Excel Coaching Classes

Time: 60min | **Physics Ch 3,8,11** | **Marks: 20**

SECTION A

1. **Select and write the correct answer for the following multiple choice type of questions:** **3**

i. **Electric intensity at a point near a charged sphere of charge q is given by**

- [x] (A) E = $\frac{1}{4\pi\varepsilon_0 k} \frac{q}{r^2}$
- [ ] (B) E = $\frac{1}{2\pi\varepsilon_0 k} \frac{q}{r}$
- [ ] (C) E = $\frac{\sigma}{\varepsilon_0 k}$
- [ ] (D) E = $\frac{1}{4\pi\varepsilon_0} \frac{q}{r}$

ii. **Susceptibility of a paramagnetic substance**

- [ ] (A) increases with increase in temperature.
- [x] (B) decreases with increase in temperature.
- [ ] (C) remains same at any temperature.
- [ ] (D) first increases then decreases with increase in temperature.

iii. **The electric field intensity at a point 2 m from an isolated point charge is 500 N/C. The electric potential at the point is**

- [ ] 0 V
- [ ] 2.5 V
- [ ] 250 V
- [x] 1000 V

(D)

2. **Answer the following questions:** **3**

i. **What does the hysteresis loop represents?**

The hysteresis curve represents the relation between magnetic induction $\vec{B}$ (or intensity of magnetization $\vec{I}$) of a ferromagnetic material with magnetizing force or magnetic intensity $\vec{H}$

ii. **The magnetic susceptibility of annealed iron at saturation is 4224. Find the permeability of annealed iron at saturation.**

($\mu_0 = 4\pi \times 10^{-7}$ SI unit).

$\mu = \mu_0 (1 + \chi)$

$\therefore \ \mu = 4\pi \times 10^{-7} (1 + 4224)$

$= \mathbf{5.31 \times 10^{-3}\ Hm^{-1}}$

iii. **If r = 1 then, it is a white body. Is it true?**

Given condition, r = 1

$\Rightarrow a = 0 \quad (\because a + r + t = 1)$

$\Rightarrow e = 0 \quad (\because a = e)$

Such a situation is impossible as every body at a temperature above 0 K emits thermal radiation.
Hence, given statement is false.

SECTION B

Attempt any TWO questions of the following: **4**

3. Two vessels A and B are filled with same gas where volume, temperature and pressure in vessel A is twice the volume, temperature and pressure in vessel B. Calculate the ratio of number of molecules of gas in vessel A to that in vessel B.

The ratio of number of molecules is 2 : 1.

4. Derive the quantity for Bohr Magneton and also state its value.

i. According to Bohr's theory, an electron in an atom can revolve only in certain stationary orbits in which angular momentum (L) of electron is an integral multiple (n) of $\frac{h}{2\pi}$, where h is Planck's constant.

∴ $L = m_e vr = \frac{nh}{2\pi}$ ....(1)

ii. The orbital magnetic momentum of an electron is given as, $m_{orb} = \frac{eL}{2m_e}$ ....(2)

iii. Substituting equation (1) and (2), we have,

$m_{orb} = n\left(\frac{eh}{4\pi m_e}\right)$ ....(3)

iv. For the 1st orbit, n = 1,

∴ $m_{orb} = \frac{eh}{4\pi m_e}$

v. The quantity $\frac{eh}{4\pi m_e}$ is called Bohr Magneton and its value is 9.274×10^{-24} Am^2.

vi. The magnetic moment of an atom is stated in terms of Bohr magnetons (B.M.).

