②

Solutions

1. Frequency of emitted photon is given by

$$\nu = cR\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\Rightarrow \quad \nu = cR\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$ [1/2]

$$\Rightarrow \quad \nu = cR\left(\frac{5}{36}\right) = \frac{5cR}{36}$$ [1/2]

Or

Wavelength obtained in hydrogen spectrum can be given as

$$\frac{1}{\lambda} = R\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) \quad \dots(\text{i})$$

For λ to be shortest, $\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ should be minimum. [1/2]

So, $n_f = \infty, n_i = 1$

Now, from Eq. (i)

$$\frac{1}{\lambda} = R\left(\frac{1}{1}\right) = R$$

$$\Rightarrow \quad \lambda = \frac{1}{R} = \frac{1}{10^7}\,\text{m} = 1000\text{Å}$$ [1/2]

2. We have,

$$B = 2\times10^{-7}\sin(0.5\times10^3 x + 1.5\times10^{11} t)$$

Comparing with standard equation,

$$B = B_0\sin(kx + \omega t), \text{ we get}$$

$$k = 0.5\times10^3\ \text{rad m}^{-1}$$

$$\Rightarrow \quad \lambda = \frac{2\pi}{k} = \frac{2\pi}{0.5\times10^3} = 0.01256\,\text{m}$$ [1/2]

This wavelength lies in the range of microwave of 10^{-3}m to 0.1 m. Hence, equation represents microwave. [1/2]

3. Flux through the entire cube,

using Gauss's law, $\phi = \frac{q_0}{\varepsilon_0}$ [1/2]

∴ Flux through any one face $= \frac{1}{6}\left(\frac{q_0}{\varepsilon_0}\right) = \frac{q_0}{6\varepsilon_0}$

Thus, flux through two faces $= 2\left(\frac{q_0}{6\varepsilon_0}\right) = \frac{q_0}{3\varepsilon_0}$ [1/2]

4. Given, $m_1 = 2m_2$

$$\Rightarrow \quad \frac{f}{f - 0.15} = 2\left(\frac{f}{f - 0.10}\right) \qquad \left[\because m = \frac{f}{f+u}\right]$$ [1/2]

$$\Rightarrow \quad f - 0.10 = 2f - 0.30$$

$$0.20 = f$$

or $f = 0.20\,\text{m}$ [1/2]

5. Given, $H_E = 0.26\,\text{G}$

and $B_E = 0.52\,\text{G}$

As, $H_E = B_E\cos\delta$

$$\Rightarrow \quad \cos\delta = \frac{H_E}{B_E} = \frac{0.26}{0.52} = \frac{1}{2}$$ [1/2]

$$\Rightarrow \quad \delta = \cos^{-1}\left(\frac{1}{2}\right) = 60^\circ$$ [1/2]

Or

$$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0\times35}{2\pi\times(0.20)}$$

$$= \frac{2\times10^{-7}\times35\times10^2}{20}$$

$$= 3.5\times10^{-5}$$ [1]

6. The basic cause of quantisation of charge is that only integral number of electron can be transferred from one body to another, i.e. $q = \pm ne$. [1]

Or

$$V = \frac{kq}{r} \Rightarrow V \propto \frac{1}{r}$$

$$\frac{V_{20}}{V_5}=\frac{5}{20}$$

$$\Rightarrow \quad \frac{15}{V_5}=\frac{5}{20} \qquad [1/2]$$

$$\Rightarrow \quad V_5=\frac{20\times15}{5}=60\text{ V}$$

Now potential inside the hollow sphere = potential at the surface = 60 V [1/2]

7. On adding a pentavalent impurity an additional energy level called the donor level is added between valence and conduction band. Thus, the energy gap between the two bands decreases on adding pentavalent impurity. [1]

8. In photoelectric effect, we can observe that most electrons get scattered into the metal by absorbing a photon. Thus, all the electrons that absorb a photon does not come out as photoelectron. Only a few come out of metal whose energy becomes greater than the work function of metal. [1]

9. In situation (i), there is no change in the magnetic flux linked with the loop PQR. So, emf is not induced. [1/2]

In situation (ii), the loop is moving out of the magnetic field. So, the magnetic flux linked with the loop decreases. Hence, there is an induced emf. [1/2]

10. Radius of orbit is given by $r_n \propto n^2$

where, r_n = radius of nth orbit and
n = principal quantum number. [1/2]

