# XII - ISC Board

**Date: 20.02.2018** **Physics - Solutions**

**SECTION - A**

**Question 1**

**(A)** Choose the correct alternative (a), (b), (c) or (d) for each of the questions.

(i) The order of coloured rings in a carbon resistor is red, yellow, blue and silver. The resistance of the carbon resistor is:

(a) $24 \times 10^6\ \Omega \pm 5\%$ (b) $24 \times 10^6\ \Omega \pm 10\%$

(c) $34 \times 10^4\ \Omega \pm 10\%$ (d) $26 \times 10^4\ \Omega \pm 5\%$

Ans. (b)

$R = 24 \times 10^6 \Omega \pm 10\%$

(ii) A circular coil carrying a current I has radius R and number of turns N. If all the three, i.e. the current I, radius R and number of turns N are doubled, then, magnetic field at its centre becomes:

(a) Double (b) Half (c) Four times (d) One fourth

Ans. (a)

$$B = \frac{\mu_0 NI}{R}$$

(iii) An object is kept on the principal axis of a concave mirror of focal length 10 cm. at a distance of 15 cm from its pole. The image formed by the mirror is:

(a) Virtual and magnified (b) Virtual and diminished

(c) Real and magnified (d) Real and diminished

Ans. (c)

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$u = -15,\ f = -10$$

$$\therefore v = -30$$

(iv) Einstein's photoelectric equation is:

(a) $E_{\max} = h\lambda - \varphi_0$ (b) $E_{\max} = \frac{hc}{\lambda} - \varphi_0$ (c) $E_{\max} = hv + \varphi_0$ (d) $E_{\max} = \frac{hv}{\lambda} + \varphi_0$

Ans. (b)

$\because hv = \phi_0 + E_{\max}$

(v) In Bohr's model of hydrogen atom, radius of the first orbit of an electron is $r_0$. Then, radius of the third orbit is:

(a) $\frac{r_0}{9}$ (b) $r_0$ (c) $3r_0$ (d) $9r_0$

Ans. (d)

$\because r_n = n^2 (r_0)$

**(B)** Answer the following questions briefly and to the point.

(i) In a potentiometer experiment, balancing length is found to be 120 cm for a cell $E_1$ of emf 2V. What will be the balancing length for another cell $E_2$ of emf 1.5V? (No other changes are made in the experiment.)

Ans. $\frac{E_1}{E_2} = \frac{\ell_1}{\ell_2}$

$\frac{2}{1.5} = \frac{120}{\ell_2}$

$\ell_2 = 90\,cm$

(ii) How will you convert a moving coil galvanometer into a voltmeter?

Ans. By connecting high resistance in series.

(iii) A moving charged particle q travelling along the positive x-axis enters a uniform magnetic field B. When will the force acting on q be maximum?

Ans. When charge particle sends perpendicular to field.

(iv) Why is the core of a transformer laminated?

Ans To reduce eddy current losses.

(v) Ordinary (i.e. unpolarised) light is incident on the surface of a transparent material at the polarising angle. If it is partly reflected and partly refracted, what is the angle between the reflected and the refracted rays?

Ans. $90^o$, Brewster's law.

(vi) Define coherent sources of light.

Ans. Sources must having zero or constant phase difference.

(vii) Name a material which is used in making control rods in a nuclear reactor.

Ans. Boron, Silver, Indium and Cadium.

## SECTION B

**Question 2**

Define current density. Write an expression which connects current density with drift speed.

Ans. Current density is defined as current per unit cross section area of conductor.

$$\overline{J} = \frac{I}{A}$$

Relation

$$\overline{J} = n e \overline{V} d$$

$n \rightarrow$ electron density.

**Question 3**

(a) A long horizontal wire P carries a current of 50A. It is rigidly fixed. Another wire Q is placed directly above and parallel to P, as shown in Figure 1 below. The weight per unit length of the wire Q is 0.025 $Nm^{-1}$ and it carries a current of 25A. Find the distance 'r' of the wire Q from the wire P so that the wire Q remains at rest.

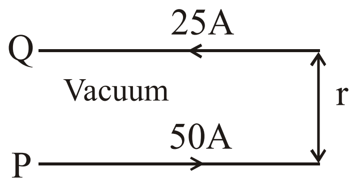



***Figure 1***

Ans. $$\frac{F}{\ell} = \frac{\mu_0}{4\pi} \frac{2 I_1 I_2}{r}$$

$$0.025 = 10^{-7} \times \frac{2 \times 50 \times 25}{r}$$

$$\boxed{r = 0.01 m}$$

**OR**

(b) Calculate force per unit length acting on the wire B due to the current flowing in the wire A.(See Figure 2 below)

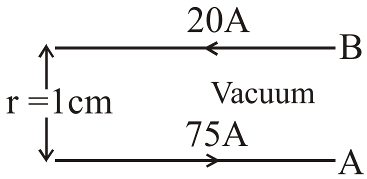



***Figure 2***

Ans. $\frac{F}{\ell}=\frac{\mu_0}{4\pi}\frac{2I_1 I_2}{r}$

$10^{-7}\times\frac{2\times 20\times 25\times 75}{0.01}$

$=\boxed{0.03\ \text{N/m}}$

**Question 4**

(i) Explain Curie's law for a paramagnetic substance.

