ISC SEMESTER 2 EXAMINATION
SAMPLE PAPER - 1
PHYSICS PAPER 1 (THEORY)

Maximum Marks: 35

Time allowed: One and a half hour

*Candidates are allowed an additional **10 minutes** for **only** reading the paper.*

*They must **NOT** start writing during this time.*

***All questions are compulsory**.*

*This question paper is divided in **3 Sections A, B** and **C***

All working, including rough work, should be done on the same sheet as and adjacent to the rest of the answer.

Answers to sub parts of the same question must be given in one place only.
A list of useful physical constants is given at the end of this paper.

A simple scientific calculator without a programmable memory may be used for calculations.

Section-A

Question 1.

(i) Two coherent sources whose intensity ratio is 144 : 1 produce interference fringes. Calculate the ratio of intensities of maxima and minima in the fringe system.

(ii) What is the relation between wavelength and momentum of moving particles ?

(iii) Which has greater resistance, a forward biased *p-n* junction or a reverse biased *p-n* junction ?

(iv) In Young's double slit experiment, the slit separation is made 3-fold. The fringe width becomes :

(a) 1/3 times
(b) 1/9 times
(c) 3 times
(d) 9 times

(v) On increasing the focal length of the objective, the magnifying power:

(a) of microscope will increase, of telescope will decrease.
(b) of both will increase.
(c) of both will decrease.
(d) of microscope will decrease, of telescope will increase.

(vi) If the radius of first electron orbit in hydrogen atom be r then the radius of the fourth orbit will be:

(a) r
(b) $4r$
(c) $9r$
(d) $16r$

(vii) Highest energy photoelectrons will be produced by:

(a) visible light
(b) X-rays
(c) ultraviolet light
(d) gamma rays

Section-B

Question 2.

Write down two conditions to obtain the sustained interference fringe pattern of light. What is the effect on the interference fringes in Young's double slit experiment, when monochromatic source is replaced by source of white light?

Question 3.

(i) A real image is formed by a lens at a distance of 20 cm from the lens. The image shifts towards the combination by 10 cm when a second lens is brought in contact with the first lens. Determine the power of the second lens.

OR

(ii) A parallel beam of light is incident normally on a plane transmission diffraction grating and coloured fringe lines are observed. The red line of the second order spectrum overlaps exactly on the blue line of the third order at an angle of diffraction of 30°. If the wavelength of red light is 7500 Å. What is the wavelength of blue light? What is the number of lines per cm on the grating surface ?

Question 4.

(i) The focal lengths of the objective and the eyepiece of a telescope are 50 cm and 5 cm respectively. Least distance of distinct vision is 25 cm. The telescope is focused for distinct vision on a scale placed at a distance of 200 cm away from the objective. Calculate :

(a) separation between the objective and the eye piece,

(b) magnification.

(ii) How is a wavefront defined? Distinguish between a plane wavefront and a spherical wavefront. Using Huygen's constructions draw a figure showing the propagation of a plane wave refracting at a plane surface separating two media. Hence verify Snell's law of refraction.

Question 5.

Explain photodiode.

Question 6.

(i) In Bohr's model of hydrogen atom, the radius of the first electron orbit is 0.53 Å. What will be the radius of the third orbit? What will be the radius of the first orbit of singly ionized helium atom?

OR

(ii) Explain the term chain reaction with a suitable example.

Section-C

Question 7.

(i) Explain the formation of primary and secondary rainbow.

OR

(ii) Derive the formula for the focal length of a combination of two thin lenses placed in contact.

Question 8.

Two coherent sources whose intensity ratio is 100:1 produce interference fringes. Calculate the ratio of intensities of maxima and minima in the fringe system.

Question 9.

The refractive indices of a material for red, violet and yellow colour light are 1.52, 1.62 and 1.59 respectively.

Calculate the dispersive power of the material. If the mean deviation is 40°. What will be the angular dispersion produced by a prism of this material?

Question 10.

Using Bohr's postulates derive the expression for the radius of n^{th} orbit of electron.

Question 11.

Read the passage given below and answer that follow:

Ernest Rutherford proposed a model of the atomic structure known as Rutherford's model of atoms. Rutherford proposed that an atom is composed of empty space mostly with electron orbiting around a fixed, positive changed nucleus. Rutherford's earlier model of the atom had also assumed that electrons moves in circular orbits around the nucleus. Although we know that the assumption of circular orbit was incorrect, Bohr's insight was to propose that the electron could occupy only certain region of space.

Bohr showed that the energy of electron in a perticular orbit is given by $E_n = \frac{Rhc}{n^2}$

(i) Describe Rutherford's model of an atom, stating its main features. Discuss two major shortcomings of the model.