For ground state, $n=1$
For second excited state, $n=3$

$$\Rightarrow \quad \frac{r_3}{r_1}=\left(\frac{3}{1}\right)^2=9$$

$$\Rightarrow \quad r_3=9r_1=9\times5.1\times10^{-11}$$

$$=4.59\times10^{-10}\text{ m} \qquad [1/2]$$

Or

Radius of the nucleus, $R=R_0A^{1/3}$

where, A = mass number.

$$\Rightarrow \quad \frac{R_1}{R_2}=\left(\frac{A_1}{A_2}\right)^{1/3} \qquad [1/2]$$

$$\Rightarrow \quad \frac{R_1}{R_2}=\left(\frac{3}{81}\right)^{1/3}=\frac{1}{3} \qquad [1/2]$$

11. (a) Manganin and constantan have very low temperature coefficient of resistance. So, their resistance values change very little with temperature.

This is the reason, they are widely used in standard resistors.

Therefore, A and R are true and R is the correct explanation of A. [1]

12. (a) In an atom, electron revolves around nucleus, for this required centripetal force is provided by electrostatic force of attraction between negatively charged electron and positive nucleus.

If the electrons were stationary, then the electrostatic force will remain unbalanced, which leads to the electron to fall into the nucleus.

Therefore, A and R are true and R is the correct explanation of A. [1]

13. (a) It is known experimentally that neutrons/thermal neutrons are much likely to cause fission in $^{235}_{92}$U than fast neutrons.

Because, fast neutrons liberated in fission can escape nuclear reactor instead of causing fission reaction.

Therefore, A and R are true and R is the correct explanation of A. [1]

14. (a) According to Bohr atomic model, in an isolated atom the energy of any of its electrons is decided by the orbit in which it revolves. But when the atoms come together to form a solid they are close to each other. So, the outer orbits of electrons from neighbouring atoms would come very close or could even overlap.

This would make the nature of electrons motion in a solid very different from that in an isolated atom.

Therefore, A and R are true and R is the correct explanation of A. [1]

15. (i) (a) When source moves away from the observer, frequency observed is smaller than that emitted from the source and (as if light emitted is yellow but it will be observed as red) this shift is called red shift. [1]

(ii) (d) The important applications of Doppler's effect are as given below
  (a) Measuring the speed of stars and galaxies.
  (b) Measuring speed of rotation of the sun.
  (c) Estimation of velocity of aeroplanes, rockets and submarines, etc. [1]

(iii) (b) The fractional change in frequency is given by

$$\frac{\Delta\nu}{\nu}=-\frac{v_{\text{radial}}}{c} \qquad [1]$$

(iv) (c) Doppler's shift is given by

$$\frac{\Delta\nu}{\nu}=\frac{v_{\text{radial}}}{c} \Rightarrow \frac{\Delta\nu}{\nu}=\frac{3\times10^3}{3\times10^8}=10^{-5} \qquad [1]$$

(v) (a) Here, $\lambda=400$ nm

$$\Delta\lambda=400.1\text{ nm}-400\text{ nm}=0.1\text{ nm}$$

as $$\frac{v_s}{c}=\frac{\Delta\lambda}{\lambda}$$

$$v_s=\frac{\Delta\lambda}{\lambda}c=\frac{0.1\text{ nm}}{400\text{nm}}\times3\times10^8\text{ms}^{-1}$$

$$=75\times10^3\text{ms}^{-1}$$

$$=75\text{ kms}^{-1} \qquad [1]$$

16. (i) (c) One method to induce an emf or current in a loop is through a change in the loop's orientation or a change in its effective area.

As the coil rotates in a magnetic field **B**, the effective area of the loop (the face perpendicular to the field) is $A\cos\theta$, where θ is the angle between **A** and **B**. [1]

(ii) (c) When the coil is rotated with a constant angular speed ω, the angle θ between the magnetic field vector **B** and the area vector **A** of the coil at any instant t is $\theta = \omega t$ (assuming $\theta = 0°$ at $t = 0$). [1]

(iii) (a) $\frac{d\phi_B}{dt} = -NBA\omega \sin \omega t$, change of flux is greatest for $\omega t = \theta = 90°, 270°$, $\theta = 90°, 270°$. [1]

(iv) (b) When the coil passes through its vertical position, its side is moving parallel to the magnetic flux between the magnetic poles, so no change of flux occurs. Hence, no emf is induced in it and output voltage is zero, i.e. at point Q. [1]

