LIBERTY PAPER SET

STD. 12 : Physics

Full Solution

Time : 3 Hours **ASSIGNTMENT PAPER 11**

Section A

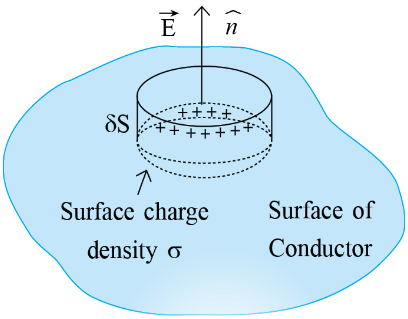
1. (B) **2.** (C) **3.** (C) **4.** (C) **5.** (C) **6.** (D) **7.** (D) **8.** (A) **9.** (A) **10.** (A) **11.** (B) **12.** (C) **13.** (B) **14.** (C) **15.** (D) **16.** (D) **17.** (B) **18.** (A) **19.** (B) **20.** (C) **21.** (C) **22.** (D) **23.** (D) **24.** (C) **25.** (B) **26.** (B) **27.**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

Section A

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

1.

➥ To derive the result, choose a pill box (a short cylinder) as the Gaussian surface about any point P on the surface, as shown in the figure.



➥ The pill-box is partly inside and partly outside the surface of the conductor. It has a small area of cross section δS and negligible height.

➥ Electro static field just inside the surface is zero. Just outside the surface, field is normal to the surface with magnitude E.

➥ Thus, the contribution to the total flux through the pill box comes only from outside (circular) cross section of the pill box. Which is equal to ± E δS (Positive for σ > 0, negative for σ < 0.)

➥ The total charge enclosed by the pill-box is $\delta q = |\sigma|\, \delta S$.

➥ By Gauss's law,

$$E\,\delta S = \frac{\delta q}{\varepsilon_0}$$

$$E\,\delta S = \frac{|\sigma|\delta S}{\varepsilon_0}$$

$$\therefore E = \frac{|\sigma|}{\varepsilon_0}$$

➥ In vector form,

$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$$

Where, σ - Surface charge density

$\hat{n}$ - Unit vector normal to the surface in the outward direction

➥ For σ > 0, electric field is normal to the surface in outward direction.

➥ For σ < 0, electric field is normal to the surface in inward direction.

2.

➥ Suppose two charges q_1 and q_2 are at infinite distance.

➥ Work done in bringing q_1 from infinity to $\vec{r}_1$ is $q_1 V(\vec{r}_1)$.

To bring charge q_2 from infinity to a point (having position vector $\vec{r}_2$), work needs to be done against external electric field $\vec{E}$ as well as against the electric field of q_1 charge.

(i) Work done on q_2 against the external field = $q_2 V(\vec{r_2})$

(ii) Work done on q_2 against the electric field of charge $q_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{12}}$

Where, r_{12} is the distance between charges q_1 and q_2 i.e. the work W which needs to be done can be written as follows :

$$U = q_1 V(\vec{r_1}) + q_2 V(\vec{r_2}) + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{12}}$$

3.

- Conductivity of conductor arises from mobile charge carriers.
- In metals, electrons are mobile charge carriers. In an electrolyte they are positive and negative ions while in an ionised gas, they are electrons and positive charged ions. In semi conductors, free electrons and holes are mobile charge carriers.
- *"The magnitude of the drift velocity per unit electric field is called the mobility (∝)."*

$$\propto = \frac{|\vec{\upsilon}_d|}{E} \quad ... (1)$$

- The SI unit of mobility is m^2/Vs and practical unit is cm^2/Vs
- Dimensional formula of mobility is $M^{-1}L^0T^2A^1$
- Using drift velocity $|\vec{v}_d| = \frac{Ee}{m} \cdot \tau$

  in equation (1).

  we get,

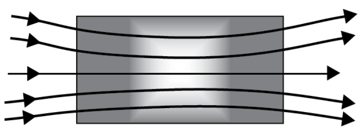
$$\propto = \frac{\frac{eE}{m}\tau}{E}$$

$$\therefore \propto = \frac{e\tau}{m}$$

where τ is the average collision time for electrons.

4.

- Paramagnetic substances are those which get weakly magnetised when placed in external magnetic field.
- Atoms (or ions or molecules) of paramagnetic materials possess a permanent magnetic dipole moment, but due to continuous (ceaseless) random thermal motion of atoms, net magnetisation is zero. So in normal condition, such substances do not behave as a magnet.
- When such substances are placed in sufficiently strong external magnetic field ($\vec{B}_0$) at low temperature, the atomic dipole moments of individual atoms are aligned in the direction of magnetic field ($\vec{B}_0$), and they get weakly magnetised.



- Therefore, as shown in Fig., magnetic field inside a paramagnetic substance is enhanced, and the field lines get concentrated inside the material. This enhancement is slight, generally one part in 10^5.
- When placed in a non-uniform magnetic field, they tend to move from weak field to strong, i.e. get weakly attracted to a magnet.
- This effect (property) is known as paramagnetism and such materials are known as paramagnetic materials.
- Some examples of paramagnetic materials are : aluminium, sodium, calcium, oxygen (at STP) and copper chloride.
- For a paramagnetic material both χ and $\propto_r$ depend not only on the material, but also on the sample temperature. As the field is increased or the temperature is lowerd the magnetisation increases until it reaches the saturation value at which point all the dipoles are perfectly aligned with the field.

