Solutions

1. For photoemission, a minimum frequency called threshold frequency is required. As green light can emit electrons and yellow light does not, so red light also shows no photoemission. This is because the frequency of red light is least amongst all three colours. [1]

2. Eddy currents are minimised by using laminations of metal to make a metal core. [1/2]

This laminations reduces the strength of the eddy current. So, the dissipation of the strength of electric current or heat loss is substantially reduced. [1/2]

Or

Here, $\phi = 40 \text{ mWb} = 40 \times 10^{-3}$ Wb

and $I = 2\text{A}$

Self-inductance, $L = \frac{\phi}{I}$ [1/2]

$= \frac{40 \times 10^{-3}}{2}$

$= 2 \times 10^{-2}$ Wb [1/2]

3. As, ${}_1\mu_2 = \frac{1}{\sin C}$

$\Rightarrow \quad \frac{\mu_2}{\mu_1} = \frac{\lambda_1}{\lambda_2} = \frac{1}{\sin C}$ [1/2]

$\frac{6000}{4000} = \frac{1}{\sin C}$ or $C = \sin^{-1}\left(\frac{2}{3}\right)$ [1/2]

4. As, we know that,

wavelength, $\lambda = \frac{hc}{E_g} = \frac{1240 \text{ eV - nm}}{2.8 \text{ eV}}$ [1/2]

$\approx 440 \text{ nm} \approx 4400$ Å [1/2]

5. Volume $= \frac{\text{Mass}}{\text{Density}} = \frac{66 \times 10^{-3} \text{ kg}}{7500 \text{ kgm}^{-3}}$ [1/2]

$= \frac{66 \times 10^{-5}}{75} \text{m}^3$

Magnetisation, $M = \frac{m}{V} = \frac{2.5}{\frac{66 \times 10^{-5}}{75}}$

$= 2.84 \times 10^5 \text{ Am}^{-1}$ [1/2]

Or

As, $v = \frac{reB}{m} = \frac{0.15 \times 1.6 \times 10^{-19} \times 4 \times 10^{-4}}{9 \times 10^{-31}}$ [1/2]

$= 1.07 \times 10^7$ m/s [1/2]

6. Energy released on bombarding U^{235} by neutron

$= 200$ MeV

Power output of atomic reactor $= 1.6$ MW

We know, $P = \frac{nE}{t}$ (where n = total number of fissions) [1/2]

$\Rightarrow$ Rate of fission $= \frac{n}{t} = \frac{P}{E}$

$\therefore$ Rate of fission $= \frac{1.6 \times 10^6}{200 \times 10^6 \times 1.6 \times 10^{-19}}$

$= 5 \times 10^{16} \text{s}^{-1}$ [1/2]

Or

Given, orbital radius, $r = 4.7 \times 10^{-11}$ m

Kinetic energy,

$K = \frac{e^2}{8\pi\varepsilon_0 r}$

$= \frac{(9 \times 10^9 \text{ Nm}^2/\text{C}^2)(1.6 \times 10^{-19}\text{C})^2}{(2)(4.7 \times 10^{-11}\text{m})}$ [1/2]

$= 2.45 \times 10^{-18}$ J

$= 2.45 \times 10^{-18}/1.6 \times 10^{-19}$ eV

$= 15.3$ eV [1/2]

7. The maximum kinetic energy of emitted photoelectrons depends on the frequency of radiation source and nature of the material of plate, but is independent of the intensity of light.

So, it will remain unchanged. [1]

8. When a charged capacitor is disconnected from a battery and if its plates are separated further, then its potential energy will rise.

Since, charge, Q = constant

and potential energy $(E) = \frac{Q^2}{2C} = \frac{Q^2 d}{2\varepsilon_0 A}$ [1/2]

where, d is the separation between the plates.

