LIBERTY PAPER SET

STD. 12 : Physics

Full Solution

Time : 3 Hours **ASSIGNMENT PAPER 12**

Section A

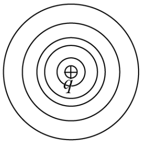
1. (D) **2.** (A) **3.** (D) **4.** (C) **5.** (B) **6.** (D) **7.** (B) **8.** (D) **9.** (D) **10.** (D) **11.** (A) **12.** (B) **13.** (B) **14.** (D) **15.** (D) **16.** (B) **17.** (A) **18.** (C) **19.** (B) **20.** (B) **21.** (A) **22.** (C) **23.** (B) **24.** (A) **25.** (A) **26.** (C) **27.**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

Section A

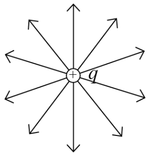
➢ **Write the answer of the following questions : (Each carries 2 Mark)**

1.

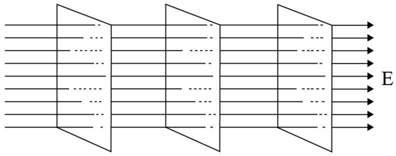
➥ *"An imaginery surface, any surface that have same electric potential at every point on it is called equipotential surface."*



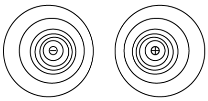
(a)
equipotential surfaces are spherical surfaces centred at the charge



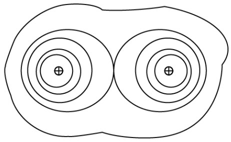
(b)
electric field lines are radial starting from the charge if $q > 0$



(c)
equipotential surface for a uniform electric field.



(d)
equipotential surface of electric dipole.



(e)
equipotential surfaces for two identical positive charges.

➥ Electric potential at distance r from a point charge q,

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$ If r is constant then

V = const. also

➥ Hence, equipotential surface for a point charge q are different spheres having charge q at centre, and having different radii. (Fig. a)

➥ For such two different equipotential surfaces, potential will be different but potential for all points on any one equipotential surface will be same.

➥ Electric field lines for a point charge are radial lines starting (originating) from the charge and ending at infinity. (or in negative charge.) So we can say that electric field lines are perpendicular to equipotential surface.

➥ If the electric field is not perpendicular to the equipotential surface then there will be a component of $\vec{E}$ (electric field) parallel to the surface. Which shows work needs to be done in moving the unit test charge against this component of electric field, which is against the definition of equipotential surface.

➥ Electric potential difference between any two points on the equipotential surface is zero. (V = 0) so, no work is required to be done in moving test charge on the surface.

➥ Hence electric field at each point on the equipotential surface must be perpendicular to the surface.

➥ Equipotential surfaces for uniform electric field are shown in fig. C.

➥ If the field is along X-direction, equipotential surface must be parallel to YZ - plane.

2.

➥ When there is air between two plates of capacitor, its capacitance

$$C_0 = \frac{\varepsilon_0 A}{d} = 8 \times 10^{-12}\ \text{F}$$

➥ Distance between two plates is reduced to half, and the space between two plates is filled with a substance having its dielectric constant K = 6 the new capacitance,

$$C = \frac{\varepsilon A}{\frac{d}{2}} = \frac{2\,\varepsilon_0 KA}{d} \quad (\because \varepsilon = \varepsilon_0 K)$$

$\therefore C = 2KC_0$

$\therefore C = 2 \times 6 \times 8 \times 10^{-12}$

$\therefore C = 96 \times 10^{-12}$ F

3.

➥ Current density : *"The electric current flowing per unit cross sectional area perpendicular to the current is called the (electric) current density* $(\vec{j})$*."*

➥ Suppose current I is flowing through the cross sectional area A, then electric current density

$$\therefore j = \frac{I}{A} \quad \ldots (1)$$

➥ The SI unit of current density is $\frac{A}{m^2}$.

➥ It is a vector quantity and the dimensional formula is $M^0L^{-2}T^0A^1$.

➥ If the magnitude of uniform electric field in the conductor of length l is E, then the potential difference across its ends,

$$V = El$$

➥ According to the ohm's law

$$V = IR$$

$$\text{but } R = \frac{\varrho l}{A}$$

$$\therefore V = \frac{I\varrho l}{A}$$

$$\therefore El = \frac{I\varrho l}{A}$$

$$\therefore E = \frac{I\varrho}{A} \quad (\because V = El)$$

➥ Using equation (1),

$$\therefore E = j\,\varrho \quad \ldots (2)$$

➥ The reciprocal of resistivity is called the conductivity of material.

$$\therefore \sigma = \frac{1}{\varrho} \quad \ldots (3)$$

➥ where σ = conductivity of material

from equation (2) and (3),

$$\therefore E = \frac{j}{\sigma}$$

$$\therefore j = \sigma E$$

➥ This equation can be written in vector form

$$\therefore \vec{j} = \sigma \vec{E}$$

➥ This equation is called vector form of Ohm's law.

4.

➥ Ferromagnetic substances are those which get strongly magnetised when placed in an external magnetic field.

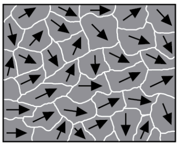
➥ The individual atoms in a ferromagnetic material possess a dipole moment as in a paramagnetic material.

➥ The neighbouring atoms are bound by strong attraction force. This bonding however, is limited to a small region. The atoms (molecules) in such small regions (small microscopic volumes) interact in such a way that their dipole moments are aligned in a common direction.

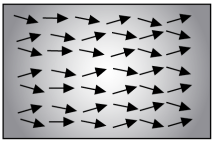
➥ Such regions (macroscopic volumes) are called domain(s).

➥ Each domain has some net magnetisation. But the magnetisation varies randomly from domain to domain, and there is no bulk magnetisation.

- Typical domain size is 1 mm and the domain contains about 10^{11} atoms.



(a)



$\overrightarrow{B}_0$

(b)

- When external magnetic field ($\overrightarrow{B}_0$) is applied, the domains orient themselves in the direction of $\overrightarrow{B}_0$.
- Simultaneously the domain oriented in the direction of $\overrightarrow{B}_0$ grow in size. As shown in fig. (b) all domains merge gradually and make a larger/'giant' domain.
- Thus, in a ferromagnetic material, field lines are highly concentrated.
- When such materials are placed in non-uniform magnetic field, they are attracted towards strong magnetic field.
- Examples : Some Ferromagnetic materials such as iron, cobalt, nickel, gadolinium etc. have relative magnetic permeability > 1000.

5.

- As shown in figure, coil C_1 made of conducting material and having a coating of non-conducting material is connected to a galvanometer (G).
- A bar magnet is placed such that N-pole of bar magnet faces coil C_1.
- On moving N-pole of bar magnet towards coil, galvanometer shows deflection. This deflection is seen till magnet is in motion.
- When magnet is stationary, no deflection is seen in galvanometer.
- Instead of N-pole, if S-pole of bar magnet is kept facing the coil and moved towards coil, galvanometer shows deflection but in opposite direction than before.
- Keeping magnet stationary, if coil is moved towards or away from magnet, then in both cases, galvanometer shows deflection in opposite directions.
- On increasing speed of relative motion between both, galvanometer shows more deflection and hence electric currents are produced.
- Clear conclusion from above experiment is that when there is a relative motion between coil and magnet, then only galvanometer shows deflection and electric current is produced in coil.
- Thus, relative motion between coil and magnet is responsible for production of electric current.