(ii) A rectangular coil having 60 turns and area of $0.4\text{m}^2$ is held at right angles to a uniform magnetic field of flux density $5 \times 10^{-5}$T. Calculate the magnetic flux passing through it.

Ans. (i) Magnetic succeptibility inversely proportional to temperature.

$$I_m \propto B$$

$$I_m \propto \frac{1}{T}$$

$$\therefore\ I_m \propto \frac{B}{T}$$

$$I_m = \frac{CB}{T}$$

$$I_m = \frac{C\cdot\mu\cdot H}{T}$$

$$\frac{I_m}{H} = \frac{C\mu}{T}$$

$$\chi = \frac{C}{T}$$

$$\therefore\ \chi \propto \frac{1}{T}$$

(ii) $\phi = NBA$

$= 60 \times 5 \times 10^{-5} \times 0.4$

$= 120 \times 10^{-5} Wb$

**Question 5:** What is motional emf? State any two factors on which it depends.

Ans. Induced EMF by change of area of the coil linked with magnetic field.

$e = Bvl$

It depends on

(i) Magnetic field

(ii) Velocity of conductor

(iii) Length of conductor

**Question 6**

(i) What is the ratio of the speed of gamma rays to that of radio waves in vacuum ?

(ii) Name an electromagnetic wave which is used in the radar system used in aircraft navigation.

Ans. (i) 1

(ii) Microwaves or Radio waves

**Question 7**

A biconvex lens made of glass (refractive index 1.5) has two spherical surfaces having radii 20 cm and 30 cm. Calculate its focal length.

Ans. $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

$\frac{1}{f} = (1.5 - 1)\left(\frac{1}{30} + \frac{1}{20}\right)$

$f = 24$ cm

**Question 8:** State any two difference between primary rainbow and secondary rainbow.

Ans. In primary rainbow, intensity of colours are more as compared to secondary rainbow.Primary rainbow lies below the secondary rainbow.

**Question 9**

(i) State de Broglie hypothesis.

(ii) With reference to photoelectric effect, define threshold wavelength.

Ans. (i) According to de Broglie a moving material particle acts as a wave and sometimes wave is associated with moving material particle which controls the particle in every respect.

$$\lambda = \frac{h}{p}$$

(ii) Maximum wavelength of incident radiation required to eject electron from photo sensetive surface.

**Question 10**

Calculate the minimum wavelength of the spectral line present in Balmer series of hydrogen.

Ans. $$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$$

$$\therefore \frac{1}{\lambda} = \frac{R}{4}$$

$$\lambda = \frac{4}{R}$$

$$\lambda = \frac{4}{10.97 \times 10^6} = 0.37 \times 10^{-6}$$

$$\lambda = 3700\, \mathring{A}$$

**Question 11**

(a) What is means by pair annihilation ? Write a balanced equation for the same.

**OR**

(b) What is meant by the terms half-life of a radioactive substance and binding energy of a nucleus ?

Ans. (a) When particle meets it anti particle, the two annihilate to form photon.

$$e^{-1} + e^{+1} \longrightarrow \text{Photon}(\text{EMW})$$

(b) Half-life period - It is time in which half of radio active substance disintegrate from its original value.

Binding energy is energy required to seperate Nucleons from nucleus.

**Question 12**

In a communication system, what is meant by modulation ? State any two types of modulation.

Ans. Superimposition of low frequency message signal on high frequency carrier wave called modulation.

1. Amplitude modulation (AM)
2. Frequency modulation (FM)

## Section C

***Answer all questions***

**Question 13**

Obtain an expression for intensity of electric field at a point in end on position, i.e., axial position of an electric dipole.

Ans. Consider an electric dipole consisting of charges $-q$ and $+q$ seperated by a small distance $2r$ in free space.

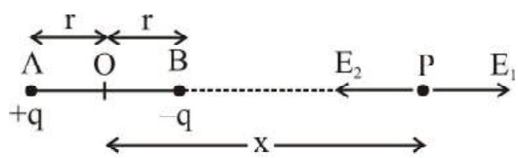
Let $P$ be a point on the axial line of the dipole at a distance $x$ from the centre $O$ of the dipole (i.e., $OP = x$)

Electric field intensity at point $P$ due to $+q$ charge,

$$E_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{AP^2} \quad \text{(direction } A \text{ to } P)$$

$$E_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(x+r)^2} \quad \text{(direction } A \text{ to } P) \quad ...(i)$$

Electric field intensity at point $P$ due to $-q$ charge,




$$E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{BP^2} \quad \text{(direction } P \text{ to } B)$$

$$E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(x-r)^2} \quad \text{(direction } P \text{ to } B) \quad ...(ii)$$

Since $E_2 > E_1$ and they act in opposite directions, resultant field intensity is given by :

$$E = E_2 - E_1 \quad \text{(direction } P \text{ to } B)$$

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(x-r)^2} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(x+r)^2}$$

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

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

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

$$= \frac{1}{4\pi\varepsilon_0} \cdot q \left[ \frac{2x \cdot 2r}{\left(x^2 - r^2\right)^2} \right]$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2xp}{\left(x^2 - r^2\right)^2} \quad [\because p = 2r \cdot q]$$

If the dipole is short (i.e., $r << x$) then $r^2$ may be neglected as compared to $x^2$.

