} = \frac{V_m}{1/\omega C} = \omega C V_m.$$

Rest statements are correct.

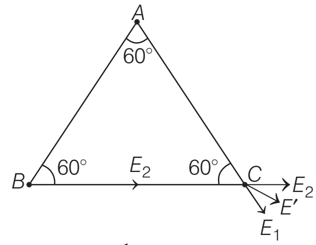
28. If magnet is cut along the axis of length l, then new pole strength, $m' = \frac{m}{2}$ and new length $l' = l$.

$\therefore$ New magnetic moment,

$$M' = \frac{m}{2} \times l = \frac{ml}{2} = \frac{M}{2}$$

29. Initially, as the current in heater filament increases, it gets heated more. Hence, its temperature increases and thereby its resistance increases. Due to which, the current will finally decrease. Hence, the variation of V and I for a heater filament will be as shown in Fig. (a).

30. According to the question, the direction of electric field on C is as shown below



Here, $E_1 = E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{a^2} = E$

Resultant of E_1 and E_2 on charge at C,

$$E' = \sqrt{E_1^2 + E_2^2 + 2E_1E_2\cos\theta}$$

Given, $\theta = 60°$

$$\Rightarrow \quad E' = \sqrt{2E^2 + 2E^2 \times \left(\frac{1}{2}\right)} = \sqrt{3E^2}$$

$$\Rightarrow \quad E' = \frac{q\sqrt{3}}{4\pi\varepsilon_0 a^2}$$

31. Given, $B = 2$ T, $R = 0.01\,\Omega$,

$$d = 20 \text{ cm} = 20 \times 10^{-1} \text{ m}$$

$$\therefore \quad r = \frac{d}{2} = 10 \times 10^{-2} = 10^{-1} \text{ m}$$

$$\theta_1 = 90° \text{ and } \theta_2 = 0°$$

As, $q = \frac{-d\phi}{R} = \frac{BA(\cos 0° - \cos 90°)}{R}$

$$= \frac{B\pi r^2(1-0)}{R} = \frac{B\pi r^2}{R}$$

$$= \frac{2 \times 3.143 \times (10^{-1})^2}{0.01}$$

$$= 6.286 \text{ C} \approx 6.3 \text{ C}$$

32. As we know, impedance,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\Rightarrow \quad 20 = \sqrt{(20)^2 + (X_L - X_C)^2}$$

$$\Rightarrow \quad 400 = 400 + (X_L - X_C)^2$$

$$\Rightarrow \quad X_L - X_C = 0 \quad \ldots \text{(i)}$$

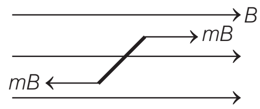
Let ϕ be the phase difference between current and voltage.

$$\therefore \quad \tan\phi = \frac{X_L - X_C}{R}$$

or $\tan\phi = \frac{0}{R}$ [from Eq. (i)]

$$\Rightarrow \quad \phi = 0°$$

33. The situation of forces acting on two poles is shown below



$\therefore$ Net magnetic force on dipole in uniform field will be always zero.

34. Since, the cells are in parallel combination.

$$\therefore \quad E_{\text{net}} = \frac{E_1/r_1 - E_2/r_2}{1/r_1 + 1/r_2}$$

Current through R will be zero, if $E_{\text{net}} = 0$.

$$\Rightarrow \quad \frac{E_1}{r_1} = \frac{E_2}{r_2}$$

35. Given, length of the wire, $\mathbf{l} = a\hat{\mathbf{i}}$

Magnetic force on the wire,

$$\mathbf{F} = I(\mathbf{l} \times \mathbf{B}) = I[a\hat{\mathbf{i}} \times B_0(2\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + \hat{\mathbf{k}})]$$

$$= B_0 Ia(\hat{\mathbf{i}} \times 2\hat{\mathbf{i}} + \hat{\mathbf{i}} \times 3\hat{\mathbf{j}} + \hat{\mathbf{i}} \times \hat{\mathbf{k}})$$

$$= B_0 Ia(3\hat{\mathbf{k}} - \hat{\mathbf{j}})$$

$$\therefore \quad |\mathbf{F}| = F = B_0 Ia\sqrt{(1)^2 + (3)^2} = \sqrt{10}\,B_0 Ia$$

