Active™ Textbook Series

Answers to the questions given under

Competency Based Questions Bank

Case/Source Based Questions

1. (i) The cause of charging is the actual transfer of electrons from one body to the other.

(ii) When glass rod is rubbed with silk, glass rod loses electrons and silk grabs them. So, after rubbing, glass becomes positively charged and silk becomes negatively charged. Thus, equal but opposite charges are produced on both.

(iii) When an object is positively charged, it loses some of its electrons. The mass of an electron is $9.11 \quad 10^{\quad 31}$ kg, so the positively charged body loses electrons and its mass decreases by a factor of $9.11 \quad 10^{\quad 31}$ kg.

(iv) $q_1 \quad q_2 \quad 0$, signifies that the net charge on the system is zero. This is possible only if q_1 and q_2 are equal but opposite in signs.

(v) Transfer of an integral number of electrons.

2. (i) P E or PE sin

(ii) The maximum torque on the dipole in an external electric field is given by

$$_{max} \quad PE \quad q(2a) \quad E$$

Here, $q \quad 1 \text{ C} \quad 10^{\quad 6}$ C, $2a \quad 2\text{cm} \quad 2 \quad 10^{\quad 2}$ m

$E \quad 10^5 \text{NC}^{\quad 1}$, ?

$$_{max} \quad 10^{\quad 6} \quad 2 \quad 10^{\quad 2} \quad 10^5 \quad 2 \quad 10^{\quad 3} \text{ Nm}$$

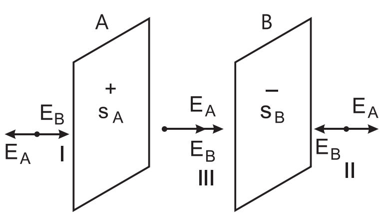
(iii) When is 0° or 180°, is minimum, which means the dipole moment should be parallel to the direction of the uniform electric field.

(iv) Net force is zero while torque is pE sin

3. (i) There are two plates A and B having surface charge densities, $_A \quad 17.0 \quad 10^{\quad 22}$ C/m^2 on A and $_B \quad 17.0 \quad 10^{\quad 22}$ C/m^2 on B, respectively.

Electric fields outside the plates are equal and opposite, therefore,

$$E_1 \quad E_A \quad E_B \quad \frac{}{2_{\ 0}} \quad \frac{}{2_{\ 0}} \quad 0$$



(ii) The electric field in region III is also zero.

$$E_{III} \quad E_A \quad E_B \quad \frac{}{2_{\ 0}} \quad \frac{}{2_{\ 0}} \quad 0$$

(iii) Electric fields between the plates are equal and in the same direction (from ve plate to ve plate)

Hence, $$E_{II} \quad E_A \quad E_B \quad \frac{}{2_{\ 0}} \quad \frac{}{2_{\ 0}}$$

$$\frac{(\ _A \text{ or } \ _B)}{_0} \quad \frac{17.0 \quad 10^{\quad 22}}{8.85 \quad 10^{\quad 12}}$$

$$E_{II} \quad 1.9 \quad 10^{\quad 10} \text{ NC}^{\quad 1}$$

(iv) Electric field due to an infinite plane sheet of charge does not depend on the distance of observation point from the plane sheet of charge.

So, ratio of E will be 1 : 1.

(v) We take a cylindrical Gaussian surface with axis perpendicular to metal sheet and extending on both sides of sheet with circular ends parallel to sheet and equidistant from it.

4. (i) **Gauss's law:** "The net electric flux through a closed surface is $\frac{1}{_0}$ times the net charge enclosed by the surface." If the net charge enclosed by a closed surface is q then according to the Gauss's law, the net electric flux passing through that surface,

$$_E \quad \frac{q}{_0}.$$

(ii) Given, E (100 N / C) i and S Sn

$S \quad (1 \text{ cm})^2 \quad (10^{\quad 2})^2 \text{m}^2 \quad 10^{\quad 4}\text{m}^2$

S $10^{\quad 4}\text{m}^2$(0.8 i 0.6 k)

$_E$ E S (100 N/C i).$10^{\quad 4}$(0.8 i 0.6 k)m

100 $10^{\quad 4}$(0.8 i i 0.6 i k)Nm^2/C

8 $10^{\quad 3}$ Nm^2/C^2

(iii) (a) Elelctric field intensity due to an infinitely long straight wire of linear charge density C/m is

$$E \quad \frac{}{2 \ _0 r}$$

E is outward if is positive.

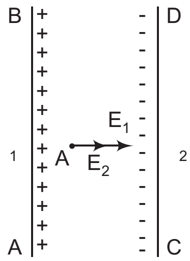
E is inward if is negative.

(b) Linear charge density on wire AB

$_1 \quad 10 \;\; C/m \quad 10 \quad 10^{\;\;6} C/m$

and on wire CD

$_2 \quad 20 \;\; C/m \quad 20 \quad 10^{\;\;6} C/m$



Distance of point A from two wires

$r \quad r_1 \quad r_2 \quad \frac{1}{2} m \quad 0.5 m$

Field intensity at A due to wire AB

$E_1 \quad \frac{1}{2 \quad _0} \frac{| \quad _1|}{r_1}$

towards wire CD and due to wire CD is

$E_2 \quad \frac{1}{2 \quad _0} \frac{| \quad _2|}{r_2}$ towards wire CD

∵ E_1 and E_2 are alike, hence net field

$E \quad E_1 \quad E_2 \quad \frac{1}{2 \quad _0} (| \quad _1| \quad\quad _2|) \frac{1}{r}$

$2 \quad 9 \quad 10^9 (10 \quad 10^{\;\;6} \quad 20 \quad 10^{\;\;6}) \quad \frac{1}{0.5}$

$36 \quad 10^9 \quad 10^{\;\;6} \quad (10 \quad 20)$

$1.08 \quad 10^5$ N/C towards wire CD.