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2p}{x^3}$$

The direction of resultant electric field $E$ is along the dipole axis i.e., from $-q$ charge to $+q$ charge.

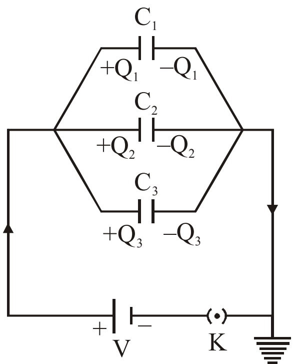
**Question 14**

Deduce an expression for equivalent capacitance C when three capacitors $C_1$, $C_2$ and $C_3$ connected in parallel.

Ans. Expression for effective capacitance in parallel grouping of capacitors :

Consider three capacitors of capacitance $C_1, C_2$ and $C_3$ are conncecred in parallel.

Let $Q_1, Q_2$ and $Q_3$ be the charges deposited on the capacitors as shown in the figure.




Suppose a potential difference '$V$' is applied across the combination. Then, the potential difference between the plates of each capacitors is $V$ but charges on each capacitors are different. Since different current flows through different branches, so the charges are given by

$Q_1 = C_1V, Q_2 = C_2V, Q_3 = C_3V$ ...(i)

From the principle of conservation of charge,

$Q = Q_1 + Q_2 + Q_3$

$Q = C_1V + C_2V + C_3V$ [From equation (i)]

$\therefore \; Q = V\left(C_1 + C_2 + C_3\right)$ ...(ii)

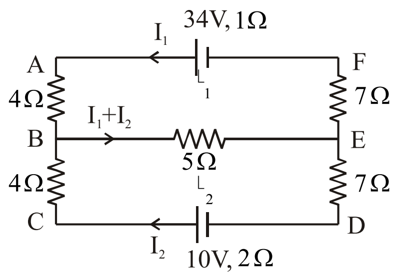
If these capacitors are replaced by a single capacitor of capacity $C_P$ such that $Q = C_PV$ then using equation (ii) we have,

$C_PV = V\left(C_1 + C_2 + C_3\right)$

$C_P = C_1 + C_2 + C_3$

**Question 15**

(a) $\varepsilon_1$ and $\varepsilon_2$ are two batteries having emf of 34V and 10V respectively and internal resistance of $1\Omega$ and $2\Omega$ respectively. They are connected as shown in figure below. Using Kirchhoff's Laws of electrical networks, calculate the currents $I_1$ and $I_2$.




(b) An electrical bulb is marked 200V, 100W. Calculate electrical resistance of its filament. If five such bulbs are connected in series to a 200V supply, how much current will flow through them ?

Ans.

(a) By Kirchoff's law of electrical networks consider closed loop ABEFA

$\therefore\ -4I_1 - 5(I_1 + I_2) - 7I_1 - I_1 + 34 = 0$

$\therefore\ -4I_1 - 5I_1 - 5I_2 - 7I_1 - I_1 = -34$

$\therefore\ -17I_1 - 5I_2 = -34$

$\therefore\ 17I_1 + 5I_2 = 34$ ...(1)

Consider closed loop BCDEB,

$4I_2 - 10 + 2I_2 + 7I_2 + 5(I_1 + I_2) = 0$

$\therefore\ 4I_2 + 2I_2 + 7I_2 + 5I_1 + 5I_2 = 10$

$18I_2 + 5I_1 = 10$ ...(2)

Mutiply equation (1) by 5 and equation (2) by 17 and Substract

$$\begin{array}{r} 65I_1 + 25I_2 = 170 \\ -65I_1 + 306I_2 = 170 \\ \hline 331I_2 = 0 \end{array} \quad \Rightarrow I_2 = 0$$

$\therefore\ I_1 = 2A$

(b) Voltage $V = 200\ V$, Power $P = 100\ W$

$\therefore$ Electrical current $= \dfrac{P}{V} = \dfrac{100}{200} = \dfrac{1}{2} Amp$

$\therefore$ Electrical resistance $R = \dfrac{V}{I} = \dfrac{200}{1/2} = 400\Omega$

if five bulbs are connected in series to $200V$

$\therefore$ Total resistance $R_T = 400 + 400 + 400 + 400 + 400 = 2000\Omega$

Current flowing thorugh a bulb $I = \dfrac{200}{2000} = 0.1A$

**Question 16**

(a) For any prism, prove that :

$$'n' \text{ or } \mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where the terms have their usual meaning.