5. State the properties of paramagnetic materials.

i. Paramagnetic materials are strongly attracted by external magnetic field.

ii. When a paramagnetic material is placed in a non-uniform magnetic field, it tends to move itself from weaker region to stronger region.

iii. When a paramagnetic liquid is placed in a U tube manometer with a magnet kept in close vicinity of one of the arms, it is observed that the liquid rises into the arm close to the magnet.

iv. The net magnetic dipole moment is reduced to zero in the absence of a magnetic field. When the external magnetic field is removed, these magnetic dipoles arrange themselves in random directions.

v. The magnetic susceptibility of paramagnetic material is positive but low and in range of 0 to 10^{-3}.

vi. **Examples:** Metals such as magnesium, lithium, molybdenum, tantalum, and salts such as M_nSO_4, H_2O and oxygen gas.

6. A. **Define emissive power.**

The quantity of heat radiated per unit area per unit time is defined as emissive power of the body at given temperature.

OR

The power emitted per unit area at given temperature is defined as emissive power or radiant power of the body.

$\therefore$ R = $\frac{Q}{AT}$

B. **What is an ideal gas?**

A gas which obeys ideal gas equation at all pressures and temperatures is an ideal gas.

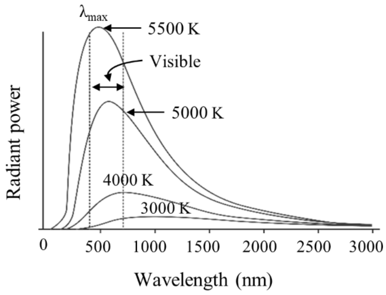
SECTION C

Attempt any TWO questions of the following: **6**

7. Explain spectral distribution of blackbody radiation.

i. The rate of emission per unit area or power per unit area of a surface is defined as a function of the wavelength λ of the emitted radiation.

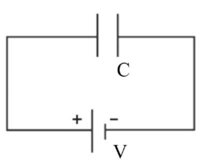
ii. Scientists studied the energy distribution of blackbody radiation as a function of wavelength.



iii. By keeping the source of radiation (such as a cavity radiator) at different temperatures they measured the radiant power corresponding to different wavelengths. The measurements were represented graphically in the form of curves showing variation of radiant power per unit area as a function of wavelength λ at different constant temperatures as shown in figure.

8. Obtain an expression for energy of a charged capacitor and express it in different forms.

i. Consider a capacitor of capacitance C being charged by a DC source of V volts as shown in figure below.



Capacitor charged by a DC source

ii. During the process of charging, let q′ be the charge on the capacitor and V be the potential difference between the plates. Hence C = $\frac{q}{V}$

iii. A small amount of work is done if a small charge dq is further transferred between the plates.

$\therefore$ dW = V dq = $\frac{q'}{C}\ dq$

iv. Total work done in transferring the charge

$$W = \int dW = \int_0^Q \frac{q'}{C}\,dq = \frac{1}{C}\int_0^Q q'\,dq$$

$= \frac{1}{C}\left[\frac{(q')^2}{2}\right]_0^Q = \frac{1}{2}\frac{Q^2}{C}$

v. This work done is stored as electrical potential energy U of the capacitor. This work done can be expressed in different forms as follows.

$\therefore$ U = $\frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$....($\because$ Q = CV)

9. **Find the temperature of a blackbody if its spectrum has a peak at**

i. λ_{max} = 700 nm (visible),

ii. λ_{max} = 3 cm (microwave region) and

iii. λ_{max} = 3 m (short radio waves)

(Take Wien's constant b = 2.897 × 10^{-3} m K).

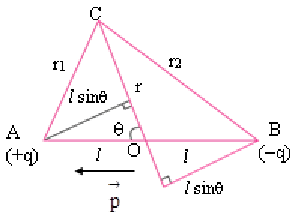
The respective temperatures of blackbody are **4138 K**, **0.0966 K** and **0.966 × 10^{-3} K**.

SECTION D

Attempt any ONE question of the following: **4**

10. **Derive an expression for electric potential due to an electric dipole.**

i. Consider an electric dipole. Let origin be at the centre of the dipole as shown in figure below.