5. (i) $V \quad E \;\; X \quad (4 \quad 10^8) \;\; 0.25 \quad 10^8$ V.

(ii) As, $U \quad q \quad V \quad 1.6 \quad 10^{\;\;19} \quad (\;1.0 \quad 10^8)$

$1.6 \quad 10^{\;\;11}$ J.

(iii) Potential energy, $U \quad \frac{1}{4 \quad _0} \frac{q_1 q_2}{r}$

$\frac{9 \quad 10^9 \quad 1.6 \quad 10^{\;\;19} \quad 1.6 \quad 10^{\;\;19}}{9 \quad 10^{\;\;15}}$

$2.56 \quad 10^{\;\;14}$ J.

(iv) Required work done

W change in electric potential energy

$U_f \quad U_i \quad 0 \quad \frac{1}{4 \quad _0} \frac{4 \quad 10^{\;\;6} \quad (\;3 \quad 10^6)}{[5 \quad (\;5)] \quad 10^{\;\;2}}$

$\frac{9 \quad 10^9 \quad 4 \quad 10^{\;\;6} \quad (\;3) \quad 10^{\;\;6}}{10 \quad 10^{\;\;2}} \quad 1.1$ J.

(v) As proton moves in the direction of the electric field or from P to Q, then its potential energy will decrease but kinetic energy will increase.

6. (i) $W \quad (PE)_{final} \quad (PE)_{initial}$

$\frac{Ke^2}{2} \quad \frac{Ke^2}{1} \quad\quad \frac{Ke^2}{2}$

(ii) Here, $q \quad 2 \;\; C \quad 2 \quad 10^{\;\;6} C, r_A \quad 2$ m, $r_B \quad 1$ m

$V_A \quad V_B \quad \frac{q}{4 \quad _0} \frac{1}{r_A} \quad \frac{1}{r_B}$

$2 \quad 10^{\;\;6} \quad 9 \quad 10^9 \frac{1}{2} \quad \frac{1}{1}$ V $\quad 9 \quad 10^3$ V

(iii) Given that,

$A \quad 3$ nC $\quad 3 \quad 10^{\;\;9}$ C

$B \quad 1$ nC $\quad 1 \quad 10^{\;\;9}$ C

Distance $r_1 \quad 5$ cm $\quad 5 \quad 10^{\;\;2}$ m

and $r_2 \quad r_1 \quad 1$

$5 \quad 1 \quad 4$ cm $\quad 4 \quad 10^{\;\;2}$ m

Required work done Change in potential energy of the system

$W \quad U_f \quad U_i \quad K\frac{q_1 q_2}{r_f} \quad K\frac{q_1 q_2}{r_i} \quad K q_1 q_2 \quad \frac{1}{r_f} \quad \frac{1}{r_i}$

$W \quad (9 \quad 10^9)(3 \quad 10^{\;\;9} \quad 1 \quad 10^{\;\;9})$

$\frac{1}{4 \quad 10^{\;\;2}} \quad \frac{1}{5 \quad 10^{\;\;2}}$

$27 \quad 10^{\;\;9} \quad \frac{1}{20 \quad 10^{\;\;2}} \quad 1.35 \quad 10^{\;\;7}$ J

7. (i) Here, $C \quad 50$ pF $\quad 50 \quad 10^{\;\;12}$ F

$R \quad \frac{1}{4 \quad _0} \quad C \quad 9 \quad 10^9$ mF$^{\;\;1} \quad 50 \quad 10^{\;\;12}$ F

$45 \quad 10^{\;\;2}$ m $\quad 45$ cm.

(ii) As, $q \quad CV \quad 25 \quad 10^{\;\;12} \quad 10^5 \quad 2.5 \;\; C$.

(iii) As charge, $q \quad CV \quad (4 \quad _0 R) V$

q depends on both V and R, *i.e.*, q is proportional to both R and V.

(iv) 64 small spheres have formed a single big sphere of radius R.

Volume of large sphere 64 volume of small spheres

$\frac{4}{3} \quad R^3 \quad 64 \quad \frac{4}{3} \quad r^3$

$R \quad 4r$ and $Q_{total} \quad 64q$

$C \quad 4 \quad _0 R$

$C \quad (4 \quad _0) \;\; 4r$

$C \quad 4C$

8. (i) (a) If space between the plates of a parallel plate capacitor is completely filled by a dielectric medium of dielectric constant K then capacitance increases by K times.

(b) Dielectric constant

$K \quad \frac{\text{Capacitance with dielectric}}{\text{Capacitance without dielectric}}$

$\frac{80 \;\; F}{4 \;\; F} \quad 20$

(ii) Capacitance of the capacitor with air between plates

$C \quad \frac{_0 A}{d} \quad 8$ pF

With the capacitor filled with dielectric ($k \quad 5$) between its plates and the distance between the plates is reduced by half, capacitance become

$C \quad \frac{_0 KA}{d/2} \quad \frac{_0 \;\; 5 \;\; A}{d/2} \quad 10C \quad 10 \quad 8 \quad 80$ pF

(iii) (a) $C \quad \frac{{}_0A}{d} \quad 1\text{pF}$ ...(1)

$C \quad \frac{X\ {}_0A}{(2d)} \quad 2\text{ pF}$ ...(2)

Dividing eq. (2) by eq. (1).