(ii) Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975 Å. How many lines are possible in the resulting emission spectrum?

Calculate the longest wavelength amongst them. You may assume the ionization energy for hydrogen atom as 13.6 eV.

Question 12.

(i) Draw V–I characteristics curves of *p–n* junction diode in forward and reverse bias.

OR

(ii) Explain formation of energy bands in solids. Distinguish between conductors, insulators and semiconductors on the basis of their energy band diagrams.

Answers

Section-A

Answer 1.

(i) We know $$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{144}{1} \quad \text{...(i)}$$

$$\frac{a_1}{a_2} = \frac{12}{1}$$

$$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2}$$

But from equation (i), $a_1 = 12a_2$

$\therefore$ $$\frac{I_{max}}{I_{min}} = \frac{(12a_2+a_2)^2}{(12a_2-a_2)^2} = \frac{169}{121}.$$

(ii) $$\lambda = \frac{h}{p}$$

Where, λ = wavelength of the moving particle,

h = Planck's constant,

p = momentum of the moving particle

(iii) Reverse biased *p-n* junction has more resistance.

(iv) (a) $\frac{1}{3}$ times

Explanation :

We know, fringe width, $\beta = \frac{\lambda D}{d}$

when d is made 3-fold then

Then, new fringe width, $\beta' = \frac{\lambda D}{d} = \frac{\lambda D}{3d} = \beta/3.$

(v) (d) of microscope will decrease, of telescope will increase.

Explanation :

$$\text{Magnifying power of microscope, } M_m = \left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$$

$$M_m \propto \frac{1}{f_0}$$

$$\text{Magnifying power of telescope } m_t = \frac{f_0}{f_e}$$

$$m_t \propto f_0.$$

(vi) (b) $16r$

Explanation :

Radius of hydrogen atom is given by

$$r_n = n^2 r$$

where n is orbit number $\quad r_4 = 16r$

(vii) (d) gamma rays

Explanation :

Gamma - Rays produce high photoelectrons.

Section-B

Answer 2.

Conditions for sustained interference:

(i) The two sources of light must be coherent to emit light of constant phase difference.

(ii) The amplitude of electric field vector of interfering wave should be equal to have greater contrast between intensity of constructive and destructive interference.

When monochromatic light is replaced by white light, then coloured fringe pattern is obtained on the screen.

Answer 3.

(i) From the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we have

$$\frac{1}{20} - \frac{1}{u} = \frac{1}{f_1} \quad \ldots\text{(i)}$$

When second lens is brought in contact, then

$$\frac{1}{10} - \frac{1}{u} = \frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \quad \ldots\text{(ii)}$$

By equations (i) and (ii), we get

$$\frac{1}{f_2} = \frac{1}{20}$$

or $$f_2 = 20 \text{ cm} = 0.2 \text{ m}$$

Its power, $$P = \frac{1}{f_2} = \frac{1}{0.2 \text{ m}} = 5 \text{ D}.$$

OR

(ii) When light of wavelength λ falls normally on a grating, the direction θ of the maximum intensity in the diffracted light is given by

$$(e + d) \sin \theta = n\lambda_1$$

If the n^{th} order of λ_1 coincides with the $(n + 1)^{th}$ order of λ_2 where $\lambda_1 > \lambda_2$ then

$$(e + d) \sin \theta = n\lambda_1 = (n + 1)\lambda_2 \quad \text{...(i)}$$

or $$\lambda_2 = \frac{n}{n+1}\lambda_1$$

Here, $$n = 2 \text{ and so, } n + 1 = 3$$

$$\lambda_1 = 7500 \text{ Å}$$

$\therefore$ $$\lambda_2 = \frac{2}{3} \times 7500 = 5000 \text{ Å}$$

Putting $n = 2$, $\lambda_1 = 7500$ Å $= 7500 \times 10^{-8}$ cm and $\theta = 30°$ in equation (i), we get

Then, $$(e + d) \sin 30° = 2 \times (7500 \times 10^{-8})$$

$$(e + d) = \frac{2 \times (7500 \times 10^{-8})}{\sin 30°} = 3 \times 10^{-4} \text{ cm}$$

Therefore, number of lines per cm on the grating is

$$\frac{1}{(e + d)} = \frac{1}{3 \times 10^{-4}} = 3333.33$$

Answer 4.