6.

- $E_0 = 120$ N/C

  $\nu = 50$ MHz $= 50 \times 10^6$ Hz
- (a) (i) Amplitude of the Magnetic field (B_0)

  From $\dfrac{E_0}{B_0} = c$,

  $\therefore B_0 = \dfrac{E_0}{c}$

  $= \dfrac{120}{3 \times 10^8}$

  $\therefore B_0 = 4 \times 10^{-7}$ T

  $\therefore B_0 = 400\ n$T

(ii) Angular frequency (ω)

$\omega = 2\pi v$

$\therefore \omega = 2 \times 3.14 \times 50 \times 10^6$

$\therefore \omega = 3.14 \times 10^8$ rad/s

(iii) Wave vector (k)

$c = \frac{\omega}{k}$ (wave speed)

$\therefore k = \frac{\omega}{c}$

$= \frac{3.14 \times 10^8}{3 \times 10^8}$

$\therefore k = 1.05$ rad/m

(iv) Wave length (λ)

$k = \frac{2\pi}{\lambda}$

$\therefore \lambda = \frac{2\pi}{k}$

$= \frac{2 \times 3.14}{1.05}$

$= 6$ m

(b) Suppose, the propogation of the electro-magnetic wave occurs in the positive X-axis direction. This can be possible only when the electric field is in the direction of positive Y-axis and magnetic field is in the direction of positive Z-axis.

- Equation of electric field,

$\vec{E} = E_0 \sin (kx - \omega t) \hat{j}$

$\therefore \vec{E} = 120 \sin (1.05x - 3.14 \times 10^8 t) \hat{j} \frac{N}{C}$

- Equation of magnetic field,

$\vec{B} = B_0 \sin (kx - \omega t) \hat{k}$

$\therefore \vec{B} = 400 \sin (1.05x - 3.14 \times 10^8 t) \hat{k}$ T

7.

➥ focal length of objective $f_0 = 140$ cm

focal length of eye-piece $f_e = 5$ cm

(a) Magnification of telescope for normal arrangement,

$m = \frac{f_0}{f_e} = \frac{140}{5} = 28$

(b) When final image is formed at near point distance, then magnification,

$m = \frac{f_0}{f_e} \left(1 + \frac{f_e}{D}\right)$

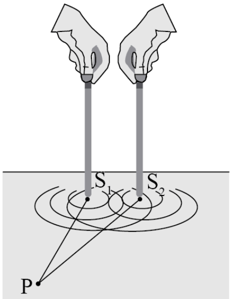
$\therefore m = \frac{140}{5} \left(1 + \frac{5}{25}\right)$

$\therefore m = 28\left(\frac{30}{25}\right)$

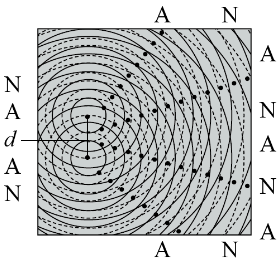
$\therefore m = 28 \times 1.2$

$\therefore m = 33.6$

8.



(a)



(b) (only for information)

- Consider two needles S_1 and S_2 moving periodically up and down in an identical fashion in a trough of water. (fig. (a))
- Consequently two ripples (/ water waves) are created in water. When the two waves superimpose at a particular point, the phase difference between the displacements produced by each of the waves does not change with time.
- When this happens, the two sources are said to be coherent sources.
- Consider a point P for which,

  $S_1P = S_2P$
- Since distances are equal, waves from S_1 and S_2 will take the same time to travel to point P and waves that emanate from S_1 and S_2 in phase will also arrive, at point P in phase.
- Displacement produced by the source S_1 at point P is given by,

  $y_1 = a \cos \omega t$ ... (1)
- Displacement produced by the source S_2 at point P is given by,

  $y_2 = a \cos \omega t$ ... (2)
- As per superposition principle,

  $y = y_1 + y_2$

  $\therefore y = a \cos \omega t + a \cos \omega t$

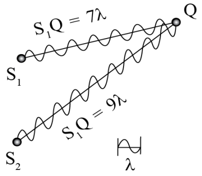
  $\therefore y = 2a \cos \omega t$
- The intensity of a wave is proportional to the square of the amplitude.

  So, the resultant intensity is given by :

  $I = 4 I_0$

  where I_0 represents the intensity produced by each one of the individual sources.
- Here, the intensity at point P is maximum, which is known as the constructive interference.
- Now, as shown in fig. (c), consider a point Q for which,

  $S_2Q - S_1Q = 2\lambda$



$\boxed{S_2Q - S_1Q = 2\lambda}$

(c)

- The waves emanating from S_1 will arrive exactly two cycles earlier, than the waves from S_2 and will be in phase. Path difference of 2λ corresponds to a phase difference of 4π rad. Hence, the wave coming from S_2 will be late in phase by 4π radian.
- If the displacement produced by S_1 is

  $y_1 = a\ cos\ \omega t$
- Then the displacement produced by S_2 will be,

  $y_2 = a\ cos\ (\omega t - 4\pi)$

  $\therefore y_2 = a\ cos\ \omega t$
- Net displacement at point Q,

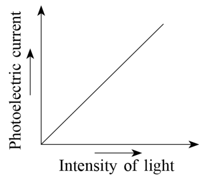
  $y = y_1 + y_2$

  $\therefore y = a\ cos\ \omega t + a\ cos\ \omega t$

  $\therefore y = 2a\ cos\ \omega t$
- The two displacements are in phase once again, and the intensity once again will be 4 I_0 giving rise to the Constructive interference.

9.

- In an experimental arrangement of the photoelectric effect the collector A is maintained at a positive potential with respect to photosensitive plate C.
- The potential difference between A and C and the frequency of the incident light is kept constant.
- The intensity of incident light is changed.
- When light is incident on plate C, electrons are emitted from it and these are attracted by plate A to form a photocurrent.
- The magnitude of photocurrent obtained for different light intensities is measured with a microammeter and a graph of photocurrent versus intensity is drawn.



- The straight line of graph suggests that the photocurrent is directly proportional to the intensity of incident light.
- Now, current $I = \frac{q}{t}$

  $\therefore I = \frac{ne}{t}$ $(\because q = ne)$

  ßÞkt, n = Number of electrons

  e = Charge of electron

  $\therefore I \propto \frac{n}{t}$ $(\because e$ is constant)
- Thus, the current (photocurrent) is directly proportional to the number of photoelectrons emitted per unit time.
- From this it can be said that the number of photoelectrons emitted per unit time (one second) is directly proportional to the intensity of incident radiation.

  Photocurrent $\propto$ Intensity

  Photocurrent $\propto$ number of electrons per unit time.

  (Number of electrons emitted per unit time) $\propto$ (Intensity)

10.