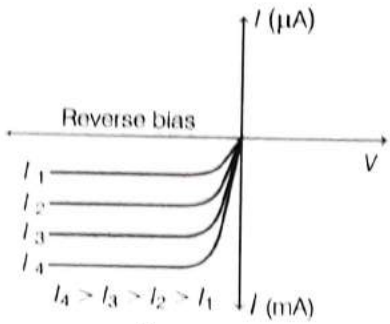
So, $\quad E \propto d$

Thus, with the increase in d, E also increases/rises. [1/2]

9. The frequency range of visible rays is 4×10^{14} Hz to 8×10^{14}Hz. [1]

10. As p-n junction diode is forward biased, so the applied voltage opposes the barrier voltage. Due to this, the potential barrier across the junction is lowered. [1]

Or



[1]

11. (a) Time period, $T = \frac{2\pi m}{Bq} \Rightarrow T \propto \frac{m}{q}$

As, $\left(\frac{m}{q}\right)_\alpha = 2\left(\frac{m}{q}\right)_p$

$\Rightarrow \quad T_\alpha = 2T_p$

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

12. (a) If the inner solenoid was much shorter than (and placed well inside) the outer solenoid, then we could still have calculated the flux linkage $N_1\phi_1$ because the inner solenoid is effectively immersed in a uniform magnetic field due to the outer solenoid.

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

13. (b) Optical fibre communication is based on the phenomenon of total internal relection at core-clad interface.

The refractive index of the material of core is higher than that of the cladding, hence light striking at core-cladding interface gets totally internally reflected. The light undergoes repeated total internal reflection and reaches the other end of the fibre.

Therefore, both A and R are true but R is not the correct explanation of A. [1]

14. (c) Photocell is technical application of the photoelectric effect. It is a device which converts light energy into electric energy. It is also called an electric eye. Photocell are used in the reproduction of sound in motion picture and in the television camera.

Therefore, A is true but R is false. [1]

15. (i) (a) The correct relation of conductivity of a solid conductor is $\sigma = \frac{ne^2}{m}\tau$. [1]

(ii) (b) Here, current $(I) = 250 \times 10^{-3}$A

Time, $(t) = 200$ ns $= 200 \times 10^{-9}$s

So, charge delivered by the acceleration per pulse

i.e. $\quad I = \frac{Q_{pulse}}{t}$

$\Rightarrow Q_{pulse} = It = (250 \times 10^{-3}\text{A})(200 \times 10^{-9}\text{s})$

$= 5.00 \times 10^{-8}$ C [1]

(iii) (c) Number of electrons delivered per pulse,

$$n = \frac{Q_{pulse}}{e} = \frac{5.00 \times 10^{-8}\text{ C}}{1.6 \times 10^{-19}\text{C}}$$

$= 3.13 \times 10^{11}$ electron / pulse [1]

(iv) (c) Average current delivered by the acceleration,

$$I_{av} = \frac{Q_{pulse}}{\Delta t} = \frac{5.00 \times 10^{-8}\text{ C}}{4.00 \times 10^{-3}\text{ s}} = 12.5\,\mu\text{A}$$ [1]

(v) (d) Maximum power delivered by the electron beam,

$$P = \frac{\Delta E}{\Delta t}$$

$$= \frac{(3.13 \times 10^{11}\text{ electrons /pulse})\ (40.0\text{ MeV / electron})}{2.00 \times 10^{-7}\text{ s / pulse}}$$

$= (6.26 \times 10^{19}$ MeV / s$)\ (1.6 \times 10^{-13}$ J / MeV$)$

$= 1.00 \times 10^7$ W $= 10.0$ MW [1]

16. (i) (c) In total internal reflection, light travels from an optically denser medium to a rarer medium at the interface, it is partly reflected back into the same medium and partly refracted back to the second medium. [1]

(ii) (d) When the angle of incidence is more than a certain value, the angle of refraction becomes more than 90°. It result into total internal reflection (critical angle.) [1]

(iii) (c) Critical angle, $\mu = \frac{1}{\sin i_C} = \frac{1}{\sin 48.6} = \frac{1}{0.75} = \frac{4}{3}$ [1]

(iv) (d) Light cannot undergoes total internal reflection when it is travelling from air to water, i.e. from rarer to denser medium. [1]

(v) (a) From total internal reflection of light,

As we know that, $\mu = \frac{1}{\sin i_C} \Rightarrow \sin i_C = \frac{1}{\mu}$

As, $\sin i_C = 1/(3/2) = \frac{2}{3} = 0.6667$

$i_C = \sin^{-1}(0.6667) = 41.8°$ [1]

17. The internal potential barrier of germanium is 0.3 V, therefore to overcome this barrier the potential of battery should be equal to or more than 0.3 V. [1]