5.

➥ $M = 1.5$ H

$\Delta t = 0.5$ sec

$\Delta I_1 = 20$ A

$\Delta \varphi_2 = (?)$

➥ For system made of two coils,

$M_{21} = \dfrac{\Delta \phi_2}{\Delta I_1}$

$\therefore \Delta \varphi_2 = M_{21} \Delta I_1$

$= 1.5 (20)$

$\Delta \varphi_2 = 30$ Wb

6.

➥ $B_0 = 510$ nT $= 510 \times 10^{-9}$ T

➥ Amplitude of Electric field (E_0)

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

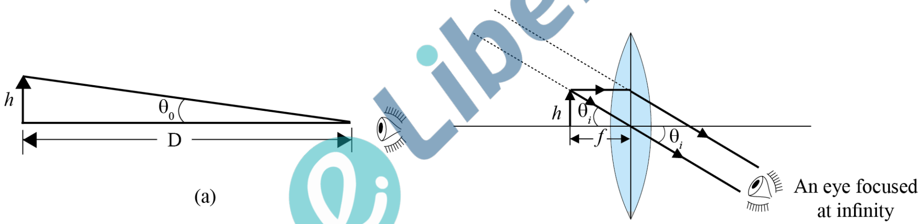
$\therefore E_0 = B_0 c$

$= 510 \times 10^{-9} \times 3 \times 10^8$

$E_0 = 153$ V/m

7.

➥



(a)

(b)

➥ When an object of height h is placed at the near point as shown in the figure (a), the angle subtended at the eye by the object is θ_0.

➥ from figure, $\tan \theta_0 = \dfrac{h}{D}$

for small angle, $\tan \theta_0 \approx \theta_0 = \dfrac{h}{D}$ ... (1)

➥ As shown in figure (b), if an object of height h is placed at the principal focus, its image will be at an infinite distance. This time, the angle subtended at the eye by the object is θ_i.

➥ from figure, $\tan \theta_i = \dfrac{h}{f}$

but for small angle, $\tan \theta_i \approx \theta_i = \dfrac{h}{f}$ ... (2)

➥ angular magnification of lens,

$$m = \frac{\theta_i}{\theta_0} = \frac{\frac{h}{f}}{\frac{h}{D}} = \frac{h}{f} \times \frac{D}{h}$$

$$\therefore m = \frac{D}{f}$$

➥ This is the magnification when the image is at infinity.

➥ Thus, the magnification obtained with simple microscope is between $\frac{D}{f}$ to $1 + \frac{D}{f}$.

8.

➥ Wavelength of the incident light wave,

$\lambda = 589$ nm

Refractive index of water $n = 1.33$

➥ (a) When the light undergoes reflection, the medium doesn't change. Hence the frequency speed and wavelength of the reflected light is same as the incident light.

(i) $\begin{matrix}\text{Speed of the} \\ \text{Reflected light}\end{matrix} = \begin{matrix}\text{Speed of the} \\ \text{incident light}\end{matrix}$

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

(ii) $\begin{matrix}\text{wavelength of} \\ \text{the reflected} \\ \text{light wave}\end{matrix} = \begin{matrix}\text{wavelength of} \\ \text{the incident} \\ \text{light wave}\end{matrix}$

$\lambda' = \lambda$

$= 589$ nm

$= 589 \times 10^{-9}$ m

(iii) Frequency of the reflected light (v)

$v = \frac{c}{\lambda'} = \frac{3 \times 10^8}{589 \times 10^{-9}}$

$v = 5.09 \times 10^{14}$ Hz

➥ (b) When light undergoes refraction and enters in another medium, its speed and wavelength change, but frequency remains the same. Because frequency of the wave is the property of the source, while the wavelength is the property of the medium in which the wave propogates.

(i) Frequency of the refracted light

$v = 5.09 \times 10^{14}$ Hz

(ii) Speed of light in water $n = \frac{c}{\upsilon}$

$\upsilon = \frac{c}{n}$

$\upsilon = \frac{3 \times 10^8}{1.33}$

$\upsilon = 2.26 \times 10^8$ m/s

(iii) Wavelength of light in water (λ_w)

As $\lambda \propto \frac{1}{n}$

$\frac{\lambda_w}{\lambda_a} = \frac{n_a}{n_w}$

$\therefore \lambda_w = \frac{n_a \lambda_a}{n_w} = \frac{1 \times 589 \times 10^{-9}}{1.33}$

$\lambda_w = 443\ nm$

9.

➥ Any metal has free electrons. These free electrons can move freely in the metal, hence they are responsible for the conductivity of the metal.

➥ However, these free electrons cannot escape from the metal surface. If an electron tries to come out of the metal, the metal surface acquires a positive charge which pulls the electron back to the metal.

