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The Weavers Institute

TARGET: Class 12th CBSE Boards 2024-25

Physics (Electrostatics)

BATCH: 12th **DURATION: 3 HR** **MAX. MARKS: 80**

Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose

INSTRUCTIONS

Section A *– From question 1 to 18 are MCQs and 7-8 are assertion and reason based of 1 mark each.*
Section B *– Question no. 19-25 are Very Short Answer Type Questions, carrying 2 marks each.*
Answer to each question should not exceed 40 words.
Section C *contains Q.26 to Q.30 are Short Answer Type Questions, carrying 3 marks each.*
Answer to each question should not exceed 60 words
Section D *– Question no. 31-33 are long answer type questions, carrying 5 marks each*
Section-E *- . Questions no 34 and 35 are case based questions with three sub questions and are of 4 marks each.*
Answer to each question should not exceed 120 words
There is no overall choice in the question paper. However, an internal choice has been provided in few questions. Only one of the choices in such questions have to be attempted.
You may use the following values of physical constants where ever necessary

$c = 3 \times 10^8 m/s$
$m_e = 9.1 \times 10^{-31}\ kg$
$e = 1.6 \times 10^{-19}\ C$
$\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$
$h = 6.63 \times 10^{-34}\ Js$
$\varepsilon_0 = 8.854 \times 10^{-12}\ C^2N^{-1}m^{-2}$
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Mass of electron $= 9.1 \times 10^{-31}\ kg$
Mass of Neutron $= 1.675 \times 10^{-27}\ kg$
Mass of Proton $= 1.673 \times 10^{-27}\ kg$
Boltzmann constant $= 1.38 \times 10^{-23}\ JK^{-1}$

Section A

1. An electric dipole of length 2 cm is placed at an angle of 30° with an electric field 2×10^5 N/C. If the dipole experiences a torque of 8×10^{-3} Nm, the magnitude of either charge of the dipole, is
   (A) 4 μC (B) 7μC
   (C) 8 mC (D) 2 mC

2. Two long parallel wires kept 2 m apart carry 3A current each, in the same direction. The force per unit length on one wire due to the other is
   (A) 4.5 × 10–7 Nm–1, attractive (B) 4.5 × 10–7 N/m, repulsive
   (C) 9 × 10–7 N/m, repulsive (D) 9× 10–7 N/m, attractive

3. Which of the following has its permeability less than that of free space?
   (A) Copper (B) Aluminium
   (C) Copper chloride (D) Nickel

4. A square shaped coil of side 10 cm, having 100 turns is placed perpendicular to a magnetic field which is increasing at 1 T/s. The induced emf in the coil is
   (A) 0.1 V (B) 0.5 V
   (C) 0.75 V (D) 1.0 V

5. Which one of the following electromagnetic radiations has the least wavelength?
   (A) Gamma rays (B) Microwaves
   (C) Visible light (D) X-rays

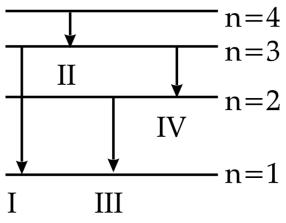
6. In a Young's double-slit experiment, the screen is moved away from the plane of the slits. What will be its effect on the following?
   (i) Angular separation of the fringes.
   (ii) Fringe-width.
   (A) Both (i) and (ii) remain constant. (B) (i) remains constant, but (ii) decreases.
   (C) (i) remains constant, but (ii) increases. (D) Both (i) and (ii) increase.

7. The energy of a photon of wavelength λ is
   (A) $hc\lambda$ (B) hc/λ
   (C) λ/hc (D) $\lambda h/c$

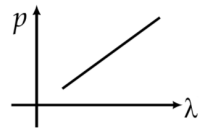
8. The ratio of the nuclear densities of two nuclei having mass numbers 64 and 125 is
   (A) 64 /125 (B) 4/5
   (C) 5/4 (D) 1

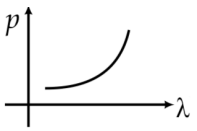
9. During the formation of a p-n junction:
   (A) diffusion current keeps increasing.
   (B) drift current remains constant.
   (C) both the diffusion current and drift current remain constant.
   (D) diffusion current remains almost constant but drift current increases till both currents become equal.

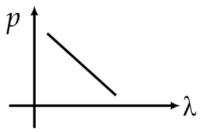
10. The diagram shows four energy level of an electron in Bohr model of hydrogen atom. Identify the transition in which the emitted photon will have the highest energy.
    (A) I (B) II (C) III (D) IV

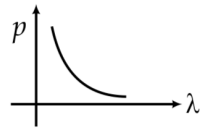


11. Which of the following graphs correctly represents the variation of a particle momentum with its associated deBroglie wavelength?

(A) 

(B) 

(C) 

(D) 

12. The capacitors, each of 4 μF are to be connected in such a way that the effective capacitance of the combination is 6 μF. This can be achieved by connecting
    (A) All three in parallel
    (B) All three in series
    (C) Two of them connected in series and the combination in parallel to the third.
    (D) Two of them connected in parallel and the combination in series to the third.