(b) When two thin lenses are kept in contact, prove that their combined or effective focal length F is given by :

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

where the terms have their usual meaning.

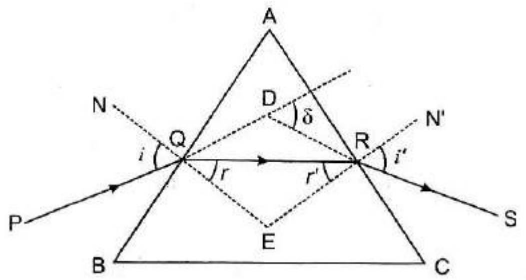
Ans.

(a) In the figure, a ray of light *PQ* is incident at an angle *i* on the face *AB* of prism *ABC*. This ray is refracted along *QR* at an angle *r*. This reflected ray is incident on the face AC at an angle $r'$ and emerges along RS at an angle $i'$.

In $\Delta QDR$,

$\delta = (i-r) + (i'+r')$

$= (i+i') - (r+r')$ ...(i)




In Quad. *AQER*, $A + E = 180°$ ...(ii)

In $\Delta QER$ $r + r' + E = 180°$ ...(iii)

$\therefore$ $r + r' = A$ [From eq. (ii) and (iii)]

Putting value of $r + r'$ in equation (i),

$\delta = i + i' - A$

In the position of minimum deviation condition,

$i = i',\ r = r',\ \delta = \delta_{m'}$

So $r + r' = A$

$2r = A$

or $r = \frac{A}{2}$

$\delta_m = 2i - A$

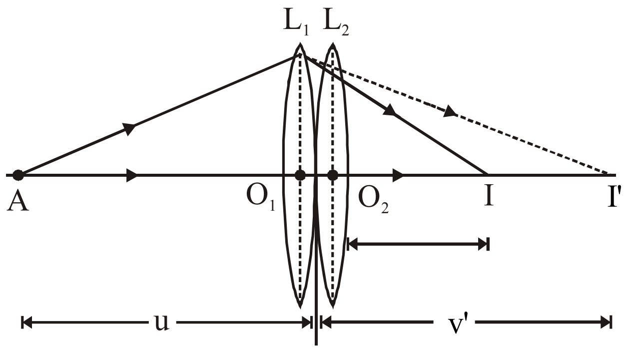
$i = \frac{A+\delta_m}{2}$

Putting value of $i$ and $r$ from (v), (vi), in Snell's law,

$$n = \frac{\sin i}{\sin r}$$

$$n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

(b)




(i) Image is formed in two steps :

In the first step, the lens $L_1$ produces image $I'$ of the object $A$. It is a real image at a distance $v'$ from $L_1$.

Then for the lens $L_1$, we have,

$$\frac{1}{v'} + \frac{1}{-u} = \frac{1}{f_1}$$

$$\therefore \quad \frac{1}{v'} - \frac{1}{u} = \frac{1}{f_1} \qquad ...(1)$$

(ii) In the second step, the image $I'$ acts as an object for $L_2$ and the final image $I$ is formed. The image $I'$ is not observed, hence it acts a virtual object for lens $L_2$ it is assumed to be kept on left, we can write for $L_2$.

$$\frac{1}{v} + \frac{1}{-v'} = \frac{1}{f_2}$$

$$\therefore \quad \frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2} \qquad ...(2)$$

(iii) Adding equtions (1) and (2), we get

$$\frac{1}{v'} - \frac{1}{u} + \frac{1}{v} - \frac{1}{v'} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\therefore \quad \frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2} \qquad ...(3)$$

(iv) If a single lens of focal length $f$ of equivalent lens is used for object A and corresponding image I is formed then we have,

$$\frac{1}{v} + \frac{1}{-u} = \frac{1}{f} \qquad ...(4)$$

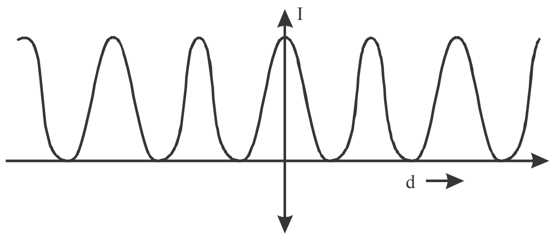
(v) From equations (3) and (4),

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \qquad ...(5)$$

**Question 17**

(i) In **Young's** double slit experiment, show graphically how intensity of light varies with distance.

Sol.




I - Intensity

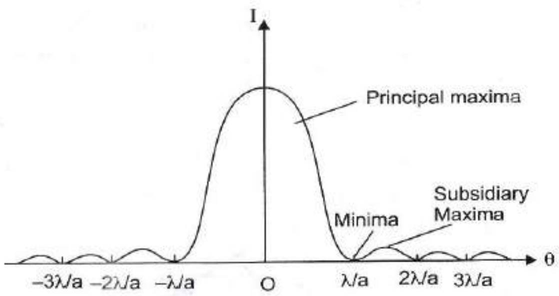
d - Distance

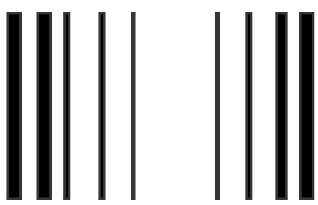
The above graph shows the intensity verses distance. The intensity of light does not vary with the distance.