- If the electron has enough energy to overcome the attraction of positive charge, it can escape from the metal.
- Thus, *"The minimum energy required by an electron to escape from the metal surface is called the work function of given metal"*.
- It is denoted by φ_0.
- The SI unit of wrok function is J. It is usually measured in eV (electron volt).

  (1 eV = 1.6×10^{-19} J)
- φ_0 depends on,

  (i) type of metal

  (ii) properties of metal and

  (iii) type of surface.

10.

- Radius of an electron revolving in the n^{th} orbit of a hydrogen atom is

  $$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2} \quad ... (1)$$
- Using $n = 1$ in above equation, we get

  $$r_1 = \frac{h^2 \varepsilon_0}{\pi m e^2} = 5.3 \times 10^{-11} \text{ m}$$
- Putting $n = 2$ in equation (1), we get

  $$r_2 = \frac{(2)^2 h^2 \varepsilon_0}{\pi m e^2}$$

  $$\therefore r_2 = 4 \times 5.3 \times 10^{-11}$$

  $$\therefore r_2 = 2.12 \times 10^{-10} \text{ m}$$
- Putting $n = 3$ in equation (1)

  $$r_3 = \frac{(3)^2 h^2 \varepsilon_0}{\pi m e^2}$$

  $$\therefore r_3 = 9 \times 5.3 \times 10^{-11}$$

  $$\therefore r_3 = 4.77 \times 10^{-10} \text{ m}$$

11.

- (i) Isotopes :
  - The atoms which have atomic number Z same but atomic mass number A different, then such type of atoms are called the isotopes of each other.
  - For example :

    Isotopes of hydrogen are ${}_1H^1$, ${}_1H^2$, ${}_1H^3$
  - ${}_1H^1$ - there is one proton but having no neutron.
  - ${}_1H^2$ - there is one proton one neutron.
  - ${}_1H^3$ - there is one proton and two neutrons.
  - Isotopes of carbon are ${}_6C^{12}$, ${}_6C^{13}$, ${}_6C^{14}$
  - Isotopes of uranium are ${}_{92}U^{233}$, ${}_{92}C^{235}$, ${}_{92}C^{238}$
- (ii) Isobar :
  - Atoms having same atomic mass number A, but different atomic number Z are called the isobars of each other.
  - For example :

    ${}_1H^3$ and ${}_2He^3$

$_{82}Pb^{214}$ and $_{83}Bi^{214}$

➥ (iii) Isotone :

- The atoms for which the neutron number N is the same but atomic number Z and mass number A are different are called isotones to each other.
- For example :
  $_{80}Hg^{198}$ and $_{79}Au^{197}$

➥ (iv) Isomer :

- The atoms for which the atomic number Z and mass number A are same but their radioactive properties are different are called isomers of each other.
- For example :
  $_{35}Br^{80}$ contains a pair of isomers.

12.

➥ *"The deliberate addition of a desired impurity is called doping. And the impurity atoms are called dopants. Such a material is also called a doped semiconductor (or extrinsic semiconductors or impurity semiconductors.)".*

➥ The dopant atom (impurity atom) has to be such that it does not distort the original pure semiconductor lattice.

➥ It occupies only a very few of the original semiconductor sites in the crystal. A necessary condition to attain this is that the sizes of the dopant and the semiconductor atoms should be nearly same.

➥ Generally a small amount, say, a few parts per million (ppm), of a suitable impurity is added to the pure semi-conductor. Due to the added impurity atoms, the conductivity of the semiconductor is increased manifold.

➥ There are two types of dopants used in doping the tetravalent Si or Ge:
(i) Pentavalent (Valency 5) : like Arsenic (As), Antimony (Sb), Phosphorous (P), etc.
(ii) Trivalent (Valency 3) : like Indium (In) Boron (B), Aluminium (Al) etc.

Section B

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

13.

➥ $q = 10\,\mu C$ $p = 2aq$

➥ $= 10 \cdot 10^{-6}$ C $p = 5 \cdot 10^{-3} \cdot 10 \cdot 10^{-6}$

$2a = 5$ mm $p = 5 \cdot 10^{-8}$ Cm

$= 5 \cdot 10^{-3}$ m

$r = 15$ cm

$= 15 \cdot 10^{-2}$ m

(i) Electric field for a point P on the axis of the dipole, ($r >> a$)

$$\therefore E_P = \frac{2kp}{r^3}$$

$$= \frac{2 \times 9 \times 10^9 \times 5 \times 10^{-8}}{(15 \times 10^{-2})^3}$$

$$\therefore E_P = 2.66 \cdot 10^5 \ \frac{N}{C} \text{ (From A to B)}$$

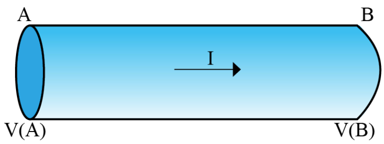
(ii) Electric field for a point Q on the equatorial line of the dipole, ($r >> a$)

$$\therefore E_Q = \frac{kp}{r^3}$$

$$= \frac{9 \times 10^9 \times 5 \times 10^{-8}}{(15 \times 10^{-2})^3}$$

$$\therefore E_Q = 1.33 \cdot 10^5 \ \frac{N}{C} \text{ (From B to A)}$$

14.