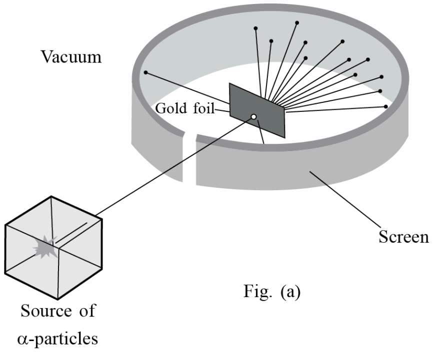


Fig. (a)

- At the suggestion of Rutherford, Geiger and Marsden did some experiments.
- In one of their experiments, as shown in the figure (a), a beam of 5.5 MeV α-particles emitted from a $_{83}Bi^{214}$ radioactive source at a thin metal foil made of gold and the entire device is placed in a vacum chamber.

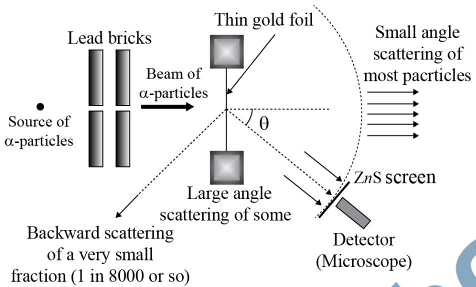


Fig. (b)

- Figure (b) shows a schematic diagram of this experiment. α-particles emitted by a radioactive source $_{83}Bi^{214}$ are passed through a block of lead to produce a narrow beam.
- This beam is projected on to a thin gold foil of thickness 2.1×10^{-7} m.
- The scattered alpha(α)-particles were observed through a rotatable detector consisting of zinc sulphide screen and a microscope. The scattered α-particles on striking the screen produced brief light flashes or scintillations. This flashes can be observed with microscope and the distribution of the number of scattered particles can be studied as a function of angle of scattering.

11.

- Mass of Fe nucleus

$$m_{Fe} = 55.85\ u$$

$$\therefore m_{Fe} = 55.85 \cdot 1.66 \cdot 10^{-27}\ \text{kg}$$

$$m_{Fe} = 9.27 \cdot 10^{-26}\ \text{kg}$$

- Radius of nucleus

$$R = R_0\ A^{\frac{1}{3}}$$

$$\therefore R = (1.2 \cdot 10^{-15})\ (56)^{\frac{1}{3}}$$

$$\therefore R = 4.59 \cdot 10^{-15}\ \text{m}$$

- Volume of nucleus

$$V = \frac{4}{3}\pi R^3$$

$$\therefore V = \frac{4}{3} \cdot 3.14 \cdot (4.59 \cdot 10^{-15})^3$$

$\therefore V = 4.05 \cdot 10^{-43}\ m^3$

➥ Nuclear density

$$\rho = \frac{\text{mass}}{\text{volume}}$$

$$\therefore \rho = \frac{9.27 \times 10^{-26}}{4.05 \times 10^{-43}}$$

$$\therefore \rho = 2.29 \cdot 10^{17}\ \text{kg m}^{-3}$$

12.

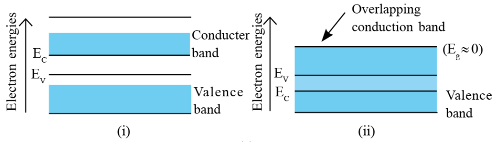
➥ *"The gap between the top of the valence band and bottom of the conduction band is called the energy band gap (Energy gap E_g.)".*

➥ There isn't any energy-level present in this energy-gap. Hence, there is not even a single electron present in this gap.

➥ This energy gap can be large, small or zero depending upon the material.

➥ Material type wise different situations are shown in the fig. below.

➥ Case I : Conductors :

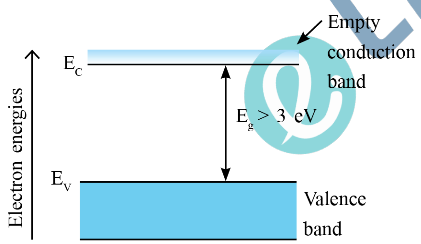


(a)

➥ As shown in fig. (i), in many metals the conduction band is partially filled and the valence band is partially empty or when the conduction and valence bands overlap. (which is shown in fig (ii))

➥ When there is overlap, electrons from valence band can easily move into the conduction band. This situation makes a large number of electrons available for electrical conduction. Therefore, the resistance of such materials is low or the conductivity is high.

➥ Case II : Insulators :



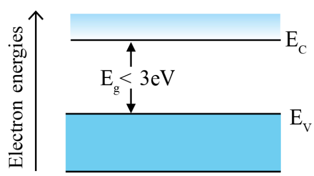
➥ In this case, as shown in fig., a large band gap E_g exists ($E_g > 3\ eV$) between the two levels. (Valence band and conduction band)

➥ There are no electrons in the conduction band, and therefore no electrical conduction is possible.

➥ Note that the energy gap is so large that electrons can not be excited from the valence band to the conduction band by thermal excitation.

This is the case of the insulators.

➥ Case III : Semi-conductors :



➥ As shown in Fig. here a finite but small band gap ($E_g < 3\ eV$) exists.

➥ Because of the small band gap, at room temperature, some electrons from valence band can acquire enough energy to cross the energy gap and enter the conduction band.

➥ These electrons (though small in numbers) can move in the conduction band.

➥ Hence, the resistance of semiconductors is not as high as that of the insulators.

Section B

➢ **Write the answer of the following questions : (Each carries 3 Mark)**

13.

➥ Draw AD ⊥ BC in equilateral triangle ABC.

From fig., from Δ ADC, $cos\ 30° = \frac{AD}{AC}$

$\therefore AD = AC\ cos\ 30° = l\left(\frac{\sqrt{3}}{2}\right)$

➥ Distance from A to centroid O,

$AO = \frac{2}{3}\ AD$

$\therefore AO = \frac{2}{3}\left(l\frac{\sqrt{3}}{2}\right)$

$\therefore AO = \frac{l}{\sqrt{3}}$

➥ From symmetry,

We get $AO = BO = CO = \frac{l}{\sqrt{3}}$.

➥ Froce exerted on Q by charge q on A,

$$\vec{F_1} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{(AO)^2} \cdot \hat{A}_0$$

(Where, $\hat{A}_0$ is the unit vector in the direction of $\vec{F_1}$.)

$$\therefore \vec{F_1} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{\frac{l^2}{3}} \cdot \hat{A}_0$$

$$= \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} \cdot \hat{A}_0 \quad ...(1)$$

➥ Froce exerted on Q by the charge q on B,

$$\vec{F_2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{(BO)^2} \cdot \hat{B}_0$$

(Where, $\hat{B}_0$ is the unit vector in the direction of $\vec{F_2}$.)

$$\therefore \vec{F_2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{\frac{l^2}{3}} \cdot \hat{B}_0$$

$$= \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} \cdot \hat{B}_0 \quad ...(2)$$

➥ Froce exerted on Q by the charge q on C,

$$\vec{F_3} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{(CO)^2} \cdot \hat{C}_0$$

(Where, $\hat{C}_0$ is the unit vector in the direction of $\vec{F_3}$.)

$$\therefore \vec{F_3} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{\frac{l^2}{3}} \cdot \hat{C}_0$$

$$= \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} \cdot \hat{C}_0 \quad \text{... (3)}$$

➥ Net resultant force acting on charge Q placed at the centroid of Δ ABC,

$$\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3}$$

$$\therefore \vec{F} = \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} \cdot \hat{A}_0 + \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} \cdot \hat{B}_0 + \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} \cdot \hat{C}_0$$

$$\therefore \vec{F} = \frac{3}{4\pi\varepsilon_0} \cdot \frac{qQ}{l^2} [\hat{A}_0 + \hat{B}_0 + \hat{C}_0]$$

➥ In $\hat{A}_0$, $\hat{B}_0$ and $\hat{C}_0$, the angle between any two unit vectors is 120°.