(v) (c) Given, $N = 1000, A = 100\text{ cm}^2 = 10^{-2}\text{m}^2$,

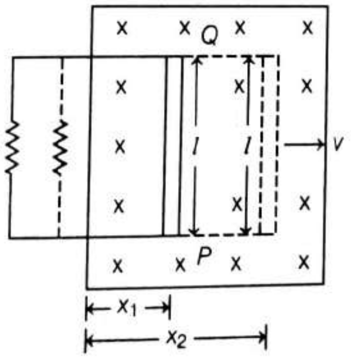
$$\nu = 100 \text{ rpm} = \frac{100}{60}\text{rps}$$

and $B = 3.6 \times 10^{-2}\text{ T}$

$\therefore$ Maximum emf produced in the coil is

$$e_0 = NBA\,\omega = NBA\,(2\pi\nu)$$
$$= 1000 \times 3.6 \times 10^{-2} \times 10^{-2} \times 2 \times \frac{22}{7} \times \frac{100}{60}$$
$$= 3.77\text{ V}$$ [1]

17. Let the lengths of horizontal arms of circuit be x_1 and x_2 at instants, t_1 and t_2, respectively.



[1]

$\therefore$ Area of loop inside the magnetic field,

$$A_1 = lx_1, A_2 = lx_2$$

$\Rightarrow$ $$\Delta A = A_2 - A_1 = l(x_2 - x_1) = l\Delta x \quad \text{...(i)}$$

As, $$\Delta\phi = B\Delta A = Bl\Delta x \quad \text{...(ii)}$$

From Eqs. (i) and (ii), we get

$$\frac{\Delta\phi}{\Delta t} = Bl\frac{\Delta x}{\Delta t} = Blv$$

By Faraday's law of induced emf (in magnitude),

$$e = \frac{\Delta\phi}{\Delta t} = vBl$$

$\therefore$ $$e = vBl$$ [1]

Or

(i) Impedance of series L-C-R circuit is given by

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

For the impedance, Z to be minimum

$$X_L = X_C$$ [1]

(ii) Given, $C = 0.0014 \times 200 = 2.8\mu\text{F} = 2.8 \times 10^{-6}\text{F}$

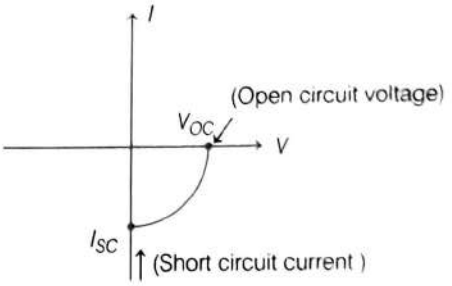
$$f = 5\text{ kHz} = 5 \times 10^3\text{ Hz}$$

Z is minimum when $X_L = X_C$.

or $$2\pi fL = \frac{1}{2\pi fC}$$

$\therefore$ $$L = \frac{1}{4\pi^2 f^2 C}$$
$$= \frac{1}{4 \times 10 \times (5 \times 10^3)^2 \times 2.8 \times 10^{-6}}$$
$$= 0.357 \times 10^{-3}\text{ H} = 0.357\text{ mH}$$ [1]

18. (i) The I-V characteristics of solar cell is



[1]

(ii) (a) Suitable band gap (1 to 1.8 eV) [1/2]

(b) High optical absorption [1/2]

19. (i) This is because of the fact that the mass of a nucleus is slightly less than the mass of the constituents nucleus. This decrease in mass is called mass defect.

Since, the mass defect in case of $^{16}_{8}\text{O}$ is not exactly twice of the mass defect in case of $^{8}_{4}\text{Be}$, thus the ratio of the atomic masses is not exactly 2. [1½]

(ii) Ordinary water under high pressure is used as coolant. [1/2]

Or

Given, radius of orbit, $r = 1.5 \times 10^{11}\text{ m}$

Orbital speed, $v = 3 \times 10^4\text{ m/s}$

Mass of earth, $M = 6 \times 10^{24}\text{ kg}$

Angular momentum, $Mvr = \frac{nh}{2\pi}$ or $n = \frac{2\pi vrM}{h}$ [1]

[where, n is the quantum number of the orbit]

$\Rightarrow$ $$n = \frac{2 \times 3.14 \times 3 \times 10^4 \times 1.5 \times 10^{11} \times 6 \times 10^{24}}{6.63 \times 10^{-34}}$$
$$= 2.57 \times 10^{74} \text{ or } n = 2.6 \times 10^{74}$$

Thus, the quantum number that characterises the earth's revolution is 2.6×10^{74} which is too large. [1]

20. We know that, $B_H = B_E \cos\delta$ ...(i)

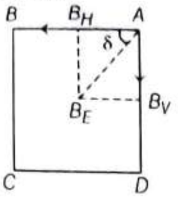
and $B_V = B_E \sin\delta$ ...(ii)

Here, B_E = earth's magnetic field,

B_H = horizontal component of magnetic field,

B_V = vertical component of magnetic field

and δ = angle of dip.