(ii) In Fraunhofer diffraction, how is the angular width of the central bright fringe affected when slit sepration is increased?

Sol. In Fraunhofer diffraction at a single slit, we obtain a central bright band,having on both sides narrower alternately dark and bright bands of decreasing intenstiy.

Finer the slit, broader is the diffraction pattern and wider is the central band as shown in the given figure.



**Question 18**

Write one balanced equation each to show :

(i) Nuclear fission

(iii) Nuclear fusion

(iii) Emission of $\beta$- (i.e. a negative beta particle)

Sol.

(i) **Nuclear Fission :**

When a slow neutron strikes ${}_{92}U^{235}$ nucleus, it is absorbed by the nucleus and an isotope $U^{236}$ is formed. But $U^{236}$, being highly unstable, is immediately broken into two fragments and emits neutrons and energy. This fission can be represented by the following equation :

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236} \rightarrow {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3\,{}_0n^1 + \text{energy}$$

(ii) Nuclear fusion :

The fusion of two nuclei of heavy hydrogen or deuterium (${}_1H^2$), the following is possible

$$_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + {}_1H^1 + 4.0\text{ MeV}$$

(iii) Emission of $\beta^-$ (i.e. a negative beta particle) :

When an energetic $\gamma - \text{ray}$ photon falls on heavy substance, it is absorbed by some nucleus of the substance, and its energy give rise to the production of an electron and a position. This phenomenon in which energy is converted into mass is called pair production.

Equation :

$$\underset{(\gamma - \text{Photo})}{\gamma} = \underset{(\text{Electron})}{{}_{-1}\beta^0} + \underset{(\text{Positron})}{{}_1\beta^0}$$

## Question 19

With reference to semi conductor devices, define a p - type semiconductor and a Zener diode. What is the use of Zener diode ?

Sol. When a trivalent impurity like aluminium, indium, boron, gallium, etc., is doped with pure germanium (or silicon) , then the conductivity of the crystal increases due ot deficiency of electrons i.e., holes and such a crystal is said to be p- type semiconductor while the impurity atoms are called acceptors.

A Zener diode is a reverse biased heavily doped p - n junction diode, which is operated in break-down region, where the current is limited by both external resistance and power dissipitation of the diode.

Zener diode is used to stabilize voltage in circuit.

## Section D
## Answer all questions

## Question 20

(a) An alternating emf of 220 V is applied to a circuit containig a resistor R having resistance of $160\Omega$ and a capacitor 'C' is series. The current is found to lead the supply voltage by an angle $\theta = \tan^{-1}(3\backslash 4)$ .

(i) Calculate :
- (1) The capacitive reactance
- (2) Impedance of the circuit
- (3) Current flowing in the circuit

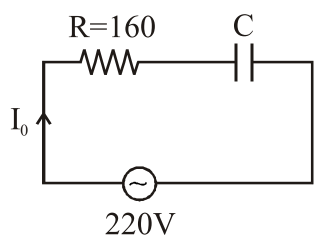
(ii) If the frequency of the applied emf is 50 Hz, what is the value of the capacitance of the capacitor 'C'?

Ans.

(a) $E = 220\ V, R = 160, C =$ Capacitor

Current leads voltage by $\phi = \tan^{-1}\left(\frac{3}{4}\right)$

Find : $X_C, Z, I$




(i) Given $\theta = \tan^{-1}\left(\frac{3}{4}\right)$ ...(1)

but $\theta = \tan^{-1}\left(\frac{X_C}{R}\right)$ ...(2)

From (1) and (2)

$\tan\theta = \frac{3}{4}$

but $\tan\theta = \frac{X_C}{R}$

$\therefore \frac{3}{4} = \frac{X_C}{R}$

$\because R = 160$

$\therefore \frac{3}{4} = \frac{X_C}{160}$

$\therefore X_C = \frac{3}{4} \times 160$

$X_C = 3 \times 40$

$X_C = 120\Omega$

Impedance $Z = \sqrt{R^2 + X_{C^2}}$

$= \left[(160)^2 + (120)^2\right]^{1/2}$

$Z = 200\Omega$

$I_0 = \frac{V}{Z} = \frac{220}{200} = 1.1A \Rightarrow I_0 = 1.1A$

(ii) $f = 50\,Hz$

$X_C = 120\Omega$

$X_C = \frac{1}{2\pi fC}$

$\therefore C = \frac{1}{(2\pi f) \times (X_C)} = \frac{1}{2\pi \times 50 \times 120} = 2.65 \times 10^{-5} F = 26.5\,\mu F$

$C = 26.5\,\mu F$

OR

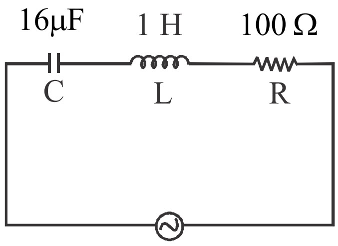
(b) An A.C. generator generating an emf of $\varepsilon = 300 \sin(100\,\pi t)$ V is connected to a series combination of $16\mu F$ capacitor, 1 H inductor and 100 $\Omega$ resistor.
Calculate :
(i) Impedence of the circuit at the given frequency.
(ii) Resonant frequency $f_0$.
(iii) Power factor at resonant frequency $f_0$.