➥ Therefore, arranging them in head to tail manner, we get a closed figure, a triangle.

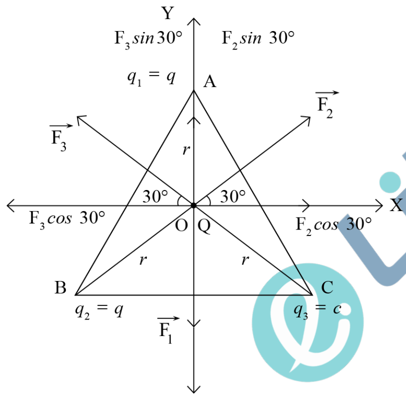
$\therefore$ The resultant vector of all 3 unit vectors will be a null vector.

$$\therefore \hat{A}_0 + \hat{B}_0 + \hat{C}_0 = \vec{0}$$

$\therefore$ Resultant force $\vec{F} = 0$.

➥ Hence, the net force acting on charge Q will be zero.

OR



➥ Here, the triangle given is an equilateral triangle.

$\therefore$ The distance from any one of the vertices to the centroid is same. Suppose, this distance is r.

$\therefore$ AO = BO = CO = r.

➥ Force acting on Q, by charge q on A,

$$\vec{F_1} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2} \hat{j} \quad \text{... (1)}$$

➥ Force acting on Q, by charge q on B,

$$\vec{F_2} = F_2 \cos 30 \,\hat{i} + F_2 \sin 30 \,\hat{j}$$

$$\vec{F_2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2} \left(\frac{\sqrt{3}}{2}\right) \hat{i} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2} \left(\frac{1}{2}\right) \hat{j} \quad \text{... (2)}$$

➥ Force acting on Q, by charge q on C,

$$\vec{F_3} = -F_3 \cos 30 \,\hat{i} + F_3 \sin 30 \,\hat{j}$$

$$\vec{F_3} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2}\left(\frac{\sqrt{3}}{2}\right)\hat{i} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2}\left(\frac{1}{2}\right)\hat{j} \quad ...(3)$$

➥ The net (/resultant) force acting on charge Q,

$$\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3} \quad (\because \text{ Super position principle})$$

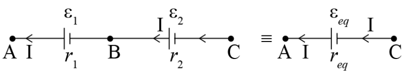
$$\therefore \vec{F} = \left(-\frac{1}{4\pi\varepsilon_0}\cdot\frac{qQ}{r^2}\hat{j}\right) + \left(\frac{1}{4\pi\varepsilon_0}\cdot\frac{qQ}{r^2}\left(\frac{\sqrt{3}}{2}\right)\hat{i} + \frac{1}{4\pi\varepsilon_0}\cdot\frac{qQ}{r^2}\left(\frac{1}{2}\right)\hat{j}\right) + \left(-\frac{1}{4\pi\varepsilon_0}\cdot\frac{qQ}{r^2}\left(\frac{\sqrt{3}}{2}\right)\hat{i} + \frac{1}{4\pi\varepsilon_0}\cdot\frac{qQ}{r^2}\left(\frac{1}{2}\right)\hat{j}\right)$$

$$\therefore \vec{F} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2}\hat{j} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2}\left(\frac{1}{2}\right)\hat{j} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2}\left(\frac{1}{2}\right)\hat{j}$$

$$\therefore \vec{F} = \vec{0}$$

➥ Hence, the net force acting on charge Q will be zero.

14.

➥ 

➥ The figure shows the series connection of two cells. The emf of two cells are ε_1 and ε_2 respectively and their internal resistences are r_1 and r_2 respectively. The current I is passing through this combination.

Remember

As shown in the figure, consider two cells connected in such a way that one terminal of the two cells is joined together leaving the other terminal in both the cells free. Such connection is called series connection of cell. Similarly, more than two cells are also connected in series.

➥ Let the potentials at points A, B and C are V(A), V(B) and V(C) respectively as shown in the figure.

➥ The potential difference between the positive and negative terminal of the first cell is

$V_{AB} = V(A) - V(B) = \varepsilon_1 - Ir_1$ ... (1)

➥ Similarly, for the second cell

$V_{BC} = V(B) - V(C) = \varepsilon_2 - Ir_2$ ... (2)

➥ The potential difference between the terminals A and C of the combination is

$V_{AC} = V(A) - V(C)$

$V_{AC} = V(A) - V(B) + V(B) - V(C)$

$= \varepsilon_1 - Ir_1 + \varepsilon_2 - Ir_2$ ($\because$ from equations (1) and (2))

$\therefore V_{AC} = (\varepsilon_1 + \varepsilon_2) - I(r_1 + r_2)$ ... (3)

➥ Suppose, the equivalent *emf* is ε_{eq} and equivalent internal resistance is r_{eq} between points A and C then.

$\therefore V_{AC} = \varepsilon_{eq} - I\, r_{eq}$ ... (4)

➥ Comparing equation (3) and (4)

$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ ... (5)

$r_{eq} = r_1 + r_2$ ... (6)

➥ Similarly, if n celll of *emf* $\varepsilon_1, \varepsilon_2, \varepsilon_3$ ..... ε_n are connected in series then the equivalent *emf* $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 + ... + \varepsilon_n$ and the equivalent internal resistance $r_{eq} = r_1 + r_2 + r_3 + ... + r_n$.

➥ If instead of the arrangement shown in the figure, a series connection is made by connecting two negative terminals then potential difference between points B and C is

$V_{BC} = -\varepsilon_2 - Ir_2$

➥ And the equivalent *emf*

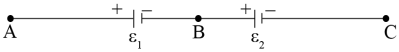
$\varepsilon_{eq} = \varepsilon_1 - \varepsilon_2$ $(\varepsilon_1 > \varepsilon_2)$ and

equivalent internal resistance is

$r_{eq} = r_1 + r_2$.

Remember

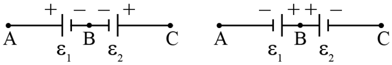
Constructive combination of cells



If the positive or negative terminal of one cell is connected to the negative or positive terminal of another cell respectivelly, then this combination of cells is called constructive combination (or connection).

In this type of connection, the equivalent *emf* is equal to the sum of the *emfs* of both the cells.

Destructive (or opposite) combination of cells

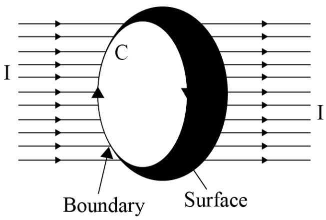


If both negative or both positive terminals of two cells are connected together, then this combination of cells is called the destructive (or opposite) combination.