➥ 

➥ As shown in figure, consider a conductor with end points A and B. In this conductor, current I is flowing from A to B.

➥ The potential at A and B are V(A) and V(B) respectively. Since current is flowing from A to B, V(A) > V(B).

➥ The potential difference across AB

$V = V(A) - V(B) > 0$ ... (1)

➥ In time interval Δt, an amount of charge $\Delta Q = I \, \Delta t$ flows from A to B.

➥ The potential energy of the charge at A is $\Delta Q.V(A)$ and at B is $\Delta Q.V(B)$.

➥ Thus, change in potential energy.

ΔU = final potential energy – initial potential energy

$\therefore \Delta U = \Delta Q \, V(B) - \Delta Q \, V(A)$

$\therefore \Delta U = \Delta Q \, (V(B) - V(A))$

$\therefore \Delta U = \Delta Q \, (-V)$ ($\because$ from eq^n (1))

$\therefore \Delta U = -\Delta Q.V$

$\therefore \Delta U = -I \, V \, \Delta t < 0$ ... (2)

➥ According to law of conservation of energy,

$\Delta K + \Delta U = 0$

$\therefore \Delta K = -\Delta U$

$\therefore \Delta K = -(-I \, V \, \Delta t)$ ($\because$ from eq^n (2))

$\therefore \Delta K = IV \, \Delta t$ (positive) ... (3)

➥ Thus, from this equation it can be seen that a charge moving freely under the effect of an electric field acquires kinetic energy, it means kinetic energy increases.

➥ But in reality, the charges in the conductor move with constant drift velocity, i.e. they gain no energy on an average.

➥ This is because of the collisions with ions and atoms during the motion. During collisions, the energy gained by the charges is shared with the atoms, So the atoms vibrate more energetically, i.e. the conductor heats up.

➥ Thus, kinetic energy of charge is converted in to heat energy.

➥ Amount of energy dissipated as heat in the conductor during the time interval Δt is

$\Delta W = VI \, \Delta t$ ... (4)

➥ The energy dissipated per unit time is the dissipated power P.

$\therefore P = \frac{\Delta W}{\Delta t}$

$\therefore P = \frac{VI\,\Delta t}{\Delta t}$

$\therefore P = VI$ ... (5)

- Using ohm's law $V = IR$

  $\therefore P = I^2R$ ... (6)

- and also $P = \frac{V^2}{R}$ can be derived. ... (7)
- The SI unit of electrical power is W (watt) OR J/s
- Equations (5), (6) and (7) show dissipated power in conductor. (power loss or ohmic loss)
- For example, when power is supplied to the coil of an electric bulb, this power is converted into heat and light.

15.

- As shown in figure, consider a uniform conducting rod of length l and cross-sectional area A.
- Suppose the number density of mobile charge carriers (moving charges) in conductor is n. Hence, the total number of (free) electric charges will be nAl.
- In this conduction rod, a steady current is I and the drift velocity of electron is $\vec{\upsilon}_d$. In the presence of an external magnetic field $\vec{B}$ The force on these carriers is

  $\vec{F} = (nlA)\,q(\vec{\upsilon}_d \times \vec{B})$ ... ... (1)

  Where, $q(\vec{\upsilon}_d \times \vec{B})$ is magnetic force acting on one particle.
- But, electric current density

  $\therefore \vec{j} = nq\vec{\upsilon}_d$ ... ... (2)
- From, equation (1) and (2)

  $\vec{F} = \vec{j}\,l\,A \times \vec{B}$
- Hence, current density $\hat{j}$ and length l both are in the same direction.

  So, $\vec{j}\,l = \vec{l}\,j$
- So, the equation becomes

  $\vec{F} = j\,\vec{l}\,A \times \vec{B}$

  But $I = jA$

  $\therefore \vec{F} = I(\vec{l} \times \vec{B})$ ... (3)
- Where, $\vec{l}$ is a vector magnitude of l and it is in the direction of the current I.
- Here equation (3) is only applicable for a straight rod. In this equation $\vec{B}$ is the external magnetic field. It is not the magnetic field which is produced by the current carrying rod.
- If the wire has an arbitrary shape, we consider the wire is made up of rubber & linear strips of dl and by summing up the force.

  $\vec{F} = \sum_j I\,d\vec{l}_j \times \vec{B}$

  If $dl \to 0$, then it is converted in to an integral.

  $\vec{F} = \int I\,d\vec{l} \times \vec{B}$
- Special Cases :

(i) If $\theta = 0$ or $\theta = \pi$ then

$F = BIl \sin\theta = 0$

because, $\sin 0 = \sin \pi = 0$

- Thus, if the current is parallel or anti-parallel to the external magnetic field, the magnetic force on the conductor is zero.