Sol. $E = 300\sin(100\,\pi t)$

$C = \text{capacitor} = 16\mu F$

$L = \text{Inductar} = 1H$

$R = 100\,\Omega$




$E = 300\sin(100\,\pi t)$

From $E = 300\sin(100\,\pi t)$

$\omega = 100\,\pi$

$2\pi f = 100\,\pi$

$\therefore\ f = 50$ Hz

$$\therefore\ X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 16 \times 10^{-6}} = \frac{1}{5026.5 \times 10^{-6}} = 1.98 \times 10^{-4} \times 10^{6}$$

$\therefore\ X_C = 198\,\Omega$

$X_L = 2\pi f L = 2\pi \times 50 \times 1 = 314.1\,\Omega$

(i) Impedence of the circuit (Z)

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

$$= \left[(100)^2 + (314 - 198)^2\right]^{1/2}$$

$$= 153.15\Omega$$

(ii) Resonant frequency ($f_0$)

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$=\frac{1}{2\pi\sqrt{1\times16\times10^{-6}}}$$

$$=39.84\text{Hz}$$

(iii) at Resonance $X_C = X_L$

$$\therefore \quad Z = R$$

$$\cos\phi = \frac{R}{Z}$$

$$\cos\phi = \frac{R}{R}$$

$$\cos\phi = 1$$

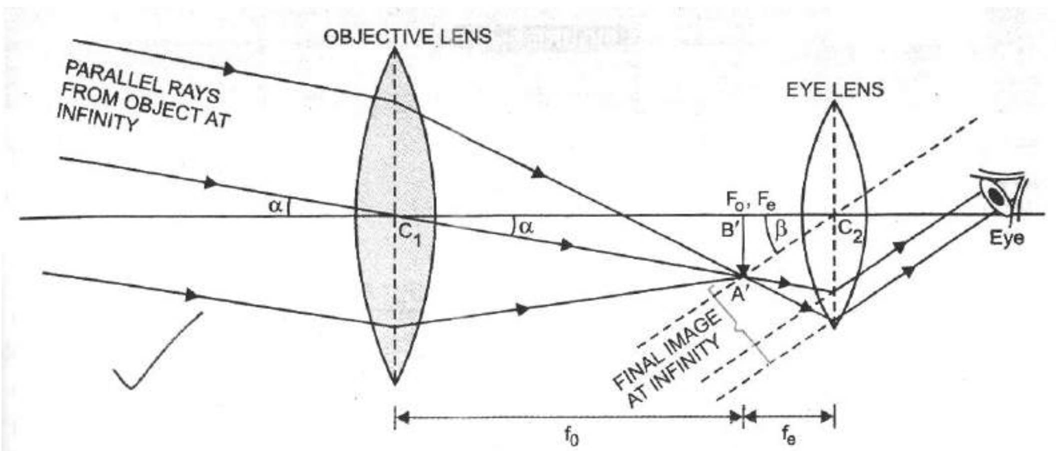
power factor $(\cos\phi) = 1$

Question 21

(a) Draw a labelled ray diagram of an image formed by a **refracting telescope** with final image formed at **inifity**. Derive an expression for its magnifying power with the final image at infinity.

Sol.

(a)




As the object lies at very huge distance, therefore, angle subtended by the object at $C_2$ (where eye is held) is almost the same as the angle subtended by the object at $C_1$ (because $C_1$ is close to $C_2$). Let it be $\alpha$, i.e. $\angle A'C_1B' = \alpha$. Rays coming from the final image at infinity make $\angle A'C_2B' = \beta$ on they eye. Therefore, by definition,

Magnifying power, $m = \frac{\beta}{\alpha}$ .....(1)

As angles $\alpha$ and $\beta$ are small, therefore, $\alpha = \tan\alpha$ and $\beta = \tan\beta$.