In this type of connection, the equivalent *emf* is equal to the subtraction of the *emfs* of both the cells.

15.

➥ As shown in the figure, Ampere's circuital law considers an open (free) surface with a boundary line.



➥ An electric current is passing through this open surface.

➥ Consider the surface boundary divided into small elements of length *dl*. At this element, the tangential component of the magnetic field is B_t (= B *cos* θ)

➥ The integral of the product of the length element (*dl*) and the tangential component of the magnetic field is equal to $\propto_0$ times the total current passing through the surface.

$$\oint B_t \, dl = \propto_0 I$$

$$\therefore \oint (B \cos\theta) \, dl = \propto_0 I$$

$$\therefore \oint \vec{B} \cdot d\vec{l} = \propto_0 I \quad \dots (1)$$

➥ Here, the integral is taken over the closed loop coinciding with the boundary C of the surface.

➥ Here, the right hand thumb rule is used for sign - convention of electric currents enclosed by a closed loop.

➥ Fingers of the right hand be curled in the sense the boundary is traversed in the loop then the direction of the thumb gives the sense in which the current is considered as positive and current in the opposite direction is considered negative.

➥ To simplify Ampere's circuital law, the loop is assumed, which is called an amperian loop.

➥ The loop is chosen in such a way that for each point of it, either

(i) $\vec{B}$ is tangential to the loop and B is a non-zero constant.

(ii) $\vec{B}$ is perpendicular (or normal) to the loop

(iii) $\vec{B}$ is eliminated (or vanishes)

➥ Now, suppose L is the length of the loop for which $\vec{B}$ is tangential and the current enclosed by the loop is I_e then equation (1) becomes.

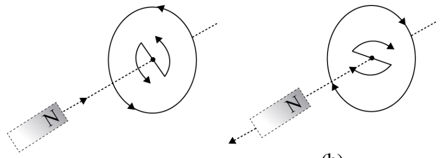
$$BL = \propto_0 I_e$$

➥ This equation is a special representation of Ampere's circuital law.

16.

➥ Lenz's law :

- *"The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it."*



(a) (b)

- In experiment of coil and magnet, keeping N-pole of magnet facing coil and moving magnet towards coil, magnetic flux linked with coil increases. As a result, electric current is induced in it.
- According to Lenz's law, this induced electric current is in such direction that it opposes increase in flux.
- This is possible only when end of coil towards magnet acts as N-pole and induced current flow in anti-clockwise direction, as shown in figure (a).
- In the same manner, as shown in figure (b), on taking N-pole of magnet away from coil, magnetic flux linked with coil decreases. As a result induced electric current flows in clockwise directions.
- The induced current is in such a direction that end of coil towards magnet behaves as S-pole.
- Thus, on changing magnetic flux linked with coil, induced current (and induced *emf*) is produced in such a direction that it opposes the change in magnetic flux.

17.

➥ Average power for L – C – R series AC circuit,

$P = VI \cos \varphi$

$\therefore P = \frac{\upsilon_m i_m}{2} \cos \varphi$

➥ Special Cases :

(i) Case I : Resistive Circtuit :

- For an AC circuit containing only resistance (i.e. for purely resistive circuits), so $\varphi = 0$

$\therefore$ Average power dissipation,

$P = VI \cos \varphi$

$\therefore P = VI \cos 0$

$\therefore P = VI$ (Maximum)

- Thus, in the AC circuit having only resistance, power dissipation is maximum.

(ii) Case II : Purely Inductive Or Purely Capacitive Circuit :

- If the circuit is purely inductive or purely capacitive, phase difference between voltage and current is $\frac{\pi}{2}$.
- Therefore, average power dissipated in circuit is :

$P = VI \cos \varphi$

$\therefore P = VI \cos \frac{\pi}{2}$

$\therefore P = 0$

- Thus, eventhough a current is flowing in the circuit, power dissipated is zero.
- Such a current is referred to as Wattless Current .

(iii) Case III : L – C – R Series Circuit :

- In an L – C – R series circuit, power dissipated is as per,

$P = VI \cos \phi$

Where, $\phi = \tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

➠ So, ϕ may be non zero in a RL or RC or RCL circuit, Even in such cases, power is dissipated only in the resistor.

(iv) Case IV : Power dissipated at Resonance in L – C – R Circuit :

➠ At resonance, $X_C = X_L$ and $\phi = 0$ so $\cos\phi = 1$

➠ Therefore, power dissipated in circuit.

$P = VI \cos\phi$

$P = VI$ (Maximum)

➠ Thus, maximum power is dissipated in a circuit (through R) at Resonance.

18.

➥ from figure (a),

angle of incidence $i = 60°$

angle of refraction $r = 35°$

➥ from Snell's rule,

air → medium 1 → Refractive index n_1

glass → medium 2 → Refractive index n_2

water → medium 3 → Refractive index n_3

$n_1 \sin 60° = n_2 \sin 35°$

$\therefore \frac{n_1}{n_2} = \frac{\sin 35°}{\sin 60°} = \frac{2 \times 0.5736}{\sqrt{3}}$

$\therefore \frac{n_1}{n_2} = 0.6630 \ldots (1)$

➥ From figure (b),

angle of incidence $i = 60°$

angle of refraction $r = 41°$

➥ from Snell's rule,

$n_1 \sin 60° = n_3 \sin 41°$

$\therefore \frac{n_1}{n_3} = \frac{\sin 41°}{\sin 60°} = \frac{0.6560 \times 2}{\sqrt{3}}$

$\therefore \frac{n_1}{n_3} = 0.7575 \ldots (2)$

➥ from figure (c),

angle of incidence $i = 45°$

angle of refraction $r = ?$

➥ from Snell's rule,

$n_3 \sin 45° = n_2 \sin r$

$\therefore \frac{n_3}{n_2} \sin 45° = \sin r$

$\therefore \sin r = \left(\frac{n_3}{n_2}\right) \frac{1}{\sqrt{2}} = \left(\frac{n_1}{n_2} \times \frac{n_3}{n_1}\right) . \frac{1}{\sqrt{2}} = 0.6630 \times \frac{1}{0.7575} \times 0.7071$

$= 0.6188$

$\therefore r = 38°22'$

19.

➥ (a) $n = 1.5$

$c = 3 \times 10^8$ m/s

➥ Refractive index of glass from $n = \frac{c}{\upsilon}$,

$\therefore \upsilon = \frac{c}{n} = \frac{3 \times 10^8}{1.5}$

$\therefore \upsilon = 2 \times 10^8$ m/s

➥ (b) Speed of light in glass is not independent of colour of light.

➥ Refractive index of medium is inversely proportional to the wavelength

$n \propto \frac{1}{\lambda}$ ... (1)

➥ and the absolute refractive index of the medium,

$n = \frac{c}{\upsilon}$ hence $n \propto \frac{1}{\upsilon}$ ... (2)

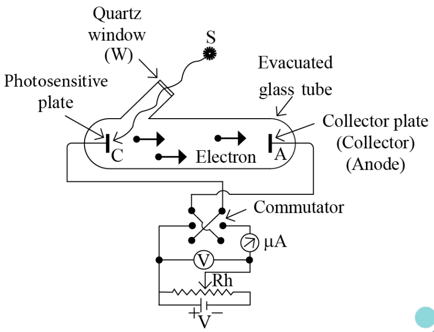
➥ From equation (1) and (2),

$\upsilon \propto \lambda$

➥ Comparing the wavelengths of red and violet, wavelength of violet is lesser. Hence, violet travels slower than red in the glass prism.