$\frac{x}{2} \quad \frac{2}{1} \qquad x \quad 4$

(b) As capacitance, $C_0 \quad \frac{{}_0A}{d}$ of partially filled parallel plate capacitor is $C \quad \frac{{}_0A}{d \quad t \quad \frac{t}{k}}$ and for copper k

and $t \quad b$

$C \quad \frac{{}_0A}{d \quad b}$

9. (i) Mobility is defined as the magnitude of drift velocity per unit electric field.

Mobility, $\frac{|v_d|}{E}$

Drift velocity, $v_d \quad \frac{eE}{m} \qquad v_d \quad E$ and v_d

(ii) Here, number density of free electrons,

$n \quad 8.5 \quad 10^{28}\text{m}^{\ 3}$

Area of cross-section of a wire, $A \quad 2.0 \quad 10^{\ 6}\text{m}^2$

Length of wire, $l \quad 3.0$, current, $I \quad 3.0$ A

Then drift velocity of an electron is

$v_d \quad \frac{I}{neA}$ ...(1)

Then time taken by the electron to drift from one end to other end of the wire is

$t \quad \frac{l}{v_d} \quad \frac{lneA}{I}$ [Using eq. (1)]

$\frac{(3.0\text{m})(8.5 \quad 10^{28}\text{m}^{\ 3})(1.6 \quad 10^{\ 19}\text{C})(2.0 \quad 10^{\ 6}\text{m}^2)}{(3.0\text{ A})}$

$2.7 \quad 10^4\text{s}$

(iii) (a) The number density of free electrons is very high and this can compensate for the low values of the electron drift speed and the very small magnitude of the electron charge.

As, $I \quad neAv_d$

v_d is of the order of few cm s $^{\ 1}$, $e \quad 1.6 \quad 10^{\ 19}$C

A is of the order of mm^2, so a large I is due to a large value of n in conductors.

(b) When we close the circuit, an electric field is established instantly with the speed of electromagnetic wave which causes electrons to drift at every portion of the circuit due to which the current is set up in the entire circuit instantly. The current which is set up does not wait for electrons to flow from one end of the conductor to another. Thus, the electric bulb glows immediately when switch is on.

10. (i) (a) Dimensions of electric resistance

$[\text{ML}^2\text{T}^{\ 3}\text{A}^{\ 2}]$

(b) **Resistivity:** It is defined as the resistance of a unit length with unit area of cross-section of the material of the conductor.

Resistivity, $R\frac{A}{l}$

where, R resistance

A cross-sectional area

l length of conductor

Resistivity depends on the nature of the material of conductor and temperature of conductor. It does not depend on cross-sectional area and length of the conductor.

(c) Resistance $R \quad \frac{V}{I} \quad \frac{2}{10^{\ 6}} \quad 2 \quad 10^6$

(ii) Given, $l \quad 1.0$ m, $D \quad 0.4$ mm $\quad 4 \quad 10^{\ 4}$ m

$R \quad 2$

Now, $A \quad \frac{D^2}{4} \quad \frac{(4 \quad 10^{\ 4})^2}{4}$

$4 \quad 10^{\ 8}\text{m}^2$

resistivity, $\frac{RA}{l} \quad \frac{2 \quad 4 \quad 10^{\ 8}}{1}$

$2.55 \quad 10^{\ 7} \quad \text{m}$

(iii) According to the question,

$l_1 : l_2 \quad 3:2$

$r_1 : r_2 \quad 2:3$

Resistance, $R_1 \quad \frac{l_1}{r_1^2}$

$R_2 \quad \frac{l_2}{r_2^2}$

Ratio of resistances,

$\frac{R_1}{R_2} \quad \frac{l_1}{l_2} \quad \frac{r_2^2}{r_1^2} \quad \frac{l_1}{l_2} \quad \frac{r_2^2}{r_1^2}$

$\frac{3}{2} \quad \frac{3}{2}^{\ 2} \quad \frac{(3)^3}{(2)^3} \quad \frac{27}{8}$

Ratio of currents,

$\frac{I_1}{I_2} \quad \frac{V/R_1}{V/R_2} \quad \frac{R_2}{R_1} \quad \frac{8}{27} \quad 8:27$

11. (i) $\because E = I(R + r)$ and $V = IR$

$$\frac{V}{R} = \frac{R}{R + r} = \frac{R}{R + R} = \frac{1}{2} \Rightarrow V = \frac{E}{2}$$

(ii) $\because \quad E = I(R + r)$

In first case, $I = 0.5\,A\,;\, R = 12\,\Omega$

$E = 6.0 + 0.5\,r$ ...(1)

In second case, $I = 0.25\,A\,;\, R = 25\,\Omega$

$E = 6.25 + 0.25r$ ...(2)

From eqs. (1) and (2), $r = 1\,\Omega$

(iii) In parallel combination of cells,

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

Here $E_1 = 2\,V, E_2 = 1\,V,\ r_1 = 1\,\Omega,\ r_2 = 2\,\Omega$

$$E_{eq} = \frac{2 \times 2 + 1 \times 1}{1 + 2} = \frac{5}{3}\,V$$

(iv) Current in the circuit, $I = \dfrac{E}{R + r}$

or $$I = \frac{E}{\sqrt{(R - r)^2 + 4rR}}$$

$$\left[\because R + r = \sqrt{(R - r)^2 + 4Rr}\,\right]$$

Obviously I will be maximum if denominator is minimum, for which we must have

$$R - r = 0$$

or $$R = r$$

When $R = r$, then maximum current will flow in the external resistance.