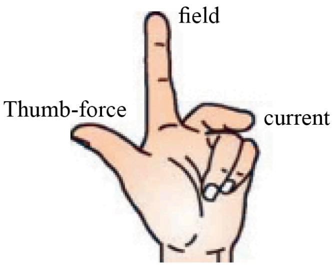
(ii) If $\theta = \frac{\pi}{2}$ then,

$F = BIl \sin\theta = BIl$

because, $\sin \frac{\pi}{2} = +1$

- Thus, if the current and the external magnetic field are mutually perpendicular, the magnetic force on the conductor is maximum.

- Note :



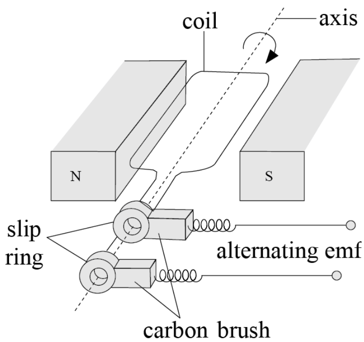
- The magnetic force exerted on a current-carrying wire placed in a uniform magnetic field.

  $\vec{F} = I\, \vec{l} \times \vec{B}$

- The direction of this force can be obtained using Fleming's left hand rule.
- *"As shown in the diagram, the first finger of the left hand is placed in the direction of the magnetic field and the middle finger in the direction of the current, the direction of the thumb represents the direction of magnetic force."*

16.

- Principle of Working :
  - When coil having area $\vec{A}$ rotates in a magnetic field $\vec{B}$, effective area $A \cos\theta$ of closed loop changes continuously and hence magnetic flux linked with loop changes continuously (where θ is angle between $\vec{A}$ and $\vec{B}$).



- Construction :
  - Basic elements of AC generator are shown in figure.
  - Magnetic field $\vec{B}$ is formed by permanent magnetic poles N and S.
  - As shown in figure, the generator consists of a coil mounted on a rotor shaft.
  - The axis of rotation of this coil is perpendicular to the direction of the magnetic field. This coil is called armature.

- Coil connected with rotor shaft can be rotated with respect to its own axis keeping perpendicular to $\vec{B}$, using external mechanical arrangement.
- Due to rotation of coil, magnetic flux linked with coil changes and hence induced *emf* is produced across two ends of coil which is joined with slip rings and brushes.

- Working :
  - When coil is rotating with angular speed ω, angle between $\vec{B}$ and area vector $\vec{A}$ at any instant is $\theta = \omega t$. $\left(\because \omega = \frac{\theta}{t}\right)$
  - Magnetic flux linked with coil at time *t* is

    $\varphi_B = BA \cos\theta = BA \cos\omega t$ ... (1)
  - According to Faraday's law,
  - induced *emf* in coil having N turns is

    $$\varepsilon = -N \frac{d\phi_B}{dt}$$

    $\therefore \varepsilon = -N BA \frac{d}{dt} (\cos\omega t)$

    $\therefore \varepsilon = +N B\omega A \sin\omega t$ ... (2)

- When value of $\sin\omega t$ is ± 1, induced *emf* becomes maximum equal to ε_0

  $\therefore \varepsilon_0 = N BA\omega$ ... (3)
- Equation (2) is expression for instantaneous induced *emf* and equation (3) for maximum induced *emf*.
- from equation (2) & (3),

  $\varepsilon = \varepsilon_0 \sin\omega t$ ... (4)
- Equation (4) is expression for induced *emf* obtained from AC generator which changes with time according to function $\sin\theta$ and also changes direction at fixed time interval. Thus it is called Alternating voltage and current.
- Equation (4) can be given as follows also,

  $\varepsilon = \varepsilon_0 \sin 2\pi vt$

  Where $\omega = 2\pi v$ with *v* as frequency of AC generator, which is equal to frequency of rotation of coil.
- Value of ε changes periodically between $+\varepsilon_0$ and $-\varepsilon_0$.

17.

- Electric current for LCR series AC circuit,

  $i = i_m \sin(\omega t + \varphi)$

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

  $X_C = \frac{1}{\omega C}$ and $X_L = \omega L$
- From this equation, it can be said that when the value of ω is varied, the current also changes.
- Then at a particular frequency $\omega = \omega_0$, $X_C = X_L$. Then the impendence becomes miniumum. $(Z = \sqrt{R^2 + (X_C - X_L)^2} = R)$
- This frequency is called resonant frequency.

  Here, $X_C = X_L$

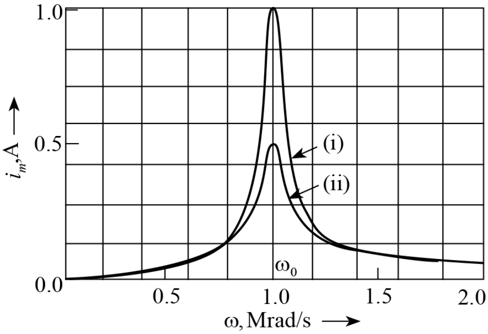
  $\therefore \frac{1}{\omega_0 C} = \omega_0 L$

  $\therefore \omega_0^2 = \frac{1}{LC}$

  $\therefore \omega_0 = \frac{1}{\sqrt{LC}}$
- At resonant freq. the current amplitude is maximum.