(i) Squaring Eqs. (i) and (ii) and then adding, we get

$$B_H^2 + B_V^2 = B_E^2 \text{ or } B_E = \sqrt{B_H^2 + B_V^2}$$ [1]

(ii) Dividing Eq. (ii) by Eq. (i), we get

$$\frac{B_V}{B_H} = \tan\delta \quad \text{or } B_V = B_H \cdot \tan\delta$$ [1]

Or

Given, $R_1 = 10\,\Omega$, $N_1 = 30$, $A_1 = 3.6 \times 10^{-3}\text{m}^2$, $B_1 = 0.25\,\text{T}$

$R_2 = 14\,\Omega$, $N_2 = 42$, $A_2 = 1.8 \times 10^{-3}\text{m}^2$, $B_2 = 0.50\,\text{T}$

$k_1 = k_2$ (spring constants are same)

(a) Using the formula of current sensitivity,

$$I = \frac{NAB}{k}$$

$$\therefore \quad \frac{I_{S_2}}{I_{S_1}} = \frac{N_2 B_2 A_2 k_1}{N_1 B_1 A_1 k_2}$$

$$= \frac{42 \times 0.50 \times 1.8 \times 10^{-3}}{30 \times 0.25 \times 3.6 \times 10^{-3}} = 1.4$$ [1]

(b) Using the formula of voltage sensitivity,

$$V = \frac{NAB}{kR}$$

$$\therefore \quad \frac{V_{S_2}}{V_{S_1}} = \frac{N_2 B_2 A_2 k_1 R_1}{k_2 . R_2 N_1 B_1 A_1}$$

$$= \frac{42 \times 0.50 \times 1.8 \times 10^{-3} \times k \times 10}{k \times 14 \times 30 \times 0.25 \times 3.6 \times 10^{-3}} = 1$$ [1]

21. Effective emf in the circuit, $E = E_2 - E_1$

The net capacitance in the circuit, $C = \frac{C_1 C_2}{C_1 + C_2}$

Charge on each capacitor, $q = C \cdot E = \frac{C_1 C_2}{C_1 + C_2}(E_2 - E_1)$ [1]

The potential difference across the plates of C_1,

$$V = \frac{q}{C_1} = \frac{C_1 C_2}{(C_1 + C_2)} \frac{(E_2 - E_1)}{C_1}$$

$$= \frac{C_2 (E_2 - E_1)}{(C_1 + C_2)}$$ [1]

22. (i) The tunning a radio set to a particular station is based on resonance of series *L-C-R* circuit. [1/2]

(ii) The resonant frequency, $\omega = \frac{1}{\sqrt{LC}}$

$\omega = 2\pi\nu$ (where, ν = frequency)

$$\Rightarrow \quad \nu = \frac{1}{2\pi\sqrt{LC}}$$

$$\Rightarrow \quad C = \frac{1}{4\pi^2 \nu^2 L}$$

Substituting values of $\nu = 800\,\text{kHz} = 800 \times 10^3\,\text{Hz}$

and $L = 200\,\mu\text{H} = 200 \times 10^{-6}\,\text{H}$

we get, $C = \frac{1}{4 \times (3.14)^2 \times (800 \times 10^3)^2 \times 200 \times 10^{-6}}$

$C = 197.8\,\text{pF}$ [1

23. Energy of the electron in *n*th orbit is given by

$$E_n = \frac{2\pi^2 m k^2 e^4}{h^2} \cdot \frac{Z^2}{n^2}$$

i.e. $E_n \propto \frac{Z^2}{n^2}$

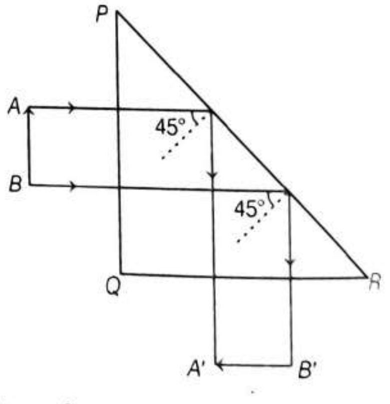
Let, $E_n(\text{Li}^{2+}) = E_1(\text{H})$

$$\therefore \quad \left[\frac{Z^2}{n^2}\right]_{\text{Li}^{2+}} = \left[\frac{Z^2}{n^2}\right]_{\text{H}}$$