36. Suppose, the initial length of the wire is l and becomes l' after stretching. The initial cross-section of the wire is A and becomes A' after stretching. As, the volume of the wire does not change on stretching,

i.e. $Al = A'l'$

$$\frac{A}{A'} = \frac{l'}{l} = n \quad \ldots \text{(i)}$$

If the specific resistance of the material of the wire be ρ, then the resistance of the wire before stretching,

$$R = \rho(l/A) \quad \ldots \text{(ii)}$$

If the resistance become R' after stretching, then

$$R' = \rho(l'/A') \quad \ldots \text{(iii)}$$

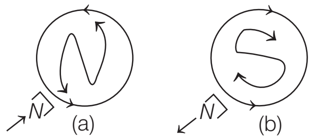
Dividing Eq. (iii) by Eq. (ii), we get

$$\frac{R'}{R} = \left(\frac{l'}{l}\right)\left(\frac{A}{A'}\right) = n^2 \text{ [using Eq. (i)]} \quad \ldots \text{(iv)}$$

$$\Rightarrow \quad R' : R = n^2 : 1$$

37. When the north-pole of a bar magnet moves towards the coil, the induced current in the coil flows in a direction such that the coil represents its north-pole to the bar magnet as shown in Fig. (a). Therefore, the induced current flows in the coil in the anti-clockwise direction.

When the north-pole of a bar magnet moves away from the coil, the induced current in the coil flows in a direction such that the coil represents its south-pole to the bar magnet as shown in Fig. (b).



Therefore, induced current flows in the coil in the clockwise direction as shown in option (a).

38. The acceleration due to given coulomb force F,

$$a = \frac{F}{m} \quad \text{or} \quad a \propto \frac{1}{m}$$

$$\therefore \quad \frac{a_p}{a_e} = \frac{m_e}{m_p}$$

where, m_e and m_p are masses of electron and proton, respectively.

$$\Rightarrow \quad a_p = \frac{a_e m_e}{m_p} = \frac{(5\times10^{22})(9.1\times10^{-31})}{(1.67\times10^{-27})}$$

$$= 27.25\times10^{18}\ \text{m/s}^2$$

$$= 2.7\times10^{19}\ \text{m/s}^2$$

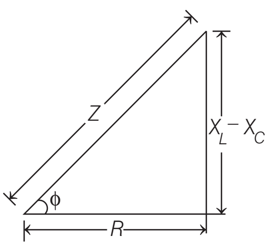
39. Statement in option (b) is correct and rest are incorrect, that can be corrected as,

In a series L-C-R circuit as the resistor, inductor and capacitor are in series. So, the AC current in each element is the same at any time, having the same amplitude and phase.

The phasor $\mathbf{I}$ is always parallel to phasor $\mathbf{V}_R$; the phase angle ϕ is the angle between $\mathbf{V}_R$ and $\mathbf{V}$ and can be determined from,

$$\tan\phi = \frac{V_L - V_C}{V_R}, \text{ when } V_L > V_C.$$

The impedance diagram is a right triangle with Z as its hypotenuse as shown



40. Given, $I = 3t \Rightarrow I^2 = 9t^2$

Mean squared value of current,

$$I_m^2 = \frac{\int_0^1 9t^2 dt}{\int_0^1 dt} = 3$$

$$\therefore \quad I_{\text{rms}} = \sqrt{I_m^2} = \sqrt{3}\ \text{A}$$

41. Given, $R = 6.4\times10^6$ m, $\frac{q}{m} = 9.6\times10^7\ \text{Ckg}^{-1}$

and $v = 1.92\times10^7$ m/s

Force, $F = qvB = \frac{mv^2}{R}$

$$\therefore B = \frac{v}{\left(\frac{q}{m}\right)R} = \frac{1.92\times10^7}{9.6\times10^7\times6.4\times10^6}$$

$$= 3.12\times10^{-8}\ \text{T}$$

42. As, $A = \pi r^2 = \rho l / R$

$$\Rightarrow \quad r = (\rho l/\pi R)^{1/2} \qquad \left(\because R = \frac{\rho l}{A}\right)$$

Here, $R = 2\ \Omega$, $\rho = 1.7\times10^{-6}\ \Omega$-m

and $l = 50$ cm $= 0.5$ m

$$\Rightarrow \quad r = \left(\frac{1.7\times10^{-6}\times0.5}{3.14\times2}\right)^{1/2} = 0.367\ \text{mm}$$

43. Impedance, $Z = \sqrt{R^2 + X_L^2}$

Here, $R = 4\,\Omega$, $X_L = L\omega$

$$= 3\times10^{-3}\times1000\ \Omega = 3\,\Omega$$

Then, $Z = \sqrt{(4)^2 + (3)^2}$

$$= \sqrt{16+9} = \sqrt{25} = 5\ \Omega$$

Hence, current, $I_0 = \frac{E_0}{Z} = \frac{4}{5} = 0.8$ A

44. According to Gauss's theorem in electrostatics, $\oint \mathbf{E}\cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$.

Here, $\mathbf{E}$ on the LHS is due to all the charges q_1, q_2, q_3, q_4 and q_5.

While q on the RHS is charge enclosed by the Gaussian surface, therefore $q = q_2 + q_4$.

