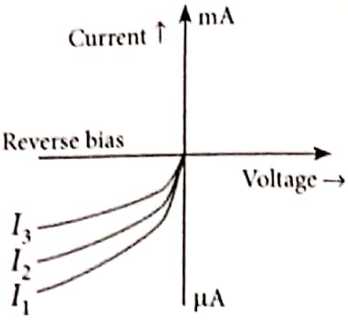
1.



$I_1 > I_2 > I_3$

2. Maximum magnification of a compound microscope is

$$m = \frac{v_0}{u_0}\left[1 + \frac{D}{f_e}\right]$$

So, for m to be 30,

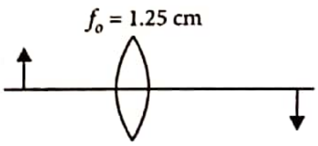
$$30 = \frac{v_0}{u_0}\left[1 + \frac{25}{5}\right] \quad \text{or} \quad 30 = \frac{v_0}{u_0}[6]$$

$v_0 = 5u_0$ ... (i)

For objective of focal length 1.25 cm,

$$\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_o}$$

$$\frac{1}{5u_o} - \frac{1}{-u_o} = \frac{1}{1.25}$$



$$\frac{1+5}{5u_o} = \frac{1}{1.25}$$

$5u_o = +7.5$ cm or $u_o = 1.5$ cm. So, $v_o = +7.5$ cm

Now u_e for required magnification,

$$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e} \quad \text{or} \quad \frac{1}{-25} - \frac{1}{-u_e} = \frac{1}{5}$$

$$\frac{1}{u_e} = \frac{1}{5} + \frac{1}{25} = \frac{5+1}{25} \quad \text{or} \quad u_e = \frac{25}{6} \text{ cm}$$

Hence, separation between two lenses should be

$$v_o + u_e = 7.5 \text{ cm} + \frac{25}{6} \text{ cm} = 11.67 \text{ cm}$$

OR

When the angle of refraction is equal to 90°, the angle of incidence is called the critical angle.

3. (i) From the given curve, we have

Voltage, $V = 0.8$ volt for current, $I = 20$ mA

Voltage, $V = 0.7$ volt for current, $I = 10$ mA

$\Rightarrow \Delta I = (20 - 10)\text{mA} = 10 \times 10^{-3}$ A

$\Rightarrow \Delta V = (0.8 - 0.7) = 0.1$ V

$\therefore$ Resistance, $R = \dfrac{\Delta V}{\Delta I}$

$$\Rightarrow R = \frac{0.1}{10 \times 10^{-3}} \Rightarrow R = 10\ \Omega$$

(ii) For $V = -10$ V, we have

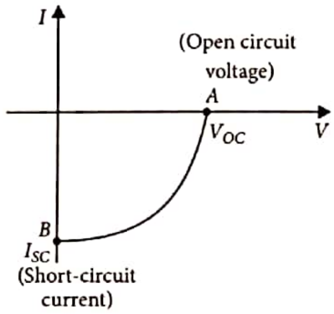
$I = -1\ \mu\text{A} = -1 \times 10^{-6}$ A

$$\Rightarrow R = \frac{-10}{-1 \times 10^{-6}} = 1.0 \times 10^{7}\ \Omega$$

4. (a) The energy for the maximum intensity of the solar radiation is nearly 1.5 eV. In order to have photo excitation the energy of radiation ($h\upsilon$) must be greater than energy band gap (E_g), *i.e.*, $h\upsilon > E_g$. Therefore, the semiconductor with energy band gap about 1.5 eV or lower and with higher absorption coefficient, is likely to give better solar conversion efficiency.

The energy band gap for Si is about 1.1 eV, while for GaAs, it is about 1.53 eV. The gas GaAs is better inspite of its higher bandgap than Si because it absorbs relatively more energy from the incident solar radiations being of relatively higher absorption coefficient.

(b)



(i) *V-I* curve is drawn in the fourth quadrant, because a solar cell does not draws current but supply current to the load.