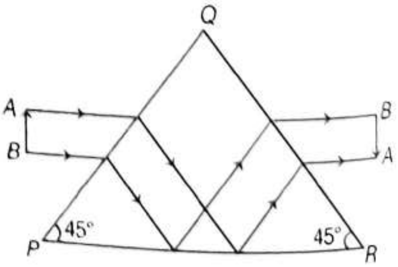
or $\frac{3^2}{n^2} = \frac{1^2}{1^2}$

or $n = 3$

24. (i) **The deviation of a ray through 90°**



(ii) **The inversion of image without any deviation**



25. They travel with speed of light, i.e. 3×10^8 m/s in vacuum.

Given, $E_0 = 200\,\text{N/C}$ and

frequency, $\nu = 50\,\text{MHz} = 50 \times 10^6\,\text{Hz}$

We know that, $\omega = 2\pi\nu$

$$\Rightarrow \quad \omega = 2 \times \frac{22}{7} \times 50 \times 10^6 = 314 \times 10^8 \text{ rad/s}$$

Also, $k = \frac{2\pi}{\lambda} = \frac{2\pi \times \nu}{c}$ [1]

$$= \frac{2\pi \times 50 \times 10^6}{3 \times 10^8} = 1.05 \text{ radm}^{-1}$$

$$B_0 = \frac{E_0}{c} = \frac{200}{3 \times 10^8} = 6.67 \times 10^{-7} \text{ T}$$

[1]

26. (i) Let ϕ_0 be the work function of the metal. E_1 and E_2 be the kinetic energies of photoelectrons corresponding to frequencies ν and 2ν of the incident radiation. [1]

Using Einstein's photoelectric equation, we have

$$h\nu = E_1 + \phi_0 \quad \dots \text{(i)}$$

and $$2h\nu = E_2 + \phi_0 \quad \dots \text{(ii)}$$

On dividing Eqs. (i) and (ii), we get

$$2 = \frac{E_2 + \phi_0}{E_1 + \phi_0}$$

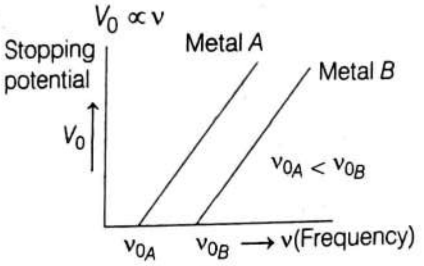
or $2E_1 + 2\phi_0 = E_2 + \phi_0$ or $E_2 = 2E_1 + \phi_0$

Thus, kinetic energy of photoelectrons is increased more than double when the frequency of incident radiation is doubled. [1]

(ii) The stopping potential is given as

$$V_0 = \frac{h\nu}{e} - \frac{\phi}{e}$$

$$\Rightarrow \quad V_0 \propto \nu$$



[1]

Or

(a) Given, $P = 10 \text{ kW} = 10 \times 10^3 \text{ W}$

Wavelength of radiowaves, $\lambda = 500$ m

Energy of each photon,

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{500}$$

$$E = 3.978 \times 10^{-28} \text{ J}$$

The number of photons emitted per second $n = \frac{P}{E}$

$$n = \frac{10 \times 10^3}{3.978 \times 10^{-28}} = 2.51 \times 10^{31}$$

$$n = 2.51 \times 10^{31} \text{ photon/s}$$ [1½]

(b) Average frequency, $\nu = 6 \times 10^{14}$ Hz

Energy/area-time $= 10^{-10} \text{ W/m}^2$

Area of pupil $= 0.4 \text{ cm}^2 = 0.4 \times 10^{-4} \text{ m}^2$

Total energy falling on pupil in unit time,

$$E' = 10^{-10} \times 0.4 \times 10^{-4}$$

$$= 4 \times 10^{-15} \text{ J/s}$$

Energy of each photon,

$$E'' = h\nu = 6.63 \times 10^{-34} \times 6 \times 10^{14}$$

$$= 3.978 \times 10^{-19} \text{ J}$$

Number of photon/s, $n = \frac{E'}{E''} = \frac{4 \times 10^{-15}}{3.978 \times 10^{-19}}$

$$= 1.006 \times 10^4 \text{ photon/s}$$

As this number is not so large as in part (a), so it is large enough for us never to sense the individual photons by our eye. [1½]

27. We shall increase the value of resistance R, joined in series with pure semiconductor S in order to maintain the ammeter reading constant when semiconductor is heated. [1]

This is because on heating the semiconductor, more charge carriers are available due to higher thermal energy and consequently, resistance of the semiconductor piece decreases. In order to maintain constant current, the total resistance of the circuit must remain constant.