20.

➥



➥ The given figure shows the experimental arrangement for studying the photoelectric effect.

➥ Here, two metal plates A and C are placed in a vacuum created tube.

➥ Plate C is the emitter plate, called the cathode and it is the photosensitive material. Plate A is the collector plate, called the anode.

➥ A transparent window (W) is formed above the plate C in the glass tube. A light source (S) is placed just above this window.

➥ Both the plates are connected to the two ends of the commutator. A microammeter is connected in series with the commutator and a voltmeter in parallel.

➥ This circuit is connected to the battery through a rheostat (Rh).

➥ Light of sufficiently short wave length (high frequency) is produced from a light source (S). This light passes through a transparent window (W) and ultraviolet light is incident on the photosensitive plate (C).

➥ Electrons are emitted from the photosensitive plate (C). These electrons are attracted by the electric field between plate A and plate C and are collected by A.

➥ These electrons are carried in the circuit and form an electric current, called photoelectric current. The magnitude of this current can be measured with a microammeter.

➥ The potential difference between the two plates can be measured with a voltmeter connected in parallel.

➥ The polarity (positive or negative potential) applied to both the plates can be changed with a commutator, i.e. A and C can be maintained at a desired positive or negative potential. A rheostat can be used to change the magnitude of the potential difference applied across the two plates.

➥ The photoelectric effect is experimentaly studied by varying the intensity and frequency of light incident on the plate (C) and by varying the potential applied to the plate.

➥ The polarity and the magnitude of potential can be changed with commutator and rheostat.

➥ By changing the distance of the light source from plate C, the intensity of light incident on C can be varied.

➥ The frequency of incident light can be varied by using different coloured filters on a transparent window.

21.

➥ For gold isotop $^{197}_{79}Au$, $A_1 = 197$

and silver isotop $^{107}_{49}Ag$, $A_2 = 107$

➥ For Gold $R_1 = R_0 \, A_1^{\frac{1}{3}}$ ... (i)

➥ and for Silver $R_2 = R_0 \, A_2^{\frac{1}{3}}$ ... (ii)

➥ From (i) and (ii),

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}}$$

$$\therefore \frac{R_1}{R_2} = \left[\frac{197}{107}\right]^{\frac{1}{3}}$$

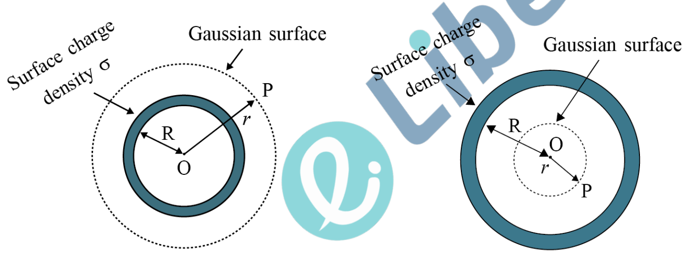
$$\therefore \frac{R_1}{R_2} = [1.8411]^{\frac{1}{3}}$$

$$\therefore \frac{R_1}{R_2} = 1.23$$

Section C

➢ **Write the answer of the following questions : (Each carries 4 Mark)**

22.

➥ 

(a) (b)

➥ Let σ be the uniform surface charge density of a thin spherical shell of radius R (Fig.).

(i) Field outside the shell :

➥ Consider a point P outside the shell with radius vector *r* Fig. (a).

➥ To calculate E at P, we take the Gaussian surface to be a sphere of radius r and with centre O, passing through P. All points on this sphere are equivalent relative to the given charged configuration.

➥ According to Gauss's law,

$$\vec{E} \cdot \vec{S} = \frac{q}{\varepsilon_0}$$

$$\therefore E \cdot S \cos 0 = \frac{q}{\varepsilon_0}$$

$$\therefore ES = \frac{q}{\varepsilon_0} \quad ... (1)$$

But $S = 4\pi r^2$ (area of Gaussian surface)

and $q = \sigma A$ (Where A - area of spherical shell)

$= \sigma(4\pi R^2)$ (Total charge on spherical shell.)

➥ From equation (1),

$\therefore E(4\pi r^2) = \frac{\sigma(4\pi R^2)}{\varepsilon_0}$

$\therefore E = \frac{\sigma R^2}{\varepsilon_0 r^2}$ ... (2)

➥ But $\sigma = \frac{q}{A} = \frac{q}{4\pi R^2}$,

$\therefore E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$ (From Eq. (2)) ... (3)

➥ The electric field is directed outward if $q > 0$ and inward if $q < 0$. This, however, is exactly the field produced by a charge q placed at the centre O.

➥ Thus for points outside the shell, the field due to a uniformaly charged shell is as if the entire charge of the shell is concentrated at its centre.

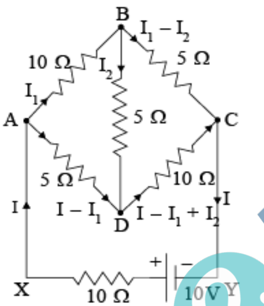
(ii) Field inside the shell :

➥ In Fig. (b), the point P is inside the shell. The Gaussian surface is again a sphere through P centred at O.

➥ Gaussian surface encloses no charge. From Gauss's law then gives the field due to a uniformly charged thin shell is zero at all points inside the shell.

23.

➥ The circuit shows the direction of currents and the currents in different branches.



➥ Applying Kirchhoff's loop rule to closed loop A – B – D – A

$-10\, I_1 - 5\, I_2 + 5(I - I_1) = 0$

$\therefore\ -2\, I_1 - I_2 + I - I_1 = 0$

$\therefore\ I - 3\, I_1 - I_2 = 0$ ... (1)

➥ Applying Kirchoff's loop rule to closed loop

B – C – D – B

$-5(I_1 - I_2) + 10(I - I_1 + I_2) + 5\, I_2 = 0$

$\therefore\ -(I_1 - I_2) + 2(I - I_1 + I_2) + I_2 = 0$

$\therefore\ -I_1 + I_2 + 2I - 2I_1 + 2I_2 + I_2 = 0$

$\therefore\ 2I - 3I_1 + 4I_2 = 0$ ... (2)

➥ Now, applying Kirchhoff's loop rule to closed loop

A – B – C – Y – X – A

$-10\, I_1 - 5(I_1 - I_2) + 10 - 10\, I = 0$

$\therefore\ -2\, I_1 - (I_1 - I_2) + 2 - 2\, I = 0$

$\therefore\ -2\, I_1 - I_1 + I_2 + 2 - 2\, I = 0$

$\therefore\ -2\, I - 3\, I_1 + I_2 = -2$

$\therefore\ 2\, I + 3\, I_1 - I_2 = 2$ ... (3)