Thus, the minimum voltage of battery = 0.3 V. If the diode is made of silicon, then the value of minimum voltage of battery is 0.7 V, as for silicon the potential barrier is 0.7 V. [1]

18. When a coil of N number of turns and area A is rotated in external magnetic field B, magnetic flux linked with the coil changes and hence an emf is induced in the coil. At an instant t, if e is the emf induced in the coil, then alternating emf induced is given by

$$e = e_0 \sin \omega t$$ [1]

Maximum current, $i_0 = \frac{e_0}{R} = \frac{NBA\omega}{R}$

Given, $N = 1, B = 10^{-2}$ T

$r = 30$ cm $= 0.3$ m

$A = \pi(0.3)^2$ m^2

$R = \pi^2\,\Omega$

$f = \frac{200}{60}\,\text{s}^{-1}$

and $\omega = 2\pi f = 2\pi\left(\frac{200}{60}\right)$

$\therefore \quad i_0 = \frac{1 \times 10^{-2} \times \pi\,(0.3)^2 \times 2\pi \times 200}{60 \times \pi^2}$

$= 6 \times 10^{-3}$ A $= 6$ mA [1]

Or

(i) Due to varying current in coil P, the flux linked with P changes. Hence, fluxed linked with coil Q changes, which in turn induces an emf in Q. Thus, bulb B lights up. [1]

(ii) When Q is moved towards left or away from P, less amount of flux change takes place in Q. This leads to decrease in the value of rate of change of magnetic flux and hence, lesser emf and bulb B gets dimmer. [1]

19. (i) From the given electric field expression, we can say that wave is propagating along negative y-direction or its direction is $-\hat{\mathbf{j}}$. [1]

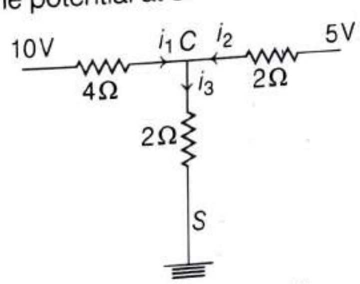
(ii) Comparing the given equation with the standard equation,

$$E = E_0 \cos\left[2\pi\left(\frac{y}{\lambda} + vt\right)\right]$$

we get, $\frac{2\pi}{\lambda} = 1.8$ rad/m

or wavelength, $\lambda = \frac{2\pi}{1.8} = \frac{2 \times 3.14}{1.8} = 3.5$ m [1]

20. Let V be the potential at C.



[1]

Using Kirchhoff's first law, $i_1 + i_2 = i_3$

$$\frac{10 - V}{4} + \frac{5 - V}{2} = \frac{V - 0}{2}$$

$\Rightarrow \quad 10 - V + 10 - 2V = 2V$

$\Rightarrow \quad 5V = 20$

$\Rightarrow \quad V = 4$ V [1]

$\Rightarrow \quad i_3 = V/2 = 4/2 = 2$A

Or

Conductivity, $\sigma = \frac{ne^2\tau}{m}$

$\Rightarrow$ Relaxation time, $\tau = \frac{\sigma m}{ne^2}$

For material A, $\tau_A = \frac{\sigma m}{ne^2}$ [1]

For material B, $\tau_B = \frac{2\sigma m}{2ne^2} = \frac{\sigma m}{ne^2}$

For material C, $\tau_C = \frac{2\sigma m}{ne^2}$

$\therefore$ From the above relations, we can say that,

$\tau_C > \tau_B = \tau_A$ [1]

21. Electric field lines follow some important properties which are discussed below

(i) Electric field lines start from positive charges and end at negative charges. In the case of a single charge, they may start or end at infinity.

(ii) Tangent to any point on electric field lines shows the direction of electric field at that point. [1]

(iii) Two field lines can never intersect each other because if they intersect, then two tangents drawn at that point will represent two directions of field at that point, which is not possible.

(iv) In a charge free region, electric field lines can be taken to be continuous curves without any breaks. [1]

Or

Since, surface D enclosed negative charge, hence it has least flux negative. [1]

In parts C and A, there is zero net charge, hence flux is zero, surface B has most flux, which is positive in nature, since it consist positive charge, i.e. $+2q$. [1]

22. (i) Converging lens, i.e. convex lens. [1/2]

(ii) The power of spectacles was 1 D, i.e. for an object at infinity, image is formed at 100 cm by the lens.