Electric potential due to an electric Dipole

ii. Let C be any point near the electric dipole at a distance r from the centre O inclined at an angle θ with axis of the dipole.

Let r_1 and r_2 be the distances of point C from charges +q and –q, respectively.

iii. Potential at C due to charge +q at A is,

$V_1 = \frac{+q}{4\pi\varepsilon_0 r_1}$

Potential at C due to charge –q at B is,

$V_2 = \frac{-q}{4\pi\varepsilon_0 r_2}$

iv. The potential at C due to the dipole is,

$V_C = V_1 + V_2 = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$ ....(1)

v. By geometry,

$r_1^2 = r^2 + l^2 - 2rl\cos\theta$

$r_2^2 = r^2 + l^2 + 2rl\cos\theta$

$r_1^2 = r^2\left(1 + \frac{l^2}{r^2} - 2\frac{l}{r}\cos\theta\right)$

$r_2^2 = r^2\left(1 + \frac{l^2}{r^2} + 2\frac{l}{r}\cos\theta\right)$

For a short dipole, 2l<< r and

If r >>l; $\frac{l}{r}$ is small

$\therefore$ $\frac{l^2}{r^2}$ can be neglected

$\therefore\ r_1^2 = r^2\left(1 - 2\frac{l}{r}\cos\theta\right)$

$r_2^2 = r^2\left(1 + \frac{2l}{r}\cos\theta\right)$

$\therefore\ r_1 = r\left(1 - \frac{2l}{r}\cos\theta\right)^{\frac{1}{2}}$

$r_2 = r\left(1 + \frac{2l}{r}\cos\theta\right)^{\frac{1}{2}}$

$\therefore\ \frac{1}{r_1} = \frac{1}{r}\left(1 - \frac{2l}{r}\cos\theta\right)^{\frac{-1}{2}}$ and

$\frac{1}{r_2} = \frac{1}{r}\left(1 + \frac{2l}{r}\cos\theta\right)^{\frac{-1}{2}}$ ....(2)

vi. Using equations (1) and (2),

$V_C = V_1 + V_2$

$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r}\left(1 - \frac{2l\cos\theta}{r}\right)^{\frac{-1}{2}} - \frac{1}{r}\left(1 + \frac{2l\cos\theta}{r}\right)^{\frac{-1}{2}}\right]$

vii. Using binomial expansion,

$(1 + x)^n = 1 + nx$, $x << l$ and retaining terms up to the first order of $\frac{l}{r}$ only, we get

$V_C = \frac{q}{4\pi\varepsilon_0}\frac{1}{r}\left[\left(1 + \frac{l}{r}\cos\theta\right) - \left(1 - \frac{l}{r}\cos\theta\right)\right]$

$= \frac{q}{4\pi\varepsilon_0 r}\left[1 + \frac{l}{r}\cos\theta - 1 + \frac{l}{r}\cos\theta\right]$

$= \frac{q}{4\pi\varepsilon_0 r}\left[\frac{2l}{r}\cos\theta\right]$

$\therefore\ V_C = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$ ....($\because p = q \times 2l$)

viii. Electric potential at C, can also be expressed as,

$V_C = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\vec{r}}{r^3}$

$V_C = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2}$ $\ldots\ \left(\hat{r} = \frac{\vec{r}}{r}\right)$

where $\hat{r}$ is a unit vector along the position vector $\overrightarrow{OC} = \hat{r}$

11. A. **One hundred twenty five small liquid drops, each carrying a charge of 0.5 μC and each of diameter 0.1 m form a bigger drop. Calculate the potential at the surface of the bigger drop.**

Electric potential is **2.25×10^6 V.**

B. **What is gyromagnetic ratio? Write the necessary expression.**

i. The ratio of magnetic dipole moment with angular momentum of revolving electron is called the gyromagnetic ratio.

ii. Gyromagnetic ratio is given by, $\frac{m_{orb}}{L} = \frac{e}{2m_e}$