  $\therefore i_m^{max} = \frac{\upsilon_m}{R}$ $(\because Z = R)$

➥ The phenomenon of maximum current is called series resonance



➥ Figure shows the variation of i_m with ω in an RLC series circuit with

L = 1.00 mH, C = 1.00 nF for two values of

R : (i) R = 100 Ω and (ii) R = 200 Ω for the source applied $\upsilon_m = 100$ V

➥ ω_0 for this case is :

$$\omega_0 = \frac{1}{\sqrt{LC}} = 1.00 \times 10^6 \text{ rad/s (substituting values)}$$

➥ We can see that current amplitude becomes maximum at the resonance frequencey.

Since, $i_m^{max} = \frac{\upsilon_m}{R}$ at resonance,

the current amplitude for case (i) is twice to that for case (ii).

18.

➥ Bohr combined classical and early quantum concepts and gave his theory in the form of three postulates. These are :

➥ (i) Bohr's first postulate : An electron in an atom could revolve in certain stable orbits without the emission of radiant energy.

➠ According to this postulate, each atom has certain definite stable states in which it can exist, and each possible state has definite total energy. These are called the stationary states of the atom.

➠ This contrary to the predictions of electromagnetic theory.

➥ (ii) Bohr's second postulate : The electron revolves around the nucleus only in those orbits for which the angular momentum is in integral multiple of $\frac{h}{2\pi}$.

➠ Where, h is Planck's constant

$h = 6.625 \times 10^{-34}$ J s.

$L = \frac{nh}{2\pi}$ Where, $n = 1, 2, 3....$

➥ (iii) Bohr's third postulate : An electron makes a transition from one of its specified non-radiating orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the initial and final states.

➠ The frequency of the emitted photon is then given by

$h\nu = E_i - E_f$

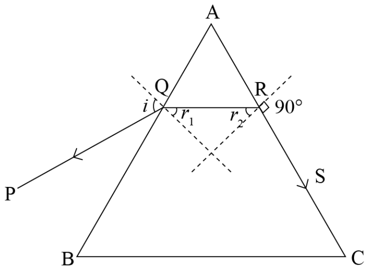
Where E_i and E_f are the energies of the initial and final states and $E_i > E_f$.

19.

➥ A = 60°

$n_a = 1$

$n_g = 1.524$



➥ In figure ΔABC is the cross section of the prism.

➥ The incident ray moves along the path PQRS.

➥ Applying Snell's law near point R,

$\therefore n_a \sin 90° = n_g \sin r_2$

$\therefore (1)(1) = 1.524 \sin r_2$

$\therefore \sin r_2 = \frac{1}{1.524}$

$\therefore \sin r_2 = 0.6542$

$\therefore r_2 = 41°$

➥ but for prism, $A = r_1 + r_2$

$\therefore 60° = r_1 + 41°$

$\therefore r_1 = 19°$

➥ Applying Snell's law near point Q,

$\therefore n_a \sin i = n_g \sin r_1$

$\therefore (1) \sin i = (1.524) \sin 19°$

$\therefore \sin i = 1.524 \times 0.3256$

$\therefore \sin i = 0.4962$

$\therefore i \approx 30°$

20.

➥ The resultant intensity at any point on the screen in the Young's Double slit Experiment is given by the following formula :

$I = 4 I_0 \cos^2 \frac{\phi}{2}$ ... (1)

where, φ - Phase difference

➥ Phase difference at the P on the screen where the path difference is λ

Phase difference = $\frac{2\pi}{\lambda}$ × Path difference

$\therefore \varphi = \frac{2\pi}{\lambda} \times \lambda$

$\therefore \varphi = 2\pi$

➥ Putting I = K and φ = 2π in equation (1),

$\therefore K = 4 I_0 \cos^2 \frac{2\pi}{2}$

$\therefore K = 4 I_0 \cos^2 \pi$

$\therefore K = 4 I_0$ ... (2) $(\because \cos^2 \pi = (-1)^2 = 1)$

➥ Phase difference at the point on the screen where the path difference is $\frac{\lambda}{3}$,

Phase difference = $\frac{2\pi}{\lambda}$ × Path difference

$$\therefore \varphi' = \frac{2\pi}{\lambda} \times \frac{\lambda}{3}$$

$$\therefore \varphi' = \frac{2\pi}{3}$$

➥ Intensity is this point is I'.

➥ From equation (1),

$$I' = 4 I_0 \cos^2 \frac{\phi'}{2}$$

$$\therefore I' = 4 I_0 \cos^2 \left(\frac{2\pi}{3 \times 2}\right)$$

$$\therefore I' = 4 I_0 \cos^2 \left(\frac{\pi}{3}\right)$$

$$\therefore I' = 4 I_0 \left(\frac{1}{2}\right)^2$$

$$\therefore I' = I_0 \; ... (3)$$

➥ Taking the ratio of equation (3) and (2),

$$\therefore \frac{I'}{K} = \frac{I_0}{4 I_0}$$

$$\therefore I' = \frac{K}{4}$$

21.

➥ The curve of binding energy per nucleon versus mass number A is shown in figure.