From (1), $m = \dfrac{\tan\beta}{\tan\alpha}$ ......(2)

In $\Delta A'B'C_2$, $\tan\beta = \dfrac{A'B'}{C_2B'}$

In $\Delta A'B'C_1$, $\tan\alpha = \dfrac{A'B'}{C_1B'}$

Putin (2), $m = \dfrac{A'B'}{C_2B'} \times \dfrac{C_1B'}{A'B'} = \dfrac{C_1B'}{C_2B'}$ or $m = \dfrac{f_0}{-f_e}$ ....(3)

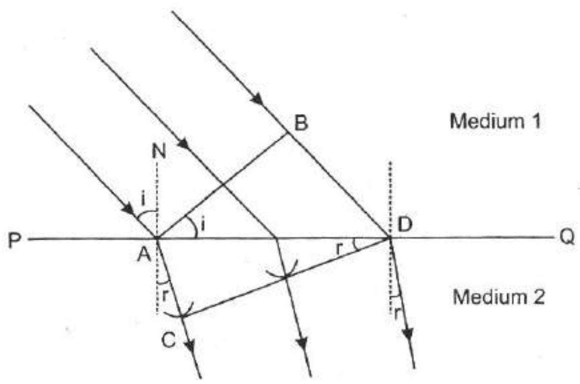
where $C_1B' = f_0 =$ focal length of objective lens, $C_2B' = -f_e =$ focal length of eye lens.
Negative sign of $m$ indicates the final image is inverted w.r.t. the object.

OR

(b) (i) Using **Huygen's** wave theory, derive **Snell's** law of refraction.
(ii) With the help of an experiment, state how will you identify whether a given beam of light is polarised or unpolarised.

Sol. (i)

**Laws of Refraction :** Consider a plane wave front AB inciden on a surface PQ separating two media (1) and (2). The media (1) is rarer, having refractive index $n_1$, in which the light travels with a velocity $c_1$. The medium (2) is denser, having refractive index $n_2$, in which the light travels with a velocity $c_2$.




At time t = 0, the incident wave front AB touches the boundary separating two medium at A.The secondary wavelets from point B advance forward with a velocity $c_1$, and after time t seconds touches at D, thus covering a distance $BD = c_1t$. In the same time interval of t seconds, the secondary wavelets from A, advance forward in the second an envelope is drawn to obtain a new refracted wave front as CD.

Consider triangle BAD and ACD,

$$\sin i = \sin(\angle BAD) = \frac{BD}{AD} = \frac{c_1t}{AD}$$

$$\sin r = \sin(\angle ADC) = \frac{AC}{AD} = \frac{c_2t}{AD}$$

$$\Rightarrow \quad \frac{\sin i}{\sin r} = \frac{c_1 t}{c_2 t} = \frac{c_1}{c_2}$$

$$\Rightarrow \quad \frac{\sin i}{\sin r} = \frac{c_1}{c_2} = \text{constant}$$

This constant is called the refractive index of the second medium with respect to the first medium.

$$\frac{c_1}{c_2} = \frac{n_2}{n_1}$$

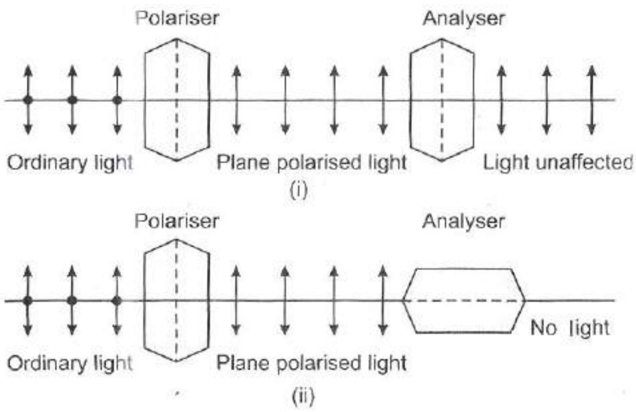
$$\therefore \quad \frac{\sin i}{\sin r} = \frac{c_1}{c_2} = \frac{n_2}{n_1} = {}_1 n_2$$

This is known as the Snell's law.

(ii)

Detection of plane polarised light : Naked eyes or the polariser alone cannot make distinction between unpolarised light and plane polarised light. To analyse the nature of light, another crystal (analyser) is used. The tourmaline crystal is used to produce plane polarised light.

If the polariseris rotated in the path of the ordinary light, the intensity of the light transmitted from the polariser remains unchanged. It is because, in each orientation of the polariser, the plane polarised light is obtained, which has vibrations in a direction parallel ot the axis of the crystal in that orientation. If the analyser is rotated in the path of the light transmitted from the polariser,so that the axis of the polariser and the analyser are parallel to each other, than the intensity of light is found to remain unaffected [see figure]
If the axis of the polariser and the anlyser are perpendicular to each other as shown in figure, then the intensity of light becomes minimum.
In this position the polariser and the analyser are said to be in crossed position.



Question 22

(a) (i) The forward characteristic curve of a junction diode is shown in Figure 4 below :

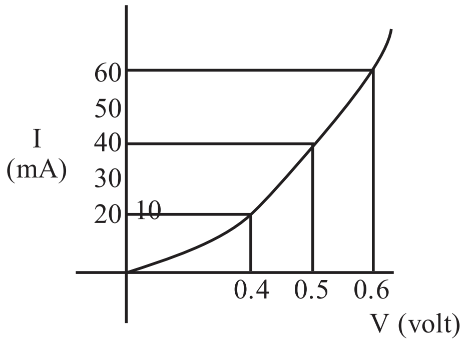



Figure 4

Calculate the resistance of the diode at :

(1) V = 0.5 V

(2) I = 60 mA

(ii) Draw separate energy band diagram for conductors, semi-conductors and insulators and label each of them.