Power of accommodation gets reduced in old age. Generally, the ability of the lens to become thick and reduce its focal length (to see nearly objects) is lost. So, near vision is affected, this can be corrected by using a convex (converging) lens of suitable focal length.

Here, the reading glass he need is of power + 0.2 D. This implies his near point has receded to 26.3 cm from 25 cm. This can be calculated using thin lens formula.

Here, $P = +\,0.2$ D

$\Rightarrow \quad f = 5$ m $= 500$ cm

also, $u = 25$ cm

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{25}$$

$$= \frac{1}{500} - \frac{1}{25} = \frac{-19}{500}$$

$$\Rightarrow \quad v = -26.3 \text{ cm}$$ [1½]

23. **Electrical power** is defined as the rate of electrical energy supplied per unit time to maintain flow of electric current through a conductor.

Mathematically, $P = VI = I^2 R = \frac{V^2}{R}$

The SI unit of power is watt (W).

where, 1 watt = 1 volt × 1 ampere = 1 ampere-volt. [1]

Power of an electric circuit is said to be one watt, if one ampere current flows in it against a potential difference of one volt. The bigger units of electrical power are kilowatt (kW) and megawatt (MW). [1]

24. Here, $\lambda_1 = 590 \text{ nm} = 590 \times 10^{-9}$ m,

$$\lambda_2 = 596 \text{ nm} = 596 \times 10^{-9} \text{m},$$

$$d = 2 \times 10^{-4} \text{ cm} = 2 \times 10^{-6} \text{ m}$$

and $D = 1.5$ m

Distance of first secondary maximum from the centre of the screen,

$$x = \frac{3}{2}\frac{D\lambda}{d}$$

For the two wavelengths, we have,

$$x_1 = \frac{3}{2}\frac{D\lambda_1}{d}$$

and $$x_2 = \frac{3}{2}\frac{D\lambda_2}{d}$$ [1]

Spacing between the first two maximum of sodium lines

$$= x_2 - x_1 = \frac{3D}{2d}(\lambda_2 - \lambda_1)$$

$$= \frac{3 \times 1.5}{2 \times 2 \times 10^{-6}}(596 \times 10^{-9} - 590 \times 10^{-9})$$

$$= 6.75 \times 10^{-3} \text{ m}$$

$$= 6.75 \text{ mm}$$ [1]

25. When nucleons approach each other to form a nucleus, they strongly attract each other. Their potential energy decreases and becomes negative. It is the potential energy which holds the nucleons together in the nucleus. The decrease in PE results from the decrease in the mass of nucleons inside the nucleons. [2]

Hence, the mass of the nucleus is less than the sum of the masses of constituent neutrons and protons.

26. The wavelengths of spectral line in these series can be expressed by the following formulae

(i) **For Lyman series**

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right), \text{ where } n = 2, 3, 4, \ldots$$

For, $n = \infty, \lambda = \frac{1}{R}$

(ii) **For Balmer series**

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \text{ where } n = 3, 4, 5, \ldots$$

For, $n = \infty, \lambda = \frac{4}{R}$

(iii) **For Paschen series**

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right), \text{ where } n = 4, 5, 6, \ldots$$ [1½]

For, $n = \infty, \lambda = \frac{9}{R}$

(iv) **For Brackett series**

$$\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right), \text{ where } n = 5, 6, 7, \ldots$$

For, $n = \infty, \lambda = \frac{16}{R}$

(v) **For Pfund series**

$$\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n^2}\right), \text{ where } n = 6, 7, 8, \ldots$$

For, $n = \infty, \lambda = \frac{25}{R}$ [1½]

Or

(i) Bohr's second postulate states that, the electron revolves around the nucleus in certain privileged orbit which satisfy certain quantum condition that angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$, where h is Planck's constant.

i.e. $$L = mvr = \frac{nh}{2\pi}$$ [1]

where, m = mass of electron, v = velocity of electron and r = radius of orbit of electron.

$$\Rightarrow \quad 2\pi r = n\left(\frac{h}{mv}\right)$$

∴ Circumference of electron in n th orbit = n × de-Broglie wavelength associated with electron $\left[\because \lambda = \frac{h}{mv}\right]$ [1]

(ii) Given, the electron in H-atom is initially in third excited state.