Hence, external resistance will rise. [1]

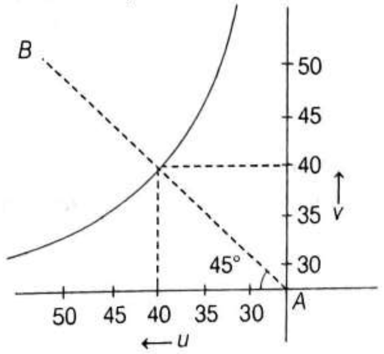
If semiconductor is replaced by a metal and it is heated, its resistance will increase. To maintain the same current in the circuit, we must decrease the value of R. [1]

28. Using data and lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

We have, got mean $f = 20$ cm.

From u-v graph,

As we already know in the case of lens as per sign convention, u is negative, v is positive, thus the graph is plotted in second quadrant as shown below



[2]

On the graph, we make a line AB making 45° angle with X-axis. On this line, $u = v$ ($\because X = Y$)

Therefore, the point where this line AB meets graph,

$u = v = 2f = 40$ cm (as $u = v$ when object is at $2f$).

$$\Rightarrow \quad f = 20 \text{ cm}$$ [1]

29. (i) From the given figure, we can analyse that the chlorine atom is at the centre of the cube, i.e. at equal distance from all the eight corners of cube where caesium atoms are placed. Thus, due to symmetry, the force due to all Cs atoms, on Cl atom will cancel out.

Since, $E = F/q'$ [where, $F = 0$]

$\therefore$ $E = 0$ [1]

(ii) The force on Cl atom at due to a single Cs atom would be given by $F = \dfrac{e^2}{4\pi\varepsilon_0 r^2}$

where, r = distance between Cl ion and Cs ion.

Applying Pythagoras theorem, we get

$$r = \sqrt{(0.20)^2 + (0.20)^2 + (0.20)^2} \times 10^{-9}\text{m}$$

$$= 0.346 \times 10^{-9}\text{m}$$

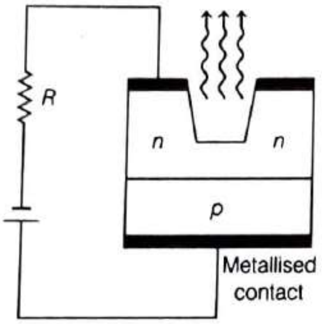
Now, $$F = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{e^2}{4\pi\varepsilon_0 r^2}$$

$$= \frac{9 \times 10^9 (1.6 \times 10^{-19})^2}{(0.346 \times 10^{-9})^2}$$

$$= 1.92 \times 10^{-9}\text{N}$$

This is the net force on the Cl-atom due to seven remaining Cs-atoms. [2]

30. Circuit diagram of LED



[1]

(i) Wavelength of light is controlled by band gap (E_g) of semiconductor material. [1]

(ii) Intensity of emitted light by the diode depends on concentration of impurity in the junction diode. [1]

Or

The differences between intrinsic and p-type extrinsic semiconductors are as

Intrinsic semiconductors	**p-type extrinsic semiconductors**
These are pure semiconducting material and no impurity is added to them. Consequently $n_e = n_h = n_i$.	These are prepared by doping a small quantity of impurity of trivalent material to the pure semiconducting material. As a result, $n_h >> n_e$.
The electrical conductivity is generally small and a function of temperature alone.	The electrical conductivity is comparatively high and mainly a function of amount of doping. [2]

A p-type semiconductor crystal is electrically neutral because the charge of additional charge carriers (i.e. holes) is just equal and opposite to that of the ionised cores in the crystal lattice. [1]

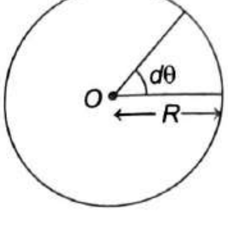
31. (i) Emf induced between the centre and the ring,

$$e = \frac{d\phi}{dt} = \frac{d(BA)}{dt} \qquad [\because \phi = B$$

$$e = B \times \frac{dA}{dt} \qquad \ldots(i)$$

[1]

Let the rod subtend an angle θ at centre in time t, then area covered by it



$$A = \frac{1}{2}R^2\theta$$

$$\therefore \quad \frac{dA}{dt} = \frac{1}{2}R^2\frac{d\theta}{dt} \Rightarrow \frac{dA}{dt} = \frac{1}{2}R^2\omega$$

(where, $\omega = d\theta/dt$ is the angular velocity)