➥ The binding energy per nucleon is nearly constant (8 MeV) in the region between A = 30 to A = 170.

➥ For the lighter nuclei region A < 30 and for the heavier nuclei region A > 170 the binding energy per nucleon is less than 8.0 MeV.

➥ If nuclei with less total binding energy transform to nuclei with greater binding energy there will be a net energy release.

➥ *"When a heavy nucleus decays into two or more intermediate mass fragments, then the total binding energy increases. Energy is released during this process. This process is called nuclear fission".*

➥ *"When two or more light nucleus fuse into heavier nucleus then also the total binding energy increases. Due to this energy is realeased during this process. This process is called nuclear fusion".*

➥ Exothermic chemical reactions underlie conventional energy sources such as coal or petroleum. Here the energies involved are in the range of electron volts. On the other hand, in a nuclear reaction, the energy release is of the order of MeV.

➥ Thus for the same quantity of matter, nuclear sources produce a million (10^6) times more energy than a chemical source.

➥ For example :

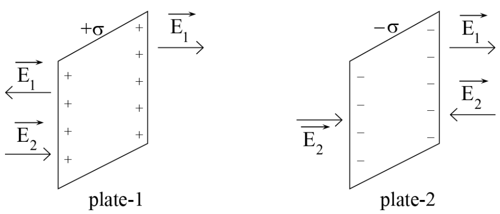
➥ Fission of 1 kg of uranium generates 10^{14} J of energy compare it with burning of 1 kg of coal that give 10^7 J.

Section C

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

22.

➥ $\sigma = 17 \cdot 10^{-22}$ C/m^2



(a) Electric field in the region outside the first plate.

$\vec{E'} = \vec{E_1} + \vec{E_2}$

$\therefore \vec{E'} = -\frac{\sigma}{2\varepsilon_0}\hat{i} + \frac{\sigma}{2\varepsilon_0}\hat{i}$

$\therefore \vec{E'} = \vec{0}$

(b) Electric field in the region outside the second plate,

$\vec{E''} = \vec{E_1} + \vec{E_2}$

$\therefore \vec{E''} = \frac{\sigma}{2\varepsilon_0}\hat{i} - \frac{\sigma}{2\varepsilon_0}\hat{i}$

$\therefore \vec{E''} = \vec{0}$

(c) Electric field in the region between the two plate,

$\vec{E'''} = \vec{E_1} + \vec{E_2}$

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

$\therefore \vec{E'''} = \frac{\sigma}{\varepsilon_0}\hat{i}$

$= \frac{17 \times 10^{-22}}{8.85 \times 10^{-12}}\hat{i}$

$\therefore \vec{E'''} = 1.92 \cdot 10^{-10}\ \frac{N}{C}\hat{i}$

23.

➥ $R_0 = 2.1\ \Omega$ $T_0 = 27.5\ °C$

➥ $R = 2.7\ \Omega$ $T = 100\ °C$

$\alpha = ?$

➥ we know that

$\therefore R = R_0\,[1 + \alpha(T - T_0)]$

$\therefore R = R_0 + R_0\,\alpha\,(T - T_0)$

$\therefore R - R_0 = R_0\,\alpha\,(T - T_0)$

$\therefore \alpha = \frac{R - R_0}{R_0(T - T_0)}$

$\therefore \alpha = \frac{2.7 - 2.1}{2.1\,(100 - 27.5)}$

$\therefore \alpha = 0.00394\ °C^{-1}$

24.

➥ $V = 220\ V$

$\nu = 50\ Hz$

$R = 100\ \Omega$

(a) rms value of current in circuit,

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

$\therefore I = \frac{220}{100}$

$\therefore I = 2.2\ A$

(b) Power consumed over a full cycle,

$P = VI$

$\therefore P = (220)\,(2.2)$

$\therefore P = 484\ W$

➥ (a) $V_m = 300$ V

➠ rms value of voltage,

$$V = \frac{V_m}{\sqrt{2}}$$

$$= \frac{300}{1.414}$$

= 212.1 V

(b) I = 10 A

➠ peak current (/ peak value of current),

➥ $I = \frac{I_m}{\sqrt{2}}$

➥ $\therefore I_m = \sqrt{2}\ I$

➥ = 1.414 × 10

➥ $\therefore I_m = 14.14$ A

25.

➥ (a) focal length $f = 10$ cm

object distance $u = -9$ cm

Area of each piece $A_0 = 1$ mm

$= 1 \times 10^{-6}\ m^2$

➠ From lens formula,

$$\frac{1}{\upsilon} - \frac{1}{u} = \frac{1}{f}$$

$$\therefore \frac{1}{\upsilon} = \frac{1}{f} + \frac{1}{u}$$

$$\therefore \frac{1}{\upsilon} = \frac{1}{10} - \frac{1}{9}$$

$$\therefore \frac{1}{\upsilon} = \frac{9-10}{90}$$

$\therefore \upsilon = -90$ cm

➠ Magnification of lens,

$$m = \frac{\upsilon}{u} = \frac{-90}{-9} = 10$$

➠ Areal magnification

= (linear magnification)^2

$= (10)^2$

= 100

➠

$$\text{Areal magnification} = \frac{\text{Area of Image}\,(A_1)}{\text{Area of Object}\,(A_0)}$$

$$100 = \frac{A_1}{(1 \times 10^{-3})^2}$$

$\therefore A_I = 100 \times 1 \times 10^{-6}$

$\therefore A_I = 1 \times 10^{-4}\ m^2$

$= 1\ cm^2$

➥ (b) angular magnification of image,

$$m = \frac{D}{|u|}$$

$\therefore m = \frac{25}{9}$

$\therefore m = 2.8$

➥ (c) magnification of lens and angular magnification (magnifying power) both are different.