∴ $n = 4$

and the total number of spectral lines of an atom that can exist is given by the relation

$$= \frac{n(n-1)}{2}$$ [1/2]

Here, $n = 4$

So, number of spectral lines

$$= \frac{4(4-1)}{2} = \frac{4 \times 3}{2} = 6$$

Hence, when a H-atom moves from third excited state to ground state, it emits six spectral lines. [1/2]

27. Given, $N = 200$ turns, $r = 10$ cm $= 0.1$ m, $B = 0.5$ T, $\theta = 90°$ and $I = 3$A

(i) As, $\tau = NIAB$

$$= 200 \times 3 \times [\pi(0.1)^2] \times 0.5 \quad [\because A = \pi r^2]$$

$$\Rightarrow \tau = 9.42 \text{ N-m}$$

[1]

(ii) The net magnetic force on circular loop is zero. [1/2]

(iii) Average force on electron,

$$F = (e)(v_d)\, B \sin 90°$$

But, $I = neAv_d$

[where, A = cross-section of the wire]

$$v_d = \frac{I}{neA}$$

$$\therefore \quad F = (e)\left(\frac{I}{neA}\right) B$$

$$F = \frac{IB}{nA} = \frac{3 \times 0.5}{10^{29} \times 10^{-5}}$$

$$\Rightarrow \quad F = \frac{1.5}{10^{24}}$$

$$\Rightarrow \quad F = 1.5 \times 10^{-24} \text{ N}$$

[1½]

28. Semiconductors in which some impurity atoms are embedded are known as extrinsic or impure semiconductors.

Extrinsic semiconductors are basically of two types

(i) *n*-type semiconductors

(ii) *p*-type semiconductors

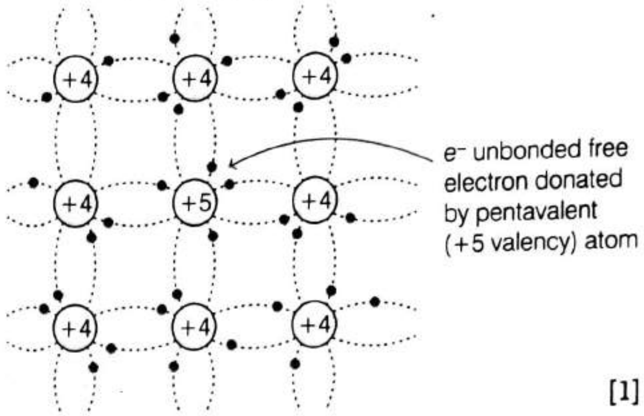
***n*-type Semiconductors**

This type of semiconductor is obtained when pentavalent impurity such as phosphorus (P), arsenic (As), etc is added to Si or Ge. During doping, four electrons of pentavalent atom bond with the four silicon neighbours while fifth remains very weakly bound to its parent atom. Also the ionisation energy required to set this electron free is very small.

Hence, these electrons are almost free to move. In other words, we can say that these electrons are donated by the impurity atoms. So, these are also known as **donor atoms** and the conduction inside the semiconductor will take place with the help of the negatively charged electrons. Due to this negative charge, these semiconductors are known as ***n*-type semiconductors**. [2]

Therefore, major conduction in *n*-type semiconductors is due to electrons. So, electrons are known as **majority carriers** and the holes are known as the **minority carriers**.

This means, $n_e >> n_h$; $I_e >> I_h$



[1]

29. (i) A choke coil reduces the current in the AC circuit without any heat loss. [1]

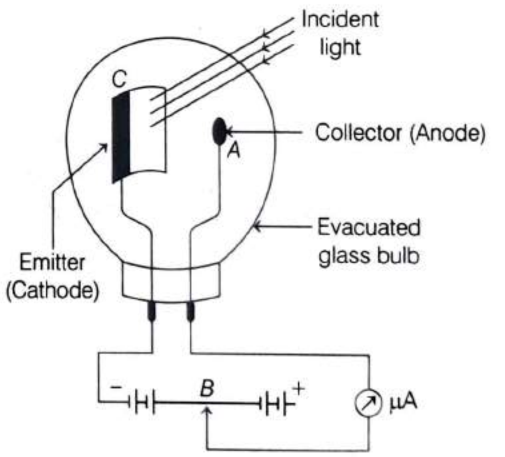
(ii) The effective resistance of a choke coil