➡ Subtracting equation (2) from equation (1) we get,

$$\begin{array}{l} I - 3\,I_1 - \;\; I_2 = 0 \\ 2I - 3\,I_1 + 4I_2 = 0 \\ \underline{-\quad\;\; + \qquad -\quad} \\ \therefore\; -I \quad - 5I_2 \quad = 0 \end{array}$$

$$\therefore\; I + 5I_2 = 0 \qquad \text{... (4)}$$

➡ By adding equations (2) and (3) we get

$$\begin{array}{l} \therefore\; 2I - 3\,I_1 + 4I_2 = 0 \\ \underline{\;\;\;\; 2I + 3\,I_1 - \;\; I_2 = 2} \\ \therefore\; 4I + 3\,I_2 \qquad = 2 \end{array} \qquad \text{... (5)}$$

➡ By multipying equation (4) by 4 and subtracting equation (5), we have

$$\begin{array}{l} 4I + 20\,I_2 = 0 \\ 4I + \;\;3\,I_2 = 2 \\ \underline{-\quad\;\; -\quad\;\; -} \\ \qquad 17\,I_2 = -2 \end{array}$$

$$\therefore\; I_2 = -\frac{2}{17}\text{ A}$$

➡ Putting the value of I_2 in equation (4)

$$\therefore\; I + 5\left(-\frac{2}{17}\right) = 0$$

$$\therefore\; I = \frac{10}{17}\text{ A}$$

$$I = \frac{10}{17}\text{ A and } I_2 = -\frac{2}{17}\text{ A}$$

➡ Putting the value of I and I_2 in equation (1)

$$\therefore\; \frac{10}{17} - 3(I_1) - \left(-\frac{2}{17}\right) = 0$$

$$\therefore\; \frac{10}{17} + \frac{2}{17} = 3\,I_1$$

$$\therefore\; \frac{12}{17} = 3\,I_1$$

$$\therefore\; I_1 = \frac{4}{17}\text{ A}$$

Current flowing in the branch AB,

$$I_1 = \frac{4}{17}\text{ A}$$

Current flowing in the branch BD,

$$I_2 = -\frac{2}{17}\text{ A}$$

➡ Here the negative sign indicates that the current actually flows in the opposite direction to the journey we have considered. i.e. from D to B.
Current flowing in the branch BC,

$$I_1 - I_2 = \frac{4}{17} - \left(-\frac{2}{17}\right)$$

$$\therefore\; I_1 - I_2 = \frac{4+2}{17}$$

$$\therefore\; \qquad = \frac{6}{17}\text{ A}$$

➡ Current flowing in the branch DC,

$$I - I_1 + I_2 = \frac{10}{17} - \frac{4}{17} + \left(-\frac{2}{17}\right)$$

$$= \frac{10-4-2}{17}$$

$$= \frac{4}{17}\text{ A}$$

➡ Current flowing in the branch AD

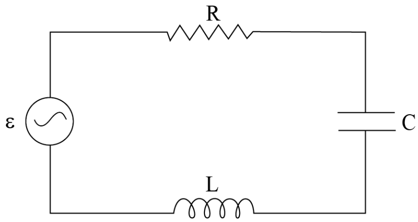
$$I - I_1 = \frac{10}{17} - \frac{4}{17}$$

$$= \frac{6}{17}\text{ A}$$

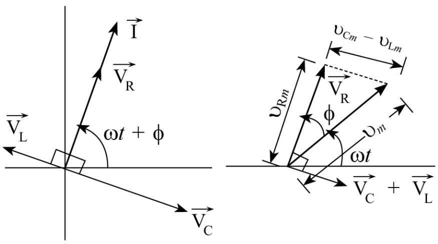
$$\text{Total current } = \frac{4}{17} + \frac{6}{17} + \frac{-4}{17} + \frac{6}{17} + \frac{-2}{17}$$

$$= \frac{10}{17}\text{A}$$

24.



- As shown in the fig., a resistor, an inductor and a capacitor are connected in series in an AC circuit.
- Voltage of the AC source $\upsilon = \upsilon_m \sin \omega t$
- As the components are in series, ac current in each element is same, having the same amplitude and phase.
- Let current i be :
- $i = i_m \sin(\omega t + \varphi)$ ... (1)
- where, φ – is the phase difference between the voltage across the source and the current in the circuit.



(a) (b)

- In the fig. (a), the phasor representing the current in the circuit as given by eq. (1), is shown by $\vec{I}$.
- Further, $\vec{V}_L$, $\vec{V}_R$, $\vec{V}_C$ and $\vec{V}$ represent the voltage across inductor L, resistor R, capacitor C and the source, respectively.
- All the phasors are shown in the fig. with their corresponding phase difference.
- The length of these phasors or the amplitudes of $\vec{V}_R$, $\vec{V}_C$ and $\vec{V}_L$ are :
- $\upsilon_{Rm} = i_m R$, $\upsilon_{Cm} = i_m X_C$, $\upsilon_{Lm} = i_m X_L$
- From the phasor diagram, the equation of resultant voltage is as follows :

$$\vec{V}_L + \vec{V}_R + \vec{V}_C = \vec{V} \quad \text{... (2)}$$

(Note : voltage equation from the vertical components of above phasor relation can be written as : $\upsilon_L + \upsilon_R + \upsilon_C = \upsilon$)

- Since $\vec{V}_C$ and $\vec{V}_L$ are always along the same line and in opposite directions, they can be combined into a single phasor ($\vec{V}_C + \vec{V}_L$) which has a magnitude $|\upsilon_{Cm} - \upsilon_{Lm}|$.
- Since $\vec{V}$ is represented as the hypotenuse of a right-angle whose sides are $\vec{V}_R$ and $\vec{V}_C + \vec{V}_L$ the phythagorean theorem gives :

$$\upsilon_m^2 = \upsilon_{Rm}^2 + (\upsilon_{Cm} - \upsilon_{Lm})^2$$

- $\upsilon_m^2 = (i_m R)^2 + (i_m X_C - i_m X_L)^2$

$$\therefore \upsilon_m^2 = i_m{}^2 R^2 + i_m{}^2 (X_C - X_L)^2$$

$$\therefore \upsilon_m^2 = i_m{}^2 [R^2 + (X_C - X_L)^2]$$

$$\therefore i_m{}^2 = \frac{\upsilon_m^2}{R^2 + (X_C - X_L)^2}$$

$$\therefore i_m = \frac{\upsilon_m}{\sqrt{R^2 + (X_C - X_L)^2}}$$

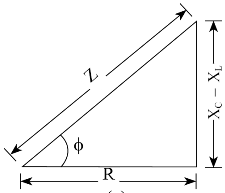
- The equation can also be written as follows :

$\therefore i_m = \frac{\upsilon_m}{Z}$

where, $Z = \sqrt{R^2 + (X_C - X_L)^2}$

➥ Z is known as impedence of the given AC circuit, which is analogous to resistance in a DC circuit. Its unit is ohm (Ω) (And it has the same dimension as resistance).

➥ Since phasor $\vec{I}$ is always parallel to phasor $\vec{V}_R$, the phase angle φ is the angle between $\vec{V}_R$ and $\vec{V}$ and it is shown in fig. (c).