(ii) In V-I curve, the point *A* indicates the maximum voltage V_{OC} being supplied by the given solar cell when no current is being drawn from it. V_{OC} is called the open circuit voltage.

(iii) In *V-I* curve, the point *B* indicates the maximum current I_{SC} which can be obtained by short circuiting the solar cell without any load resistance. I_{SC} is called the short circuit current.

5. (i) The Einstein's photoelectric equation is given as

$K_{max} = h\upsilon - \phi_0$

Since K_{max} must be non-negative implies that photoelectric emission is possible only if $h\upsilon > \phi_0$

or $\upsilon_f > \upsilon_0$ where $\upsilon_0 = \dfrac{\phi_0}{h}$, This shows that the greater the work function ϕ_0, higher the threshold frequency υ_0 needed to emit photoelectrons. Thus, there exists a threshold frequency $\upsilon_0 = \frac{\phi_0}{h}$ for the metal surface, below which no photoelectric emission is possible.

(ii) Condition for photoelectric emission,

$h\upsilon > \phi_0$

or $\frac{hc}{\lambda} > \phi_0$

for $\lambda = 3300$ Å

$$\frac{hc}{\lambda} = \frac{1.989\times10^{-25}}{3300\times10^{-10}} = \frac{6.03\times10^{-19}}{1.6\times10^{-19}} = 3.77 \text{ eV}$$

$\therefore$ Mo and Ni will not cause photoelectric emission.

If the laser source is brought nearer and placed 50 cm away, then photoelectric emission will not affect, since it depends upon the work function and threshold frequency.

6. de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$, where K is the kinetic energy.

Now, energy of electron,

$$K = \frac{13.6Z^2}{n^2} = \frac{13.6}{3^2} = 1.51 \text{ eV} = 2.41 \times 10^{-19} \text{ J}$$

$$\therefore \lambda = \frac{h}{\sqrt{2mK}} = \frac{6.63\times10^{-34}}{\sqrt{2\times9\times10^{-31}\times2.41\times10^{-19}}}$$

$\simeq 1 \times 10^{-9}$ m = 1 nm

OR

(i) The kinetic energy (E_k) of the electron in an orbit is equal to negative of its total energy (E)

$E_k = -E = -(-2.0) = 2.0$ eV

(ii) The potential energy (E_p) of the electron in an orbit is equal to twice of its total energy (E)

$E_p = 2E = -2 \times 2 = -4$ eV

(iii) Here, ground state energy of the H-atom = -13.6 eV

When the electron goes from the excited state to the ground state, energy emitted is given by

$E = -2 - (-13.6) = 11.6 \text{ eV} = 11.6 \times 1.6 \times 10^{-19}$ J

Now, $E = \frac{hc}{\lambda}$

$$\lambda = \frac{hc}{E} = \frac{6.62\times10^{-34}\times3\times10^8}{11.6\times1.6\times10^{-19}}$$

$\lambda = 1.07 \times 10^{-7}$

$\lambda = 1070$ Å

7. As, intensity $I \propto$ width of slit W

Also, intensity $I \propto$ square of amplitude A

$$\therefore \frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{A_1^2}{A_2^2}$$

But $\frac{W_1}{W_2} = \frac{1}{25}$ (given)

$$\therefore \frac{A_1^2}{A_2^2} = \frac{1}{25} \text{ or } \frac{A_1}{A_2} = \sqrt{\frac{1}{25}} = \frac{1}{5}$$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(A_1+A_2)^2}{(A_1-A_2)^2} = \frac{\left(\frac{A_1}{A_2}+1\right)^2}{\left(\frac{A_1}{A_2}-1\right)^2}$$

$$= \frac{\left(\frac{1}{5}+1\right)^2}{\left(\frac{1}{5}-1\right)^2} = \frac{\left(\frac{6}{5}\right)^2}{\left(-\frac{4}{5}\right)^2} = \frac{36}{16} = \frac{9}{4}$$

OR

Here, $u = -95$ cm, $n_1 = 1$, $n_2 = 1.67$, $R = +25$ cm

As light travels from air (rarer medium) to glass (denser medium), so

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R} \Rightarrow \frac{1.67}{v} - \frac{1}{-95} = \frac{1.67-1}{25}$$

$$\frac{1.67}{v} + \frac{1}{95} = \frac{0.67}{25} \Rightarrow \frac{1.67}{v} = \frac{0.67}{25} - \frac{1}{95}$$

$$\Rightarrow +102.62 \text{ cm}$$

The image is formed at a distance of 102.62 cm from the glass surface in the direction of incident light.