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$\because$ Choke coil is a *L-R* device. [1]

(iii) One can control high frequency alternating current by using choke coil with air cores, these are called *rf* choke coils. While in case of low frequency AC, the core is of laminated soft iron. [1]

30. It is a device which converts light energy into electrical energy. It is also called an **electric eye.** As the photoelectric current is set up in the photoelectric cell corresponding to incident light, it provides the information about the objects as done by our eye in the presence of light.



[1½]

A photocell consists of a semi-cylindrical photosensitive metal plate *C* (emitter) and a wire loop *A* (collector) supported in an evacuated glass or quartz bulb. When light of suitable wavelength falls on the emitter *C*, photoelectrons are emitted.

Some applications of photocell are given below

(i) Used in television camera for telecasting scenes and in photo telegraphy.

(ii) Reproduction of sound in cinema film.

(iii) Used in burglar alarm and fire alarm. [1½]

Or

According to de-Broglie hypothesis, the wavelength of wave associated with moving material particle is given by

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

which is the expression for de-Broglie wavelength. From the above expression the following observations are made. [1]

(i) The de-Broglie wavelength $\lambda \propto \frac{1}{v}$. So, if the particle moves faster, then the wavelength will be smaller and *vice-versa*.

(ii) If the particle is at rest ($v = 0$), then the de-Broglie wavelength is infinite ($\lambda = \infty$). Such a wave cannot be visualised.

(iii) The de-Broglie waves cannot be electromagnetic in nature because electromagnetic waves are produced by motion of accelerated charged particles.

(iv) The wavelength of a wave associated with moving particle defines a region of uncertainty, within which the whereabouts of the particle are unknown. [2]

31. (i) By Gauss's law, $\phi = \oint \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$

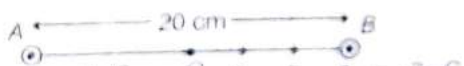
where, q is the net charge enclosed in the gaussian surface.

(a) ϕ does not change because it depends only on the total charge enclosed by the gaussian surface and not on its shape or size. [1/2]

(b) ϕ will not change because the total flux is determined by the charge inside the surface, not on the charge outside. [1/2]

(c) ϕ becomes zero because a dipole consists of two equal and opposite charges and so the net charge inside the surface is zero. Thus, the flux is also zero. [1/2]

(ii) Given, $AB = 20$ cm



$$AO = OB = 10 \text{ cm} = 0.1 \text{ m}$$

$$q_A = 3\,\mu C = 3 \times 10^{-6} \text{ C}$$

$$q_B = -3\,\mu C = -3 \times 10^{-6} \text{ C}$$

The electric field at a point due to a charge q is

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$$ [1/2]

where, r is the distance between charge and the point.

Electric field due to q_A at O

$$E_A = \frac{1}{4\pi\varepsilon_0} \frac{|q_A|}{(AO)^2}$$

$$E_A = \frac{9 \times 10^9 \times 3 \times 10^{-6}}{(0.1)^2} = \frac{27 \times 10^3}{0.1 \times 0.1}$$

$$= 2.7 \times 10^{6} \text{ N/C}$$

The direction of E_A is A to O, i.e. towards O or towards OB as the electric field is always directed away from positive charge.

Electric field due to q_B at O

$$E_B = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_B|}{(OB)^2}$$

$$E_B = \frac{9 \times 10^9 \times 3 \times 10^{-6}}{(0.1)^2}$$

$$= \frac{27 \times 10^3}{0.1 \times 0.1} = 2.7 \times 10^6 \text{ N/C}$$

The direction of E_B is O to B, i.e. towards B or towards OB as the electric field is always directed towards negative charge.

Now, we see that both E_A and E_B are in same direction. So, the resultant electric field at O is E. Hence,

$$E = E_A + E_B = 2.7 \times 10^6 + 2.7 \times 10^6$$

$$= 5.4 \times 10^6 \text{ N/C}$$

The direction of E (resultant electric field) will be from O to B or towards B.