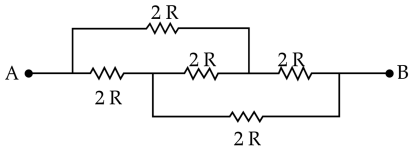
13. Which of the following statements about a series LCR circuit connected to an ac source is correct?
    (A) If the frequency of the source is increased, the impedance of the circuit first decreases and then increases.
    (B) If the net reactance (X_L - X_C) of circuit becomes equal to its resistance, then the current leads the voltage by 45°.
    (C) At resonance, the voltage drop across the inductor is more than that across the capacitor.
    (D) At resonance, the voltage drop across the capacitor is more than that across the inductor.

14. According to Huygens principle, the amplitude of secondary wavelets is
    (A) equal in both the forward and the backward directions.
    (B) maximum in the forward direction and zero in the backward direction.
    (C) large in the forward direction and small in the backward direction.
    (D) small in the forward direction and large in the backward direction.

15. The radius of the nth orbit in Bohr model of hydrogen atom is proportional
    (A) n^2 (B) $\frac{1}{n^2}$
    (C) n (D) $\frac{1}{n}$

16. Assertion (A): The resistance of an intrinsic semiconductor decreases with increase in its temperature.
    Reason (R): The number of conduction electrons as well as hole increase in an intrinsic semiconductor with rise in its temperature.

17. Assertion (A): The equivalent resistance between points A and B in the given network is 2R.
    Reason (R): All the resistors are connected in parallel



18. Assertion (A): The deflecting torque acting on a current carrying loop is zero when its plane is perpendicular to the direction of magnetic field.
    Reason (R): The deflecting torque acting on a loop of magnetic moment $\vec{m}$ in a magnetic field $\vec{B}$is given by the dot product of $\vec{m}$ and $\vec{B}$.

Section B

19. Draw a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Indicate the region in which the nuclear force is
(a) attractive and (b) repulsive.

20. (a) How will the De Broglie wavelength associated with an electron be affected when the (i) velocity of the electron decreases? and (ii) accelerating potential is increased? Justify your answer.

OR

(b) How would the stopping potential for a given photosensitive surface change if (i) the frequency of the incident radiations was increased? and (ii) the intensity of incident radiations was decreased? Justify your answer.

21. Identify electromagnetic wave whose wavelengths range is from about
(a) 10^{-12} m to about 10^{-8} m.
(b) 10^{-3} m to about 10^{-1} m.
Write one use of each.

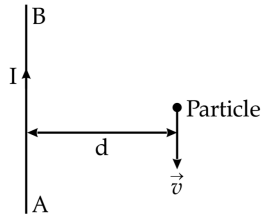
22. Depict the orientation of an electric dipole in (a) stable and (b) unstable equilibrium in an external uniform electric field. Write the potential energy of the dipole in each case.

23. (a) Write the expression for the Lorentz force on a particle of charge q moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$. When is the magnitude of this force maximum? Show that no work is done by this force on the particle during its motion from a point $\vec{r_1}$ to point $\vec{r_2}$.

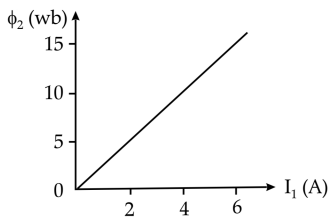
OR

(b) A long straight wire AB carries a current I. A particle (mass m and charge q) moves with a velocity $\vec{v}$, parallel to the wire, at a distance d from it as shown in the figure. Obtain the expression for the force experienced by the particle and mention its directions.

24. The potential difference applied across a given conductor is doubled. How will this affect (i) the mobility of electrons and (ii) the current density in the conductor? Justify your answers.



25. Two coils C_1 and C_2 are placed close to each other. The magnetic flux ϕ_2 linked with the coil C_2 varies with the current I_1 flowing in coil C_1, as shown in the figure. Find



(i) the mutual inductance of the arrangement, and
(ii) the rate of change of current $\frac{dI_1}{dt}$ that will induce an emf of 100 V in coil C_2.

Section C

26. (a) A plane wave-front propagating in a medium of refractive index 'μ_1' is incident on a plane surface making an angle of incidence (i). It enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$). Use Huygen's construction of secondary wavelets to trace the retracted wave-front. Hence, verify Snell's law of refraction.

OR

(b) Using Huygen's construction, show how a plane wave is reflected from a surface. Hence, verify the law of reflection.

27. An alternating voltage of 220 V is applied across a device X. A current of 0.22 A flows in the circuit and it lags behind the applied voltage in phase by $\pi/2$ radian. When the same voltage is applied across another device Y, the current in the circuit remains the same and it is in phase with the applied voltage.
(i) Name the devices X and Y and,
(ii) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

28. State the basic principle behind the working of an ac generator. Briefly describe its working and obtain the expression for the instantaneous value of emf induced.