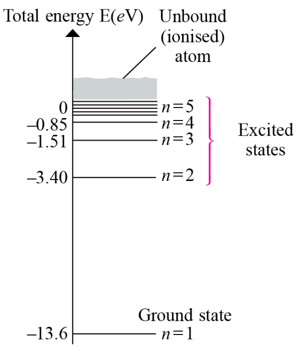
- Value of magnification = $\left|\frac{\upsilon}{u}\right|$
- angular magnification $m = \frac{D}{|u|}$
- Only when image is obtained at near point then magnification and magnifying power are same.

26.

➥ The energy of an atom is the least when its electron is revolving in an orbit closest to the nucleus i.e., for $n = 1$.

➥ As the value of n increases, the energy of the electron also increases.

➥ The lowest state of the atom is called the ground state, is that of lowest energy, with the electron revolving in the orbit of smallest radius, the Bohr radius (a_0).



The energy of this state

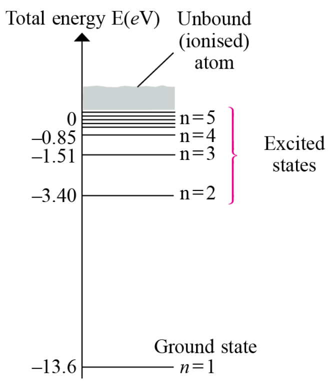
$E_n = -\frac{13.6}{n^2}\ eV$

$n = 1$

$E_1 = -13.6\ ev$

➥ Therefore, the minimum energy required to free the electron from the ground state of the hydrogen atom is 13.6 eV. It is called the ionisation energy of a the hydrogen atom.

➥



➥ At room temperature, most of the hydrogen atoms are in ground state.

➥ When a hydrogen atom receives energy by processes such as electron collisions, the atom may acquire sufficient energy to raise the electron to higher energy states. The atom is then said to be in an excited state.

➥ Putting $n = 2$ in

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

$E_2 = -3.4$ eV.

- It means that the energy required to excite an electron in hydrogen atom to its first excited state, is an energy equal to

  $E_2 - E_1 = -3.40$ eV $- (-13.6)$ eV

  $= -3.4$ eV $+ 13.6$ eV

  $= 10.2$ eV

- Similarly, $E_3 = -1.51$ eV
- To excite the hydrogen atom from its ground state to second excited state, energy required is

  $E_3 - E_1 = -1.51$ eV $-(-13.6)$ eV

  $= -1.51$ eV $+ 13.6$ eV

  $= 12.09$ eV

- In contrast, when an electron moves from an excited state to a lower energy state a photon is emitted.
- Thus, as the excitation of hydrogen atom increases (as n increases) the value of minimum energy required to free the electron from the excited atom decreases.
- The energies of the excited states come closer and closer together as n increases.

27.

- (i) ${}^{1}_{1}H + {}^{3}_{1}H \rightarrow {}^{2}_{1}H + {}^{2}_{1}H$
  - Mass Defect

    $\Delta M = [m({}^{1}_{1}H) + m({}^{3}_{1}H) - 2m({}^{2}_{1}H)]$

    $\therefore \Delta M = [1.007825 + 3.016049 - 2 \cdot 2.014102]$

    $\therefore \Delta M = [4.023874 - 4.028204]$

    $\therefore \Delta M = -0.00433\ u$

  - The equivalent energy to this mass defect is called the Q-value of the process.

    $Q = \Delta M c^2$

    $= -0.00433 \cdot 931.5$

    $= -4.033395$ MeV

  - Here, $Q < 0$ so the reaction is endothermic
- (ii) ${}^{12}_{6}C + {}^{12}_{6}C \rightarrow {}^{20}_{10}Ne + {}^{4}_{2}He + Q$

    $\therefore \Delta M = [2m({}^{12}_{6}C) - m({}^{20}_{10}Ne) - m({}^{4}_{2}He)]$

    $\therefore \Delta M = [2 \cdot 12.000000 - 19.992439 - 4.002603]$

    $\therefore \Delta M = [24.000000 - 23.995042]$

    $\therefore \Delta M = 0.004958\ u$

  - The equivalent energy to this mass defect is called the Q-value of the process.

    $\therefore Q = \Delta M c^2$

    $\therefore Q = 0.004958 \cdot 931.5$

    $\therefore Q = 4.618$ MeV

  - Here $Q > 0$, so the reaction is exothermic.