Or

(i) Here, the dipole moment of each molecule $= 10^{-29}$ C-m.

1 mole of the substance contains 6×10^{23} molecules.

Therefore, total dipole moment of all molecules

$$p = 6 \times 10^{23} \times 10^{-29} \text{C-m} = 6 \times 10^{-6} \text{ C-m}$$

Initial potential energy,

$$U = -pE\cos\theta = -6 \times 10^{-6} \times 10^6 \cos 60^\circ = -3 \text{ J}$$

Final potential energy (when $\theta = 0^\circ$),

[finally p and E are aligned in the same direction]

$$U_f = -6 \times 10^{-6} \times 10^6 \cos 0^\circ = -6 \text{ J}$$

Change in potential energy

$$= -6\text{J} - (-3\text{J}) = -3 \text{ J}$$

So, there is a loss in potential energy. This must be the energy released by the substances in the form of heat in aligning its dipole.

(ii) Initially, energy stored in the capacitor can be given as $E = \frac{1}{2} C_1 V^2$

When the switch S is connected to point 2, then energy dissipated on connecting across $8\,\mu F$ ...

$$E' = \frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)V^2 = \frac{1}{2}\left(\frac{2\times 8}{10}\right)V^2$$

$$= \frac{1}{2}\times\frac{16}{10}\times V^2$$

Therefore ,% loss of energy

$$= \left(\frac{E'}{E}\right)\times 100\%$$

$$= \left(\frac{\frac{1}{2}\times\frac{16}{10}V^2}{\frac{1}{2}\times 2\times V^2}\right)\times 100\% = 80\%$$

[2]

32\. (i) For convex lens, $f > 0$

Also, $u < 0$

But from lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{v} + \frac{1}{u}$$ [taking u with negative sign]

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{u-f}{uf}$$ [numerically]

Since, given $u < f$

Thus, $\frac{1}{v} < 0 \Rightarrow v < 0$

So, image is formed on LHS of the lens, i.e. virtual image.

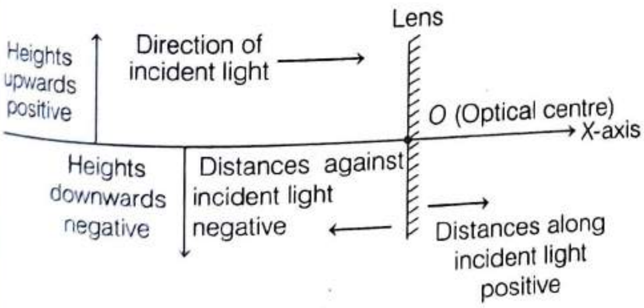
For convex lens, f is positive.

$$\Rightarrow \quad \frac{1}{|v|} < \frac{1}{|u|}$$

$$\Rightarrow \quad \frac{|v|}{|u|} > 1 \Rightarrow m > 1$$

Hence, enlarged virtual image formed on LHS of lens. [2]

(ii) To derive the relevant formulae for refraction by spherical lenses, we must first adopt a sign convention for measuring distances as shown below



According to the cartesian sign convention,

(a) All the distances are measured from the optical centre(O) of the lens.

(b) The principal axis of lens is taken as X-axis and optical centre as origin.

(c) Distances measured in the direction of the incident light are taken as positive and opposite to the direction of incident light as negative.

(d) The heights measured upwards with respect to X-axis and normal to the principal axis of the lens are taken as positive and the heights measured downwards are taken as negative. [3]

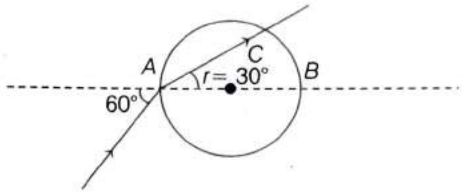
Or

(i) Given, $i = 60°$ and $\mu = \sqrt{3}$

From Snell's law, we have,

$$\frac{\sin i}{\sin r} = \mu \Rightarrow \frac{\sin 60°}{\sin r} = \sqrt{3}$$ [1]

$$\sin r = \frac{\sin 60°}{\sqrt{3}} = \frac{1}{\sqrt{3}}\times\frac{\sqrt{3}}{2}$$



$$\sin r = 0.5$$

$$\Rightarrow \quad r = \sin^{-1}(0.5)$$

$$\Rightarrow \quad r = 30°$$ [1]

(ii) **For convex lens** For erect image

$$u = -\text{ve},\ v = +\text{ve}$$

Magnification, $m = \frac{I}{O} = \frac{-v}{u}$

where, O = length of object

and I = length of image.