(v) For first case, $\dfrac{E}{R + r} = \dfrac{10}{R}$ ...(1)

For second case, $\dfrac{E}{5R + r} = \dfrac{30}{5R}$ ...(2)

Dividing eq. (1) by eq. (2), we get, $r = 5\,R$

From eq. (1), $\dfrac{E}{R + 5R} = \dfrac{10}{R}$

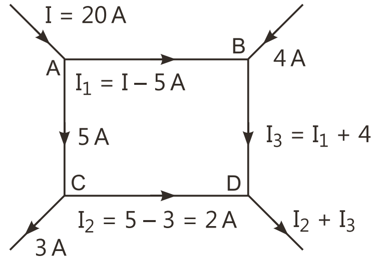
$$\Rightarrow E = 60\,V$$

12. (i) Kirchhoff's Current Law (KCL) states that the total current entering a junction must be equal to the total current leaving the junction. This law directly reflects the principle of the conservation of charge, which states that charge neither be created nor be destroyed, only transferred. Therefore, in an electrical circuit, the amount of charge flowing into a junction must equal the charge flowing out, ensuring that charge is conserved.

(ii) Using Kirchhoff's first law,

At junction A:

$I_1 = 20 - 5 = 15\,A$



At junction B:

$I_3 = I_1 + 4$

$I_3 = 15 + 4 = 19\,A$

At junction C:

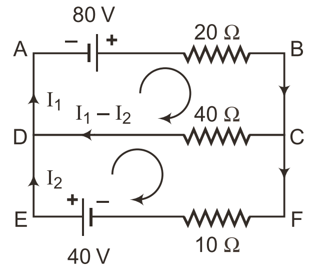
$I_2 = 5 - 3 = 2A$

At junction D:

$I = I_2 + I_3$

$= 2A + 19A = 21\,A$

(iii) Taking loops clockwise as shown in figure:



Using Kirchhoff's loop law in $ABCDA$,

$$80 - 20I_1 - 40(I_1 - I_2) = 0$$

$$\Rightarrow 3I_1 - 2I_2 = 4 \quad ...(1)$$

Using Kirchhoff's loop law in $DCFED$,

$$40(I_1 - I_2) - 10I_2 - 40 = 0$$

$$\Rightarrow 4I_1 - 5I_2 = 4 \quad ...(2)$$

From eqs. (1) and (2), we get

$$I_1 = 4A \text{ and } I_2 = 4A$$

Thus, $I_{40} = I_1 - I_2 = 0A$

and $I_{20} = I_1 = 4A$

13. (i) Let I' be the current in the region $r < R$.

Then, $$I' = \frac{I}{\pi R^2}(\pi r^2) \text{ or } I' = \frac{Ir^2}{R^2}$$

So, magnetic field, $$B = \frac{\mu_0 I'}{2\pi r} = \frac{\mu_0 I r^2}{2\pi R^2 r} = \frac{\mu_0 I r}{2\pi R^2}$$

(ii) Let the magnetic fields due to a long straight wire of radius R carrying a steady current I at a distance r from the centre of the wire are

$$B_1 = \frac{\mu_0 I r}{2\pi R^2} \text{ (for } r \le R)$$

and $$B_2 = \frac{\mu_0 I}{2\pi R} \text{ (for } r > R)$$

So, the magnetic field at $r = \dfrac{R}{2}$ is

$$B_1 = \frac{\mu_0 I}{2\pi R^2} \cdot \frac{R}{2} = \frac{\mu_0 I}{4\pi R}$$

and at $r = 2R$, $$B_2 = \frac{\mu_0 I}{2\pi (2R)} = \frac{\mu_0 I}{4\pi R}$$

Their corresponding ratio is

$$\frac{B_1}{B_2} = \frac{(\mu_0 I / 4\pi R)}{(\mu_0 I / 4\pi R)} = 1 \Rightarrow B_1 : B_2 = 1:1$$

(iii) Given that,

$$I \quad 40\,\text{A}$$
$$r \quad 15\,\text{cm}$$
$$15 \quad 10^{\ 2}\,\text{m}$$
$$B \quad \frac{{}_0 I}{2\ r} \quad \frac{4 \quad 10^{\ 7} \quad 40}{2 \quad 15 \quad 10^{\ 2}} \quad \frac{80 \quad 10^{\ 5}}{15}$$
$$5.34 \quad 10^{\ 5}\,\text{T}$$

14. (i) The proton follows a circular path because the magnetic force acts perpendicular to its velocity, providing the centripetal force required for circular motion.

The radius of the path is directly proportional to the proton's velocity and inversely proportional to the magnetic field strength and charge.

(ii) (a) The time period is constant because it depends only on the magnetic field strength and charge-to-mass ratio of the proton, which remain constants during the motion.

(b) If the proton entered the field at an angle other than 90° it would move in a helical path.

(iii) Component of velocity along the field B is

$$v_{\|} \quad 0.5 \quad 10^7\ \text{m/s}$$

and component of velocity perpendicular to field is

$$v \quad 1.0 \quad 10^7\ \text{m/s}$$

Radius of circular path is

$$r \quad \frac{mv}{qB} \quad \frac{9.1 \quad 10^{\ 31} \quad 1.0 \quad 10^7}{1.6 \quad 10^{\ 19} \quad (0.5 \quad 10^{\ 3})}$$
$$0.114\ \text{m} \quad 11.4\ \text{cm}$$

Electron also moves on straight line path due to velocity component parallel to field B.