$\therefore$ Emf induced, $e = \dfrac{1}{2}R^2\omega B$ [2]

Given, angular frequency, $\omega = 400 \text{ rad s}^{-1}$,

magnetic field, $B = 0.5\text{T}$

and length of wire, $R = L = 1\text{m}$

$\therefore$ Induced emf, $e = (1/2) \times (1)^2 \times 400 \times 0.5 = 100 \text{ V}$ [1]

(ii) Self-induction of a coil is the property by virtue of which it tends to maintain the magnetic flux linked with it and opposes any change in the flux by inducing current in it. This property of the coil is analogous to mechanical inertia, i.e. why self-induction is called the inertia of electricity. [1]

Or

(i) Given, inductance of inductor,

$$L = 80 \text{ mH} = 80 \times 10^{-3}\text{H},$$

capacitance of capacitor,

$$C = 60\mu\text{F} = 60 \times 10^{-6}\text{F},$$

voltage, $V = 230$ V

and frequency, $\nu = 50$ Hz

Impedance of the circuit,

$$Z = \left(L\omega - \frac{1}{C\omega}\right)$$

or $$Z = \left|L\omega - \frac{1}{C\omega}\right|$$

$$= \left|\left(2\pi \times 50 \times 80 \times 10^{-3} - \frac{1}{2\pi \times 50 \times 60 \times 10^{-6}}\right)\right|$$

$$= |(25.12 - 53.08)| = 27.96\,\Omega$$ [1]

(a) Current, $I_{\text{rms}} = \dfrac{V}{Z} = \dfrac{230}{27.96}\ \text{A} = 8.23\ \text{A}$

Current amplitude,

$$I_0 = I_{\text{rms}}\sqrt{2} = 8.23 \times 1.414\ \text{A}$$
$$= 11.63\ \text{A}$$

[1]

(b) Potential drop across inductor,

$$V_L = IX_L = I\omega L$$
$$= 8.23 \times 25.12 = 206.7\ \text{V}$$

Potential drop across capacitor,

$$V_C = IX_C = I \times \frac{1}{\omega C}$$
$$= 8.23 \times 53.08 = 436.8\ \text{V}$$

[1½]

(ii) As we know,

$$L = \frac{X_L}{2\pi f} = \frac{1}{2\pi} \times \text{slope of } X_L\text{-}f \text{ graph}$$
$$= \frac{1}{2\pi} \times \frac{8-0}{400-0} = \frac{1}{100\,\pi}$$
$$= 3.18 \times 10^{-3}\ \text{H}$$

[1½]

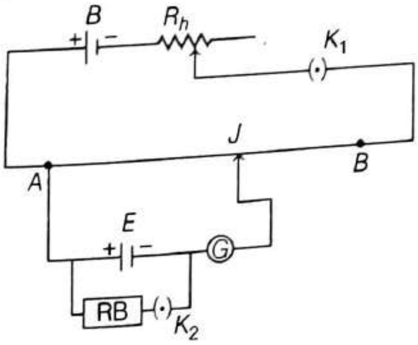
32. (i) **Principle of potentiometer** When an electric current flows through a wire of uniform cross-section area, then potential drop through it, is directly proportional to its length,

i.e. $V \propto l$

or $V = Kl$

where, K is the potential gradient. [1]

Measurement of internal resistance of a cell First of all, key K_1 is kept ON and key K_2 is kept OFF. If no deflection in galvanometer is obtained at length l_1 on wire AB,



i.e. $AJ_1 = l_1$ ...(i)

then, emf of the cell, $E = Kl_1$

Now, key K_2 is also kept ON and a resistance R is applied through resistance box. If no deflection in galvanometer is obtained at length l_2, i.e. $AJ_2 = l_2$, then terminal potential difference of the cell,

$$V = Kl_2 \qquad \text{...(ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{E}{V} = \frac{l_1}{l_2} \qquad \text{...(iii)}$$

The internal resistance of the cell

$$r = \left(\frac{E}{V} - 1\right)R$$

Using Eq. (iii), we get $r = \left(\dfrac{l_1}{l_2} - 1\right)R$ [2]

(ii) (a) In a potentiometer, we read null point. In reading the null point, there can be a maximum error.