(i) The objective of the telescope forms a real image of the scale behind it. Thus for the objective,

$$u_0 = -200 \text{ cm}, f_0 = +50 \text{ cm and } v_0 = ?$$

or $$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

$$\frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0}$$

$$= \frac{1}{50} - \frac{1}{200} = \frac{3}{200}$$

$$v_0 = +\frac{200}{3} \text{ cm}$$

For the eyepiece $v_e = -25$ cm, $f_e = +5$ cm and $v_e = ?$

or $$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$$

$$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e}$$

$$= -\frac{1}{25} - \frac{1}{5} = -\frac{6}{25}$$

$$v_e = -\frac{25}{6} \text{ cm}$$

∴ Separation between the objective and the eyepiece is then,

$$|v_0| + |u_e| = \frac{200}{3} + \frac{25}{6}$$

$$= 70.83 \text{ cm}$$

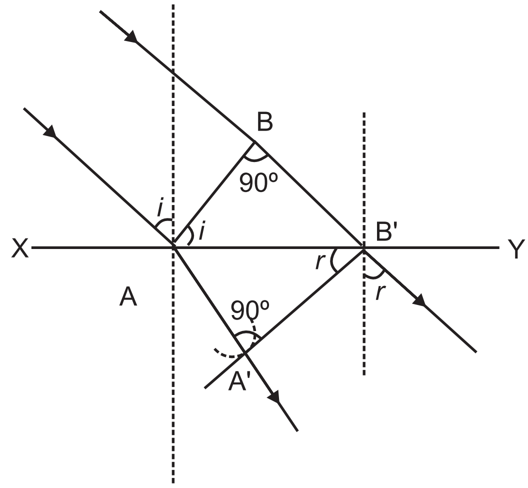
$$\text{Magnification, } m = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$$

$$= \frac{25}{5}\left(1 + \frac{5}{(-25)}\right)$$

$$= 5\left(\frac{4}{5}\right) = 4.$$

(ii) **Wavefront:** A wavefront is a locus of all particles of medium vibrating in the same phase.

Huygen's Principle: Huygen's principle states that every point on a wavefront is a source a secondary wavelet such that the wavefront at some later time is the envelope of these wavelets.



Difference between spherical and planar wavefront: The fundamental difference between plane and secondary wavefronts is that the spatial function of the amplitude is planar in plane wavefront while spherical in spherical wavefront. Also the intensity varies as the inverse square of distance in spherical wavefront and is independent of distance travelled in planar wave.

Proof of Snell's law of Refraction using Huygen's wave theory: When a wave starting from one homogeneous medium enters the another homogeneous medium, it is deviated from its path. This phenomenon is called refraction. In transversing from first medium to another medium, the frequency of wave remains unchanged but its speed and the wavelength both are changed. Let XY be a surface separating the two media '2' and '2'. Let v_1 and v_2 be the speeds of waves in these media.

Suppose a plane wavefront AB in first medium is incident obliquely on the boundary surface XY and its end A touches the surface at A at time $t = 0$ while the other end B reaches the surface at point B′ after time-interval t. Clearly BB′ = $v_1 t$. As the wavefront AB advances, it strikes the points between A and B′ of boundary surface. According to Huygen's principle, secondary spherical wavelets originate from these points, which travel with speed v_1 in the first medium and speed v_2 in the second medium. First of all secondary wavelet starts from A, which traverses a distance AA′ (= $v_2 t$) in second medium in time t. In the same time-interval t, the point of wavefront traverses a distance BB′ (= $v_1 t$) in first medium and reaches B′, from, where the secondary wavelet now starts. Clearly BB′ = $v_1 t$ and AA′ = $v_2 t$.

Assuming A as centre, we draw a spherical arc of radius AA′ (= $v_2 t$) and draw tangent B′A′ on this are from B′. As the incident wavefront AB advances, the secondary wavelets start from points between A and B′, one after the other and will touch A′B′ simultaneously. According to Huygen's principle, A′B′ is the new position of wavefront AB in the second medium. Hence, A′B′ will be the refracted wavefront.

First law: As AB, A′B′ and surface XY are in the plane of paper, therefore the perpendicular drawn on them will be the same plane. As the lines drawn normal to wavefront denote the rays, therefore we may say that incident ray, refracted ray and the nromal at the point of incident all lie in the same plane. This is the first law of refraction.

Second law: Let the incident wavefront AB and refracted wavefront A′B′ make angles i and r respectively with refracting surface XY.