$\because$ Period of revolution $T \quad \frac{2\ m}{qB}$

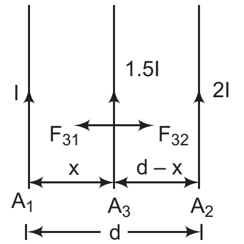
Linear distance covered during one revolution

$$s \quad v_{\|} \quad T \quad 0.5 \quad 10^7 \quad \frac{2 \quad 3.14 \quad 9.1 \quad 10^{\ 31}}{1.6 \quad 10^{\ 19} \quad 0.5 \quad 10^{\ 3}}$$
$$35.7 \quad 10^{\ 2}\,\text{m} \quad 0.36\,\text{cm}$$

15. (i) The wires attract each other because the magnetic field created by one wire exerts a force on the other wire and according to Fleming's left hand rule, pulling them together when the currents flow in the same direction. When the current in one wire is reversed, the magnetic fields oppose each other, resulting in a repulsive force.

(ii) If the currents are doubled, the force increases four times because the force is proportional to the product of the currents ($F \quad i_1, i_2$). The force is inversely proportional to the distance between the wires ($F \quad 1/r$). Increasing the distance reduces the force.

(iii) Let the current in the third wire A_3 be in same direction as that of A_1 and A_2. So, it will experience attractive force due to both.



The force on length l of wire A_3 due to A_1 is

$$F_{31} \quad \frac{{}_0}{2} \frac{l \quad 1.5I \quad l}{x}$$

where x distance between A_1 and A_3

Similarly, force on length l of wire A_3 due to A_2 is

$$F_{32} \quad \frac{{}_0}{2} \frac{1.5I \quad 2I \quad l}{(d \quad x)}$$

According to question, $F_{31} \quad F_{32}$

$$\frac{{}_0}{2} \frac{1.5I^2 l}{x} \quad \frac{{}_0}{2} \frac{3I^2}{(d \quad x)} l$$
$$\frac{1.5}{x} \quad \frac{3}{d \quad x}$$
$$d \quad x \quad 2x$$

or $$x \quad \frac{d}{3}$$

Yes, the net force acting on A_3 depends on the current flowing through it.

16. (i) Torque is given by $\quad NIAB\sin$, where is the angle between the normal to the loop and the magnetic field.

(ii) Maximum torque occurs when $\sin \quad 1$, i.e., $\quad 90$

$${}_{\max} \quad NIAB \quad (1)(2)(0.1 \quad 0.05)(0.5) \quad 0.005\ \text{Nm}.$$

Doubling the current would double the torque since $\quad I$.

(iii) This principle is used in electric motors, where the torque on a current loop generates rotational motion.

17. (i) The potential energy of a dipole in uniform magnetic field is given by $U \quad M \quad B \quad MB\cos$

(ii) The potential energy decreases from maximum $U \quad MB.(\quad 180 \ )$ to minimum, $U \quad MB(\quad 0 \ )$ as the dipole aligns with the field.

(iii) Work done, $W \quad U_{\text{final}} \quad U_{\text{initial}} (\quad MB\cos 180 \quad)$

$(\quad MB\cos 0 \quad) \quad 2MB.$

Substituting $M \quad 1\,\text{Am}^2$ and $B \quad 0.2\,\text{T}$

$W \quad 2 \quad 1 \quad 0.2 \quad 0.4\,\text{J}$

18. (i) The classification is based on the magnetic susceptibility ( ) and the material's response to an external magnetic field:

(a) Diamagnetic materials: These have a negative susceptibility (0), meaning they create an induced magnetic field in the opposite direction and are repelled by the external field.

(b) Paramagnetic materials: These have a small positive susceptibility (0) and are weakly attracted to the external field.

(c) Ferromagnetic materials: These have a very high positive susceptibility and permeability, are strongly attracted to the magnetic field and exhibit permanent magnetisation due to domain alignment.

Classification of the given materials:

(a) Copper: Diamagnetic

(b) Aluminium: Paramagnetic

(c) Iron: Ferromagnetic

(d) Nickel: Ferromagnetic

(ii) Iron has much higher magnetic permeability because it is ferromagnetic, meaning its magnetic domains align strongly in the presence of an external field, enhancing the material's ability to support the formation of a magnetic field. Aluminium (paramagnetic) and copper (diamagnetic) do not exhibit this domain alignment, resulting in significantly lower permeability.

(iii) As the temperature increases,. the magnetic susceptibility of ferromagnetic materials like iron decreases. This is because thermal agitation disrupts the alignment of magnetic domains, reducing the material's ability to retain magnetisation.

19. (i) Direction of current induced in a wire moving in a magnetic field is found by using Fleming's right hand rule.

(ii) Induced emf $\quad Blv$

current in the rod, $I \quad \frac{}{R} \quad \frac{Blv}{R}$

But current in rod is possible only if the rod forms a part of closed circuit.

(iii) Here, $l \quad 0.1\,\text{m}, v \quad 1\,\text{ms}^{\;\;1}$

$I \quad 50\,\text{A}, B \quad 1.25\,\text{mT} \quad 1.25 \quad 10^{\;\;3}\,\text{T}$

The induced emf is $\quad Blv$

The mechanical power is

$P \quad I \quad BlvI \quad 1.25 \quad 10^{\;\;3} \quad 0.1 \quad 1 \quad 50$

$6.25 \quad 10^{\;\;3}\,\text{W} \quad 6.25\,\text{mW}$

(iv) emf induced, $\quad Blv$

Here, B, l and v are mutually perpendicular for given B and l, $\quad v$.

$$\frac{_1}{_2} \quad \frac{v_1}{v_2}$$

Here, $_1 \quad 1.5\,\text{V}, v_1 \quad 15\,\text{km/hr} \quad 15 \quad \frac{5}{18}\text{ms}^{\;\;1}$