Maximum error $= \dfrac{\text{Emf of the battery}}{\text{Length of the wire}}$

The maximum error can be reduced by using longer bridge wire. So, longer bridge wire is used in potentiometer. [1]

(b) On increasing reactance from resistance box, current drawn from cell E reduce. So, its terminal voltage 'V' increases. This shifts the null point towards B. [1]

Or

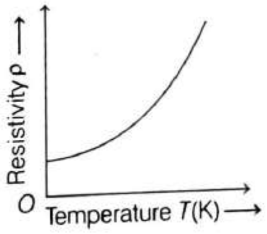
Resistivity The resistivity of a metal is equal to the electrical resistance of its wire of unit length and unit area of cross-section. It is denoted by ρ and its unit is 'ohm-metre'. [1]

Temperature dependence of resistivity

Resistivity of a metal is given by $\rho = m/ne^2\tau$

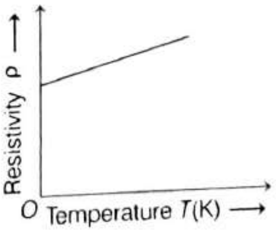
where, m is the mass of an electron, e is charge of an electron, n is electron density and τ is relaxation time. With increase in temperature, the average velocity of free electrons increases due to increase in KE and therefore relaxation time $\tau = \lambda / v$, decreases. As a result, the resistivity of a metal increases. Therefore, the resistivity of metal increases with increase in temperature. [1]

(i) **For the metal** On the basis of above explanation the graph between resistivity and temperature can be plotted as



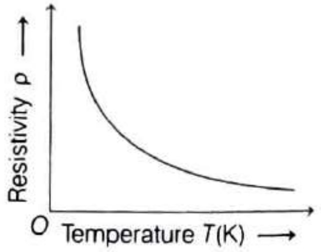
[1]

(ii) **For the alloy** Resistivity of an alloy increase very slowly with increases in temperature.



[1]

(iii) **For the semiconductor** Resistivity of a semiconductor decreases with increase in temperature.



[1]

33. (i) Wavelength of incident light,

$\lambda = 400\text{ nm} = 400 \times 10^{-9}\text{ m} = 4 \times 10^{-7}\text{ m}$ [1]

For refracting surface AB, $i_1 = 0°, r_1 = 0°$

For refracting surface AC, $r_2 = 90°$ and $i_2 = \theta$

Using Snell's law at surface AC,

$$\frac{\sin i_2}{\sin r_2} = \frac{1}{\mu}$$

$$\Rightarrow \quad \frac{\sin\theta}{\sin 90°} = \frac{1}{\mu}$$

$$\Rightarrow \quad \frac{1}{\sin\theta} = \mu \qquad [\because \sin 90° = 1]$$ [1]

$$\Rightarrow \quad \mu = \frac{1}{0.625} = 1.6$$

[given, $\sin\theta = 0.625$]

But the relation is $\mu = 12 + \frac{b}{\lambda^2}$ [given]

$$\therefore \quad 1.6 = 12 + \frac{b}{(4 \times 10^{-7})^2}$$

$$b = 0.4 \times (4 \times 10^{-7})^2$$

$$= 6.4 \times 10^{-14}\text{ m}^2$$

For wavelength, $\lambda = 5000\text{ Å} = 5 \times 10^{-7}\text{ m}$

Refractive index, $\mu = 1.2 + \frac{6.4 \times 10^{-14}}{(5 \times 10^{-7})^2}$

$$= 1.2 + \frac{6.4}{25}$$

$$= 1.2 + 0.256$$

$$= 1.456$$ [1]

(ii) We know that,

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

For glass, $\mu_g = 1.5$ and for water, $\mu_w = 1.33$

$$\Rightarrow \quad \frac{1}{f} = \left(\frac{1.5}{1.33} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

So, focal length of the lens gets increased, thus the power of the lens decreases as $P \propto \frac{1}{f}$ [2]

Or

(i) Phenomena of redistribution of intensity of light due to superposition of two light waves, is called interference.

For sustained interference pattern, the source should be coherent, i.e. should produce wave having zero or constant phase difference. [1]

(a) From the fringe width expression, $\beta = \frac{\lambda D}{d}$

With the increase in separation between two slits d, the fringe width β decreases [1]

(b) For interference fringes to be seen, $\frac{s}{S} < \frac{\lambda}{d}$

Condition should be satisfied,

where, s = size of the source

and S = distance of the source from the plane of two slits.

As, the source slit width decreases fringe pattern gets more sharp. [1]

(ii) For path difference. λ, phase difference $= 2\pi$

$\Rightarrow$ Intensity, $I = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

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

According to the question, $4I_0 = K$

For path difference $\frac{\lambda}{3}$, phase difference $= \frac{2\pi}{3}$

$\Rightarrow$ Intensity $= 4I_0\cos^2\left(\frac{2\pi}{3 \times 2}\right) = \frac{K}{4}$. [2]