45. The connections are made of thick copper wires to minimise the resistance of connection wires.

As, resistance is inversely proportional to cross-sectional area, so thick wire has low resistance.

Therefore, both A and R are true and R is the correct explanation of A.

46. When a bird is perched on a bare high power line, the circuit does not get completed between the bird and the earth, therefore nothing happens to the bird.

When a man standing on ground touches the same line, the circuit between the man and the earth gets completed. As a result, he gets a fatal shock.

Therefore, both A and R are true but R is not the correct explanation of A.

47. Ampere can be used to define both DC and AC. As we know that, the AC current changes its direction with time. So, AC ampere must be defined in terms of some property which is independent of direction of current. Thus, Joule's heating effect is the property, which defines rms value of AC.

Therefore, A is true but R is false.

48. The magnetic field lines always form closed loops. As, the turns of the wires in a toroidal solenoid are wound over its core in circular form, the field lines are confined within the core of toroid.

In a straight solenoid, the magnetic field lines cannot form closed loops within the solenoid.

Therefore, A is true but R is false.

49. If a dielectric slab of dielectric constant K is filled in between the plates of a capacitor while charging it, the potential difference between the plates does not change, but the capacity becomes K times. Therefore,

$$V' = V \text{ and } C' = KC$$

$\therefore$ Energy stored in the capacitor,

$$U' = \frac{1}{2}C'V'^2 = \frac{1}{2}(KC)(V^2)$$

$$= \left(\frac{1}{2}CV^2\right)K = KU$$

Thus, energy stored becomes K times.
Surface charge density,

$$\sigma' = \frac{q'}{A} = \frac{C'V'}{A}$$

$$= \frac{KCV}{A} = K\frac{q}{A} = K\sigma$$

Therefore, A is true but R is false.

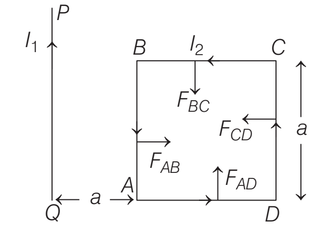
50. Net force experienced by two current carrying wires separated by some distance is attractive, if currents flow in them in same direction. However, this force is repulsive in nature, if currents in them flow in opposite directions.

Force on a wire 1 in which current I_1 is flowing due to another wire 2 which are separated by a distance r is given as

$$\mathbf{F} = I_1(l \times \mathbf{B}_2)$$

or $$F = \frac{\mu_0 I_1 I_2}{2\pi r} \cdot l\sin\theta \qquad \left(\because \mathbf{B}_2 = \frac{\mu_0 I_2}{2\pi r}\right)$$

The given square loop can be drawn as shown below



$$F_{AB} = \frac{\mu_0 I_1}{2\pi a} \cdot I_2 a \qquad \text{(away from wire } PQ\text{)}$$

$$F_{BC} = F_{AD} = 0 \qquad (\because \theta = 0°)$$

$$F_{CD} = \frac{\mu_0 I_1}{2\pi(2a)} \cdot I_2 a$$

$$= \frac{\mu_0 I_1}{4\pi a} \cdot I_2 a \qquad \text{(towards the wire } PQ\text{)}$$

$$\therefore F_{\text{net}} = F_{AB} - F_{CD} = \frac{\mu_0 I_1 I_2}{2\pi} - \frac{\mu_0 I_1 I_2}{4\pi}$$

(away from wire)

$$= \frac{\mu_0 I_1 I_2}{4\pi} \qquad \text{(repulsive in nature)}$$

51. In a potentiometer experiment, the emf of a cell can be measured, if the potential drop along the potentiometer wire is more than the emf of the cell to be determined. As values of emfs of two cells are approximately 5 V and 10 V, therefore the potential drop along the potentiometer wire must be more than 10 V. Hence, option (b) is correct.

52. Magnetic flux linked with the ring changes, so according to Faraday's law of electromagnetic induction, current will be induced in the copper ring.

53. Induced emf = Total flux $\times$ Current per second. It depends on the strength of the magnet, speed of motion the magnet, number of turns of the coil and area of cross-section of the coil. Only the current is decided by the emf and the resistance.
$\therefore$ emf is independent of the resistance of the coil.

54. When current passes through a solenoid A as shown, the current entering at A is clockwise. When seen from the side A, it develops south polarity at A and north polarity at B.

If current through A increases, magnetic field, linked with coil B increases. Hence, according to Lenz's law, anti-clockwise current induces in coil B. Thus, both the currents produce repulsive effect.

55. Charge, $\Delta Q = \frac{\Delta\phi}{R} = \frac{n \times BA}{R}$

$\therefore$ Magnetic flux density,

$$B = \frac{\Delta Q \cdot R}{nA} = \frac{2 \times 10^{-4} \times 80}{40 \times 4 \times 10^{-4}} = 1 \text{ Wb/m}^2$$