(c)

➥ $tan\ \phi = \frac{\upsilon_{Cm} - \upsilon_{Lm}}{v_{Rm}}$

$tan\ \phi = \frac{i_m X_C - i_m X_L}{i_{m}R}$

$\therefore tan\ \phi = \frac{X_C - X_L}{R}$

➥ The diagram shown in fig. (c) is known as Impedence diagram, which is a right-triangle with Z as its hypotenuse.

25.

➥ Nucleus of copper contains 29 protons and number of neutrons N = A – Z

= 34

➥ Mass Defect $\Delta M = [Zm_p + Nm_n] - m({}^{63}_{29}Cu)$

$\therefore \Delta M = [29 \cdot 1.007825 + 34 \cdot 1.008665] - 62.92960$

$\therefore \Delta M = [29.226925 + 34.29461] - 62.92960$

$\therefore \Delta M = 0.591935\ u$

➥ Binding Energy

$E_b = \Delta M c^2$

$\therefore E_b = 0.591935 \times 931.5$

$\therefore E_b = 551.39$ MeV

➥ An energy of 551.39 MeV is required to separate protons and neutrons in a copper nucleus.

➥ Number of atoms in 3 g copper coin,

Mass of Cu Number of atoms in Cu

63 g $6.022 \cdot 10^{23}$

$\therefore$ 3 g (?)

➥ Number of atoms in coin,

$N = \frac{3 \times 6.022 \times 10^{23}}{63} = 2.87 \cdot 10^{22}$

➥ The energy required to separate all the neutrons and protons from the copper of 3 g.

$E = E_b \cdot N$

$\therefore E = 551.39 \cdot 2.87 \cdot 10^{22}$ MeV

$\therefore E = 1582.4893 \cdot 10^{22}$ MeV

$\therefore E = 1582.4893 \cdot 10^{22} \cdot 10^6 \cdot 1.6 \cdot 10^{-19}$ J

$\therefore E = 2531.98 \cdot 10^9$ J

$\therefore E = 2.53 \cdot 10^9$ J

26.

➥ Total energy of electron in ground state of

H-atom = –13.6 eV

➥ Total energy after bombarding electron beam of

12.5 eV on H-atom = –13.6 + 12.5

= –1.1 eV

➥ So, $E_n = -1.1\ eV$

$$\text{But } E_n = \frac{-13.6}{n^2}\ eV$$

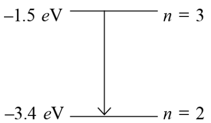
$$n^2 = \frac{-13.6}{E_n}\ eV$$

$$n^2 = \frac{-13.6}{-1.1}$$

$$n^2 = 12.36$$

$$n = 3.51$$

➥ An integer value of n is given as $n = 3$, which means that the electron is excited to level $n = 3$.

➥ 

(i)

➠ In transition from $n = 3$ to $n = 2$, wavelength of α-line emitted in Balmar Series

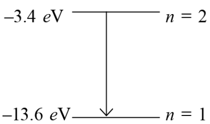
$$E_3 - E_2 = \frac{hc}{\lambda_{32}}$$

$$\therefore \lambda_{32} = \frac{hc}{E_3 - E_2} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{(-1.51) - (-3.4)\ eV}$$

$$= \frac{19.875 \times 10^{-26}}{1.89 \times 1.6 \times 10^{-19}}$$

$$= 6.575 \times 10^{-7}\ \text{m}$$

$$\therefore \lambda_{32} = 657\ \text{nm}$$

➥ 

(ii)

➠ When electron transition from $n = 2$ to $n = 1$, the wavelength of α-line emitted in Lyman Series.

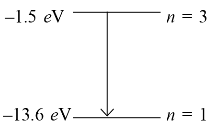
$$E_2 - E_1 = \frac{hc}{\lambda_{21}}$$

$$\therefore \lambda_{21} = \frac{hc}{E_2 - E_1} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{(-3.4) - (-13.6)\ eV}$$

$$= \frac{19.875 \times 10^{-26}}{10.2 \times 1.6 \times 10^{-19}}$$

$$= 1.22 \times 10^{-7}\ \text{m}$$

$$\therefore \lambda_{21} = 122\ \text{nm}$$

➥ 

(iii)

➠ When electron transits from $n = 3$ to $n = 1$, the wavelength of β-line emitted in Lyman Series,

$$E_3 - E_1 = \frac{hc}{\lambda_{31}}$$

$$\therefore \lambda_{31} = \frac{hc}{E_3 - E_1}$$

$$= \frac{6.625 \times 10^{-34} \times 3 \times 10^{8}}{(-1.51) - (-13.6)\, eV}$$

$$= \frac{19.875 \times 10^{-26}}{12.09 \times 1.6 \times 10^{-19}}$$

$$= 1.03 \times 10^{-7} \text{ m}$$

$$\therefore \lambda_{31} = 103 \text{ nm}$$

27.

- ➥ In compound microscope image is obtained at near point.
- ➥ focal length of objective $f_0 = 1.25$ cm

  focal length of eye-piece $f_e = 5$ cm
- ➥ Angular magnification of eye-piece,

$$m_e = 1 + \frac{D}{f_e}$$

$$\therefore m_e = 1 + \frac{25}{5}$$

$$\therefore m_e = 6$$

- ➥ Total magnification of microscope,

$$m = m_0 \times m_e$$

$$\therefore 30 = m_0 \times 6$$

$$\therefore m_0 = 5$$

$$\therefore \frac{\upsilon_0}{u_0} = 5$$

$$\therefore \upsilon_0 = 5\, u_0$$

- ➥ From lens formula,

$$\frac{1}{\upsilon_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

$$\therefore \frac{1}{5\, u_0} - \frac{1}{(-u_0)} = \frac{1}{f_0}$$

(According to sign convention substituting $-u_0$ instead of $+ u_0$)

$$\therefore \frac{1+5}{5\, u_0} = \frac{1}{1.25}$$

$$\therefore \frac{5\, u_0}{6} = 1.25$$

$$\therefore u_0 = \frac{6 \times 1.25}{5}$$

$$\therefore u_0 = 1.5 \text{ cm}$$

- ➥ but $\upsilon_0 = 5\, u_0$,

$$\therefore \upsilon_0 = 5 \times -1.5$$

$$\therefore \upsilon_0 = 7.5 \text{ cm}$$

- ➥ for eye-piece,

object-distance $\upsilon_e = D = -25$ cm

focal length $f_e = 5$ cm

➥ from lens formula,

$$\frac{1}{\upsilon_e} - \frac{1}{u_e} = \frac{1}{f_e}$$

$$\therefore \frac{1}{u_e} = \frac{1}{\upsilon_e} - \frac{1}{f_e}$$

$$\therefore \frac{1}{u_e} = -\frac{1}{25} - \frac{1}{5}$$

$$\therefore \frac{1}{u_e} = \frac{-1-5}{25}$$

$$\therefore u_e = -\frac{25}{6} \text{ cm}$$

$$\therefore u_e = -4.17 \text{ cm}$$

➥ In compound microscope distance between objective and eye-piece.

$|u_e| + \upsilon_0 = 4.17 + 7.5 = 11.67$ cm