8. As, $\mu = \frac{3}{2}$

According to lens maker's formula

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

For biconvex lens, $R_1 = +20$ cm, $R_2 = -20$ cm

$$\therefore \frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{20}+\frac{1}{20}\right) = \frac{1}{20} \text{ or } f = 20 \text{ cm}$$

According to thin lens formula

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

Here, $u = -30$ cm

$$\therefore \frac{1}{20} = \frac{1}{v} - \frac{1}{-30} \Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{30}$$

$\therefore v = 60$ cm

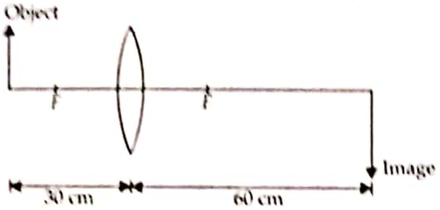
The image is formed at a distance of 60 cm on the right hand side of the lens. It is a real image.

Magnification, $m = \frac{v}{u} = \frac{h_I}{h_o}$

$$\frac{60\text{ cm}}{-30\text{ cm}} = \frac{h_I}{2\text{ cm}} \Rightarrow h_I = -4\text{ cm}$$

–ve sign shows that image is inverted.

The image is real, inverted and height of 4 cm as shown in figure.



9. (a) Microwaves are suitable for radar system used in aircraft navigation.

(b) X-rays are produced by bombarding a metal target by high speed electrons.

10. For first minimum, the path difference between extreme waves, $a\sin\theta = \lambda$

Here, $\theta = 30° \Rightarrow \sin\theta = \frac{1}{2}$ $\therefore a = 2\lambda$ ...(i)

For first secondary maximum, the path difference between extreme waves

$a\sin\theta' = \frac{3}{2}\lambda$ or $(2\lambda)\sin\theta' = \frac{3}{2}\lambda$ [Using eqn (i)]

or $\sin\theta' = \frac{3}{4}$ $\therefore$ $\theta' = \sin^{-1}\left(\frac{3}{4}\right)$

11. (a) An oscillating or accelerated charge is supposed to be source of an electromagnetic wave. An oscillating charge produces an oscillating electric field in space which further produces an oscillating magnetic field which in turn is a source of electric field. These oscillating electric and magnetic field hence, keep on regenerating each other and an electromagnetic wave is produced.

(b) Electromagnetic waves or photons transport energy and momentum. When an electromagnetic wave interacts with a small particle, it can exchange energy and momentum with the particle. The force exerted on the particle is equal to the momentum transferred per unit time. Optical tweezers use this force to provide a non-invasive technique for manipulating microscopic-sized particles with light.

12. (i) **(b)**

(ii) **(b):** Fast neutrons are slowed down by elastic scattering with light nuclei as each collision takes away nearly 50% of energy.

(iii) **(d):** Reactions I and II represent fission of uranium isotope $^{235}_{92}U$, when bombarded with neutrons that breaks it into two intermediate mass nuclear fragments. However, reaction III represents two deuterons fuses together to from the light isotope of helium.

(iv) **(c):** On an average 2.5 neutrons are released per fission of the uranium atom.

The energy of the neutron released per fission of the uranium atom is 2 MeV.

(v) **(a):** In fission process, when a parent nucleus breaks into daughter products, then some mass is lost in the form of energy. Thus,

mass of fission products < mass of parent nucleus.

$$\Rightarrow \frac{\text{Mass of fission products}}{\text{Mass of parent nucleus}} < 1$$

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