$v_2 \quad 10\,\text{km/hr} \quad 10 \quad \frac{5}{18}\text{m s}^{\;\;1}, \;_2 \quad ?$

$$\frac{1.5}{_2} \quad \frac{15 \quad \frac{5}{18}}{10 \quad \frac{5}{18}} \quad \frac{3}{2} \qquad _2 \quad 1\,\text{V}$$

(v) $\frac{[W]}{q} \quad \frac{[\text{ML}^2\text{T}^{\;\;2}]}{[\text{AT}]} \quad [\text{ML}^2\text{T}^{\;\;3}\text{A}^{\;\;1}]$

20. (i) Here, $I \quad 2.5\,\text{A}, L \quad 5\,\text{H}$

Magnetic flux linked with the coil is

$_B \quad LI \quad (5\text{H})(2.5\,\text{A}) \quad 12.5\,\text{Wb}$

(ii) The inductance of a solenoid is

$$L \quad _0 n^2 Al$$

where, A is the area of cross-section of the solenoid, l its length and n is the number of turns per unit length.

As, $A \quad R^2$, where R is the radius of the solenoid.

$$L \quad _0 n^2 \quad R^2 l$$

Thus, inductance of a solenoid depends on area of solenoid, length of solenoid, number of turns and radius of solenoid.

(iii) Unit of self inductance is Henry.

(iv) Here, $L \quad 10\,\text{H}, I_1 \quad 9\,\text{A}, I_2 \quad 4\,\text{A}$

and $\quad t \quad 0.2\,\text{s}$

Then induced emf

$$L\frac{dI}{dt} \quad L\frac{(I_2 \quad I_1)}{t}$$

$$\frac{10 \quad (4 \quad 9)}{0.2} \quad \frac{50}{0.2} \quad 250\,\text{V}$$

21. (i) Here, $L \quad 0.12\,\text{H}, C \quad 480\,\text{nf} \quad 480 \quad 10^{\;\;9}\,\text{F}$

$R \quad 23 \quad , V \quad 230\,\text{V}$

$V_0 \quad \sqrt{2} \quad 230 \quad 325.22\,\text{V}$

Current amplitude will be maximum at resonance. For which source frequency is

$$\frac{1}{2\ \sqrt{LC}} \quad \frac{1}{2 \quad 3.14 \quad \sqrt{0.12 \quad 480 \quad 10^{\quad 9}}}$$

$$R \quad \frac{4166.67}{2 \quad 3.14} \quad 663.48 \text{ Hz}$$

(ii) At resonance $Z \quad R$, hence maximum current

$$I_0 \quad \frac{V_0}{R} \quad \frac{325.22}{23} \quad 14.14 \text{ A}$$

(iii) Maximum power, $P_{max} \quad \frac{1}{2}(I_0)^2 R$

$$\frac{1}{2} \quad (14.14)^2 \quad 23 \quad 2299.3 \text{ W}$$

(iv) At resonance, current is maximum.

22. (i) Resistance of the wire of the two wire lines carrying power $\quad 0.5 \quad$ km

Total resistance $\quad (15 \quad 15)0.5 \quad 15$

(ii) Power supplied to primary $P \quad 800$ kW

$$800 \quad 10^3 \text{ W}$$

and $\quad V_P \quad 4000$ V

$$I_P \quad \frac{P}{V_P}$$

rms current in the coil,

$$I_P \quad \frac{P}{V_P} \quad \frac{800 \quad 10^3}{4000} \quad 200 \text{ A}$$

Power loss in wire line $\quad I_P^2 \quad R$

$$(200)^2 \quad 15 \quad 600 \text{ kW}$$

(iii) Assuming that the power loss is negligible due to the leakage of the current.

The total power supplied by the plant

$$800\text{kW} \quad 600\text{kW} \quad 1400\text{kW}$$

(iv) Voltage drop in the power line $\quad IR \quad 200 \quad 15$

$$3000 \text{ V}$$

(v) Total voltage transmitted from the plant

$$3000 \text{ V} \quad 4000 \text{ V} \quad 7000 \text{ V}$$

23. (i) Given, B $\quad B_0 \sin(kx \qquad t)$ JT

The relation between magnitudes of electric and magnetic field is,

$$c \quad \frac{E_0}{B_0} \text{ or } E_0 \quad cB_0$$

The electric field component is perpendicular to the direction of propagation and the direction of magnetic field. Therefore, the electric field component along Z-axis is obtained as E $\quad cB_0 \sin(kx \qquad t)$k V/m.

(ii) Since, $\frac{dE}{dz} \quad \frac{dB}{dt}$

$$\frac{dE}{dz} \quad 2E_0 k \sin kz \cos \quad t \quad \frac{dB}{dt}$$

$$dB \quad 2E_0 k \sin kz \cos \quad t\, dt$$

$$B \quad 2E_0 k \sin kz \cos \quad t\, dt \quad 2E_0 \frac{k}{} \sin kz \sin \quad t$$

$$\because \frac{E_0}{B_0} \quad \frac{}{k} \quad c$$

$$B \quad \frac{2E_0}{c} \sin kz \sin \quad t$$

Thus, magnetic field component,

$$B \quad \frac{2E_0}{c} \sin kz \sin \quad t \text{ j}$$

(iii) Given, $E \quad 6.3$ j V/m, $c \quad 3 \quad 10^8$ m/s

The magnitude of magnetic field,

$$B_z \quad \frac{E}{c} \quad \frac{6.3}{3 \quad 10^8} \quad 2.1 \quad 10^{\quad 8} \text{ T} \quad 0.021 \quad \text{T}$$

The magnetic field will be perpendicular to the direction of propagation and direction of electric field.