Sol. (a)

Resistance of Diode

(i) $V = 0.5V$

At $V = 0.5V, \quad I = 40 \text{ mA}$

We know that $V = IR$

$$\therefore \quad R = \frac{V}{I} = \frac{0.5}{40 \times 10^{-3}} = 12.5\,\Omega$$

$\because \quad I = 60 \text{ mA}$

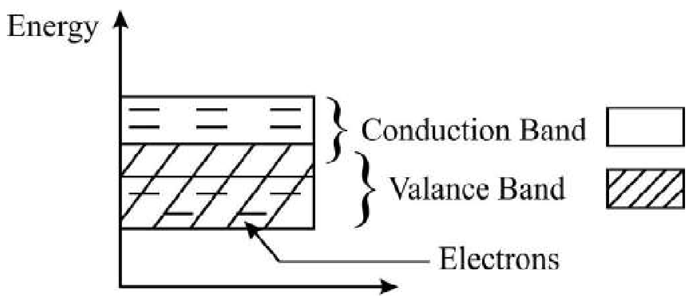
we get $V = 0.6$

$$\therefore \quad R = \frac{V}{I} = \frac{0.6}{60 \times 10^{-3}} = 10\,\Omega$$

(ii) Energy Band Diagrams : -

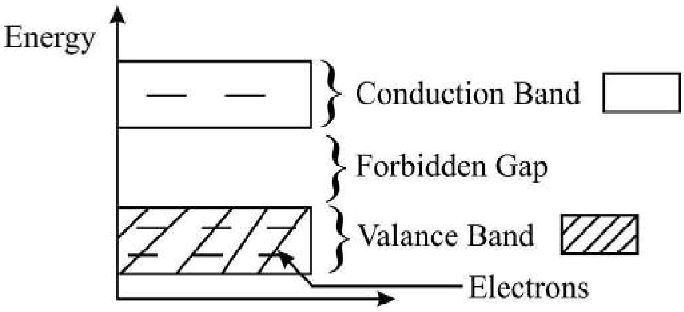
Conductors

Here conduction Band and valance Band are partly overlapped.

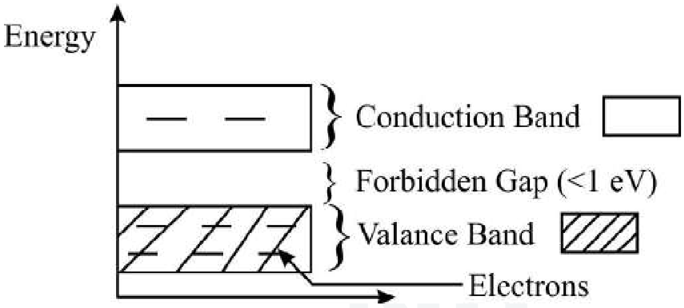



Insulators

Here forbidden gap is large between conduction Band and Valance Band.

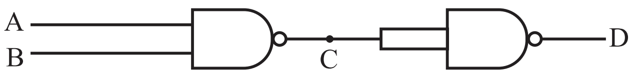



Semiconductors
Here forbidden gap is less than 1 eV




OR

(b) (i) The arrangement give below represents a logic gate :




Copy the following truth table in your answer booklet and complete it showing outputs at C and D.

| A | B | C | D |
|---|---|---|---|
| 0 | 0 | | |
| 1 | 0 | | |
| 0 | 1 | | |
| 1 | 1 | | |

(ii) Draw a labelled diagram of a common **emitter amplifier**, showing waveforms of signal voltage and output voltage.

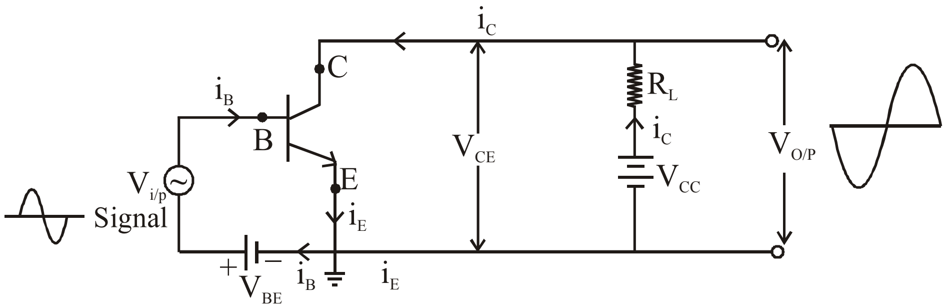
Sol. (b)
(i)

| *A* | *B* | *C* | *D* |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 |

(ii)

Common Emitter Amplifier

Common emitter Amplifier using n-p-n transistor as below.




**Useful Constants and Relations :**

1. Permeability of vacuum $(\mu_0)$ $= 4\pi \times 10^{-7} H\ m^{-1}$
2. Rydberg's constant $(R)$ $= 1.097 \times 10^{7} m^{-1}$