Given, $f = +20$ cm, $I = 4 \times$ length of object

$$\Rightarrow \quad \frac{I}{O} = 4 \Rightarrow \frac{v}{-u} = 4$$

$$\Rightarrow \quad v = -4u$$ [1]

Using lens formula,

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

$$\frac{1}{f} = \frac{1}{(-4u)} - \frac{1}{(-u)}$$

$$\Rightarrow \quad \frac{1}{f} = -\frac{1}{4u} + \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{20} = \frac{4-1}{4u} = \frac{3}{4u}$$

$$\Rightarrow \quad u = \frac{20\times 3}{4} = 15 \text{ cm}$$ [1]

$\Rightarrow u = 15$ cm, $v = 4u = 15 \times 4 = 60$ cm

Distance of the object, $u = 15$ cm

Distance of the image, $v = 60$ cm

The image is on the same side of the object. [1]

33. (i) The number of turns per unit length is

$$n = \frac{N}{l} = \frac{500}{0.5} = 1000 \text{ turns/m}$$ [1/2]

The length $(l) = 0.5$ m and radius $(r) = 1\text{cm} = 0.01$ m.

Thus, $l/r = 50$, i.e. $l >> r$.

Hence, we can use the long solenoid formula, i.e.

$$B = \mu_0 nI = 4\pi \times 10^{-7} \times 10^3 \times 5$$

$$= 6.28 \times 10^{-3} \text{ T}$$ [1]

(ii) Mean radius,

$$r_m = \frac{0.25 + 0.26}{2} = 25.5 \times 10^{-2} \text{m}$$ [1/2]

and turns per unit length, $n = \frac{N}{2\pi r_m}$

$$= \frac{3500}{2\pi \times 25.5 \times 10^{-2}}$$ [1/2]

Magnetic field of a toroid,

$$B = \mu_0 nI$$

$$= 4\pi \times 10^{-7} \times \frac{3500}{2\pi \times 25.5 \times 10^{-2}} \times 11$$

$$= 3 \times 10^{-2} \text{ T}$$ [1]

(iii) Given, $I_1 = 4\text{A}, I_2 = 5\text{A}, d = 4 \times 10^{-2}$ m

and $l = 0.20$ m

Force on a current carrying wire,

$$F = \frac{\mu_0 I_1 I_2 l}{2\pi d} = \frac{4\pi \times 10^{-7} \times 4 \times 5}{2 \times \pi \times 4 \times 10^{-2}} \times 0.20$$

$= 2 \times 10^{-5}$ N, towards B [1½]

Or

(i) Magnetic field induced at the centre of a circular loop, i.e.

$$B = \frac{\mu_0 I}{2r}$$

$$\Rightarrow 7 \times 10^{-5} = \frac{4\pi \times 10^{-7} \times I}{2 \times 5 \times 10^{-2}}$$

$\therefore$ Current in the circular loop,

$$I = \frac{7 \times 10^{-5}}{4\pi \times 10^{-6}} = 5.6 \text{ A}$$ [1½]

(ii) Yes, it is possible to have magnetic field configuration with three poles. It can be done by putting north poles or south poles of two magnets together.

Gauss's law of magnetism can be modified as

$$\Sigma \mathbf{B} \cdot d\mathbf{S} = \mu_0 m$$

where, m is the strength of the monopole. [1½]

(iii) (a) The field H is dependent of the material core and is expressed as

$$H = nI = 1000 \times 2.0 = 2 \times 10^3 \text{ Am}^{-1}$$

(b) Magnetisation,

$$M = (B - \mu_0 H)/\mu_0$$

As, $B = \mu_r \mu_0 H$

$\therefore$ $M = (B - \mu_0 H)/\mu_0 = (\mu_r \mu_0 H - \mu_0 H)/\mu_0$

$$= (\mu_r - 1) H = (400 - 1) \times 2 \times 10^3$$

$$= 8 \times 10^5 \text{ Am}^{-1}$$ [2]