Therefore, B $\quad 2.1 \quad 10^{\quad 8}$ k T

(iv) Given, $E_0 \quad 66 \text{ Vm}^{\quad 1}, E_y \quad 66 \cos \quad t \quad \frac{x}{c}$,

$$3 \text{ mm} \quad 3 \quad 10^{\quad 3} \text{m}, k \quad \frac{2}{}$$

$$\frac{}{k} \quad c \qquad ck \quad 3 \quad 10^8 \quad \frac{2}{3 \quad 10^{\quad 3}}$$

or $\quad 2 \quad 10^{11}$ rad/s

$$E_y \quad 66 \cos 2 \quad 10^{11} \quad t \quad \frac{x}{c}$$

$$B_z \quad \frac{E_y}{c} \quad \frac{66}{3 \quad 10^8} \cos 2 \quad 10^{11} \quad t \quad \frac{x}{c}$$

$$2.2 \quad 10^{\quad 7} \cos 2 \quad 10^{11} \quad t \quad \frac{x}{c}$$

Value Based Questions

1. Coulomb's Law helps in reducing air pollution by utilising the principle of charged particles. In a factory that produces dust and smoke, electrostatic precipitators are used to trap harmful particles. These devices work by charging the dust particles using an electric field, causing them to move toward oppositely charged plates or surfaces. Once the particles are attracted to these plates, they are collected and removed, preventing them from being released into the air.

This process not only cleans the air but also helps in maintaining a healthier environment, reducing the risk of respiratory diseases and other pollution-related health issues. By using this application of Coulomb's Law, industries can minimise the environmental impact, promoting sustainable practices and ethical responsibility. This method shows how physics can be used to solve real-world problems and contribute to cleaner air and better public health.

2. Understanding electric field lines is critical for safety around electrical installations. Electric field lines illustrate how electric fields extend into space around charged objects, indicating areas where high voltage can pose risks, knowledge of these fields enables individuals to recognise safe distances to avoid electrical hazards, preventing accidents such as electrocution or equipment damage. This awareness fosters a culture of safety and responsibility.

3. The discovery and application of laws Gauss's Law deepen our understanding of the natural world by explaining the behaviour of electric fields and charge distributions, ensbling advancements in technology and environment protection. Values associated with scientific inquiry include curiosity, critical thinking, innovation, responsibility, collaboration, perseverance and humility, fostering ethical and impactful contributions to society.

4. Accuracy and precision are crucial in scientific calculations, especially when applying fundamental laws like Gauss's Law, because even small errors in measurements or calculations can lead to incorrect conclusions or faulty designs. Gauss's Law, for example, relies on precise calculations of electric flux and enclosed charge to determine electric fields in different systems. Any inaccuracy could impact the understanding of electric forces, leading to practical consequences in engineering and technology.

5. A bird does not get electrocuted because both its feet are at the same electric potential. There is no potential difference across its body, so no current flows through it. However, if the bird touches another line with a different potential or the ground, it could get electrocuted due to the potential difference.

6. Walking on a carpet can cause your body to accumulate static charge, creating a potential difference between you and the doorknob. When you touch the metal, the potential difference causes a sudden flow of electrons (current), resulting in a small spark.

7. Capacitors store electrical energy and release it quickly, producing the intense burst of light required for camera flashes or emergency lighting.

Values Demonstrated by Sanya: Scientific curiosity and practical knowledge, sharing knowledge with others and enthusiasm for applying physics concepts in real life.

8. Capacitors in LED lights regulate the flow of current, ensuring steady light output and reducing energy consumption.

Values Demonstrated by Rita: Awareness of energy efficiency and conservation, environmental responsibility, practical problem-solving for cost savings.

9. During summer, the ambient temperature in creases, which causes an increase in the resistance of the fan's motor windings. Higher resistance results in reduced current flow, leading to a decrease in the fan's speed. Here, curiosity to understand scientific phenomena, keen observation skills are the values demonstrated by Rahul.

10. Copper has higher electrical conductivity and lower resistivity compared to aluminium, ensuring efficient power transmission and reduced energy loss. Copper is also more durable and less prone to oxidation.

Values Demonstrated by Priya: Awareness of electrical safety and efficiency, problem-solving and concern for long-term benefits over immediate cost savings.

11. Kirchhoff's laws help calculate the current in each branch, ensuring that the total current does not exceed the capacity of the circuit. Proper distribution of loads prevents overheating and power cuts. The values demonstrated by Nisha are Social responsibility, Knowledge sharing and concern for the community.

12. The Wheatstone bridge helps troubleshoot electrical faults by accurately measuring and comparing resistances in a circuit. It detects breaks, loose connections or defective components by identifying imbalances in resistance, making it a precise tool for locating and resolving issues in electrical wiring or devices.

Values Demonstrated by Suman: Accuracy and attention to detail, commitment to scientific and practical design and contribution to innovative solutions.

13. The Biot-Savart law can be used to calculate the magnetic field produced around a current-carrying wire, such as in power transmission lines. The law explains that the magnetic field strength depends on the current and the distance from the wire. As power lines carry electricity, the resulting magnetic field can affect the surrounding environment and people. Society should consider the environmental and health risks associated with long-term exposure to magnetic fields and balance the need for efficient energy distribution with concerns about electromagnetic pollution. A responsible approach includes investingating safe transmission practices and using underground power lines where possible to minimize exposure.

14. The controlled motion of charged particles in a magnetic field allows their use in targeted therapies, improving healthcare and saving lives. This demonstrates values like innovation, dedication to societal welfare and empathy for patients.

15. The forces between conductors are accounted for to maintain the structural integrity of the wires and prevent short circuits or accidents. This reflects values like responsibility, teamwork and a commitment to providing essential services efficiently and safely.