29. (a) Briefly describe how the current sensitivity of a moving coil galvanometer can be increased.
(b) A galvanometer shows full scale deflection for current Ig. A resistance R1 is required to convert it into a voltmeter of range (0 – V) and a resistance R_2 to convert it into a voltmeter of range (0 – 2V). Find the resistance of the galvanometer.

30. (a) (i) Differentiate between 'distance of closest approach' and 'impact parameter'.
(ii) Determine the distance of closest approach when an alpha particle of kinetic energy 3.95 MeV approaches a nucleus of Z = 79, stops and reverses its directions.

OR

(b) (i) State three postulates of Bohr's theory of hydrogen atom.
(ii) Find the angular momentum of an electron revolving in the second orbit in Bohr's hydrogen atom.

Section D

31. (a) (i) Explain how free electrons in a metal at constant temperature attain an average velocity under the action of an electric field. Hence obtain an expression for it.
(ii) Consider two conducting wires A and B of the same diameter but made of different materials joined in series across a battery. The number density of electrons in A is 1.5 times that in B. Find the ratio of drift velocity of electrons in wire A to that in wire B.

OR

(b) (i) A cell emf of (E) and internal resistance (r) is connected across a variable load resistance (R). Draw plots showing the variation of terminal voltage V with (i) R and (ii) the current (I) in the load.
(ii) Three cells, each of emf E but internal resistances 2r, 3r and 6r are connected in parallel across a resistor R. Obtain expressions for (i) current flowing in the circuit, and (ii) the terminal potential difference across the equivalent cell.

32. (a) Draw the circuit arrangement for studying V-I characteristics of a p-n junction diode in (i) forward biasing and (ii) reverse biasing. Draw the typical V-I characteristics of a silicon diode. Describe briefly the following terms: (i) minority carrier injection in forward biasing and (ii) breakdown voltage in reverse biasing.

OR

(b) Name two important processes involved in the formation of a p-n junction diode. With the help of a circuit diagram, explain the working of junction diode as a full wave rectifier. Draw its input and output waveforms. State the characteristic property of a junction diode that makes it suitable for rectification.

33. (a) (i) Draw a ray diagram to show the working of a compound microscope. Obtain the expression for the total magnification for the final image to be formed at the near point.
(ii) In a compound microscope an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. If the eye-piece has a focal length of 5 cm and the final image is formed at the near point, find the magnifying power of the microscope. 2

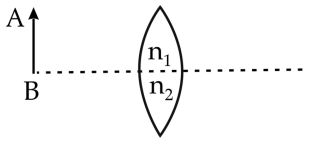
OR

(b) (i) Draw a ray diagram for the formation of image of an object by an astronomical telescope, in normal adjustment. Obtain the expression for its magnifying power.
(ii) The magnifying power of an astronomical telescope in normal adjustment is 2.9 and the objective and the eyepiece are separated by a distance of 150 cm. Find the focal lengths of the two lenses.

Section E

Note: Questions number 34 and 35 are Case Study based questions.
Read the following paragraph and answer the questions.

34. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Considering image formation by a single spherical surface successively at the two surfaces of a lens, lens maker's formula is obtained. It is useful to design lenses of desired focal length using surfaces of suitable radii of curvature. This formula helps us obtain a relation between u, v and f for a lens. Lenses form images of objects and they are used in a number of optical devices, for example microscopes and telescopes.
(i) An object AB is kept in front of a composite convex lens, as shown in figure. Will the lens produce one image? If not, explain.



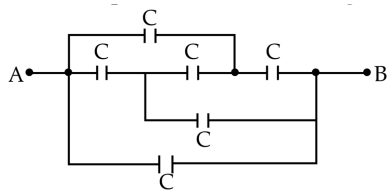
(ii) A real image of an object formed by a convex lens is observed on a screen. If the screen is removed, will the image still be formed? Explain.
(iii) A double convex lens is made of glass of refractive index 1.55 with both faces of the same radius of curvature. Find the radius of curvature required if focal length is 20 cm.

OR

(iii) Two convex lenses A and B of focal lengths 15 cm and 10 cm respectively are placed coaxially 'd' distance apart. A point object is kept at a distance of 30 cm in front of lens A. Find the value of 'd' so that the rays emerging from lens B are parallel to its principal axis.

35. A capacitor is a system of two conductors separated by an insulator. The two conductors have equal and opposite charges with a potential difference between them. The capacitance of a capacitor depends on the geometrical configuration (shape, size and separation) of the system and also on the nature of the insulator separating the two conductors. They are used to store charges. Like resistors, capacitors can be arranged in series or parallel or a combination of both to obtain desired value of capacitance.

(i) Find the equivalent capacitance between points A and B in the given diagram.



(ii) A dielectric slab is inserted between the plates of a parallel plate capacitor. The electric field between the plates decreases. Explain.

(iii) A capacitor A of capacitance C, having charge Q is connected across another uncharged capacitor B of capacitance 2C. Find an expression for (a) the potential difference across the combination and (b) the charge lost by capacitor A.

OR

(iii) Two slabs of dielectric constants 2K and K fill the space between the plates of a parallel plate capacitor of plate area A and plate separation d as shown in figure. Find an expression for capacitance of the system.