16. The Earth behaves like a giant magnetic dipole with its magnetic south pole near the geographic north pole and magnetic north pole near the geographic south pole. This causes Earth's magnetic field lines to form a pattern similar to a bar magnet. A compass, being a small magnetic dipole, aligns itself with Earth's magnetic field, with the north-seeking end pointing toward the magnetic north. This simple yet effective tool helps in navigation, enabling hikers to determine directions even in dense forests where landmarks or other navigation aids may be unavailable.

Relying on this natural phenomenon reflects values like adaptability and resourcefulness by utilising nature's reliable guidance system. It also demonstrate trust in natural laws and an appreciation of Earth's inherent systems. Furthermore, it fosters environmental awareness by highlighting the importance of preserving our planet's magnetic field.

17. The torque on a current-carrying loop in a magnetic field causes the loop to rotate, converting electrical energy into mechanical energy, which powers the motor. Understanding this principle allows engineers to design energy-efficient motors, reducing energy consumption and promoting sustainability. Efficient electric motors reflect values like innovation, resourcefulness and environmental responsibility, as they minimise energy waste and contribute to reducing the carbon footprint in daily life.

18. Diamagnetic materials are important for pacemakers because they repel external magnetic fields, preventing interference that could disrupt the pacemaker's functioning. These materials are used in pacemaker shielding to protect the device from strong magnetic fields, such as those in MRI machines, ensuring accurate and reliable operation. The ethical values reflected include patient safety by preventing malfunction, responsibility in creating dependable medical technology and compassion for improving the lives of people with heart conditions.

19. Magnetic susceptibility helps in pollution monitoring by enabling the detection of magnetic minerals, which often accumulate due to industrial or vehicular pollution. By measuring the magnetic properties of soil, water and air samples, scientists can assess the extent of contamination and pinpoint pollution sources. This method is efficient, cost-effective and non-destructive, providing valuable data for environmental management.

The ethical values reflected here include environmental responsibliity and sustainability by promoting the protection of ecosystems. Through these efforts, we ensure justice by safeguarding both the environment and public health, especially in vulnerable areas.

20. A renewable energy system with wind turbines based on electromagnetic induction helps the school generate electricity sustainably. It converts wind energy into electrical energy, reducing reliance on fossil fuels. This lowers electricity costs and minimizes the carbon footprint. The system promotes clean energy and reduces pollution. It reflects environmental responsibility, sustainability and innovation. The school sets an example of leadership in tackling climate change.

21. Electromagnetic induction is used in regenerative braking systems of electric vehicles and trains. This technology converts the vehicle's kinetic energy into electrical energy, which is stored in batteries for reuse. It reduces energy consumption and promotes sustainable urban transport.

22. AC is used in homes because it is more efficient and economical for transmitting electricity over long distances. It can be easily stepped up to high voltages for transmission an stepped down for household use using transformers, reducing energy loss. AC is compatible with a wide range of household devices and systems, making it versatile. It is also safer, as circuit breakers and fuses work effectively with AC to prevent electrical hazards. Although some applianaces like mobile chargers require DC, they internally convert AC to DC for their use. The cost-effectiveness and ease of distribution of AC make it the preferred choice for power supply. The values reflected in the use of AC for household power supply highlight efficiency, safety and cost-effectiveness.

23. A choke coil is necessary for a fluorescent tube because it regulates the current without much loss in electrical energy. Without the choke coil, the tube might flicker or get damaged. Values shown by Mohan's friend are responsibility and knowledge sharing by advising the correct usage of electrical components and ensuring safety.

24. Remote controls use infrared radiation, which is a part of the electromagnetic spectrum. The frequency range of infrared radiation typically lies between $4\ 10^{14}$ Hz to $6\ 10^{10}$ Hz. Meera demonstrates patience, knowledge-sharing and encouragement for learning. By explaining the concept clearly and motivating her brother to explore more, she shows responsibility and a nurturing attitude toward his curiosity.

25. It is important to limit exposure to X-rays because excessive exposure can damage living tissues and cells. This may lead to mutations, an increased risk of cancer, or other harmful effects on the body. Proper shielding and minimal exposure help ensure safety while benefiting from the diagnsostic capabilities of X-rays. Ananya exhibits curiosity, responsibility, and awareness by inquiring about the safe use of X-rays. Her questions reflect a genuine interest in understanding medical technology and a concern for health and safety.

Assertion & Reason Type Questions

1. (c), **2.** (d), **3.** (b), **4.** (b), **5.** (b), **6.** (a), **7.** (b), **8.** (d), **9.** (a), **10.** (b), **11.** (a), **12.** (c), **13.** (a), **14.** (c), **15.** (a), **16.** (c), **17.** (c), **18.** (c), **19.** (a), **20.** (a), **21.** (a), **22.** (b), **23.** (d), **24.** (c), **25.** (a), **26.** (a), **27.** (d), **28.** (c), **29.** (a), **30.** (a), **31.** (a), **32.** (c), **33.** (a), **34.** (d), **35.** (d), **36.** (a), **37.** (c), **38.** (a), **39.** (a), **40.** (a), **41.** (d), **42.** (d), **43.** (d), **44.** (a), **45.** (a), **46.** (a), **47.** (a), **48.** (a), **49.** (a), **50.** (c), **51.** (d), **52.** (b), **53.** (a), **54.** (b), **55.** (a), **56.** (a), **57.** (a), **58.** (a), **59.** (d), **60.** (d), **61.** (a), **62.** (a), **63.** (d), **64.** (d), **65.** (a), **66.** (a), **67.** (b), **68.** (a), **69.** (a).