In right-angled triangle AB′B, $\angle ABB' = 90°$

$$\therefore \quad \sin i = \sin \angle BAB' = \frac{BB'}{AB} = \frac{v_1 t}{AB'} \quad \ldots(i)$$

Similarly in right-angled triangle AA′B′,

$$\angle AA'B' = 90°$$

$$\therefore \quad \sin r = \sin \angle AB'A' = \frac{AA'}{AB'} = \frac{v_2 t}{AB'} \quad \ldots(ii)$$

Dividing equation (i) by (ii), we get

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \text{constant} \quad \ldots(iii)$$

As the rays are always normal to the wavefront, therefore, the incident and refracted rays make angle i and r with the normal drawn on the surface XY *i.e.*, i and r are the angles of incidence and angle of refraction respectively. According to equation (iii),

The ratio of sine of single of incidence and the sine of angle of refraction for a given pair of media is a constant and is equal to the ratio of velocities of waves in the two media. This is the second law of refraction and is called the Snell's law.

Answer 5.

A photodiode is a reverse-biased *p-n* junction made from a photo-sensitive semiconductor. The junction is embedded in clear plastic. The upper surface across the junction is open to light while the remaining sides of the plastic are painted black or enclosed in a metallic case. When no light is falling on the junction and the reverse bias is of the order of a few tenths of a volt, almost constant small current (≈ μA) is obtained. This "dark" current is the reverse saturation current due to the thermally generated minority carriers. When light of appropriate frequency is made incident on the junction, additional electron-hole pairs are created near the junction. These light-generated minority carriers cross the (reversed-biased) junction and contribute to the (reverse) current due to thermally generated carriers. Therefore, the current in the circuit increases (a fraction of a mA). This, so called "photoconductive" current varies almost linearly with the incident light flux.

Answer 6.

(i) The radius of the n^{th} Bohr orbit is given by

$$r = n^2 \frac{h^2 \varepsilon_0}{\pi m Z e^2}$$

or

$$r \propto n^2$$

$$\frac{r_1}{r_3} = \frac{n_1^2}{n_3^2} = \frac{1}{9}$$

$$r_3 = 9 \times r_1$$
$$= 9 \times 0.53 \text{ Å}$$
$$= 4.77 \text{ Å}$$

We know that radius $\propto \frac{1}{Z}$ or $r \propto \frac{1}{Z}$ (where Z is atomic no. of element)

For hydrogen Z = 1 and for helium Z = 2.

$\therefore$ Radius of first helium orbit $= \dfrac{\text{Radius of first } H_2 \text{ atom}}{Z}$

$$= \frac{0.53 \text{ Å}}{2}$$

$$= 0.265 \text{ Å}$$

OR

(ii) When uranium nucleus is bombarded by a slow neutron, the nucleus is split into two nearly equal fragments along with emission of energy and two or three fast moving neutrons. Thus, a chain of nuclear fission is established which continues until the whole of the uranium is consumed. This process is called nuclear chain reaction.

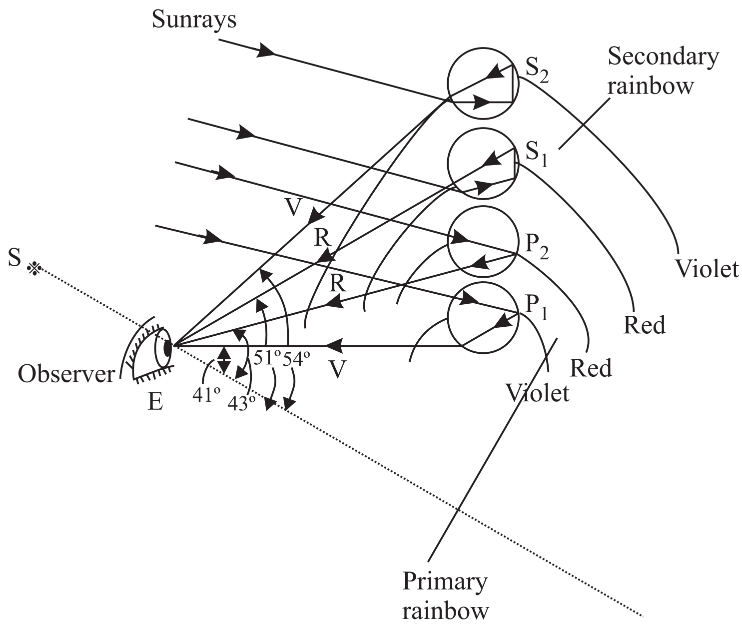
$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Q \text{ (energy)}.$$

Section-C

Answer 7.

(i) When the sun shines upon falling raindrops, an observer with his back towards the sun sees concentric arcs of spectral colours hanging in the sky. These coloured arcs, which have their common centre on the line joining the sun and the observer, are called 'rainbow'. Usually, two rainbows are seen, one above the other.

The lower one is called the 'primary' rainbow and the higher one is called the 'secondary' rainbow. The primary rainbow is brighter and narrower, having its inner edge violet and the outer edge red. The secondary rainbow, which is comparatively fainter, has reverse order of colours.

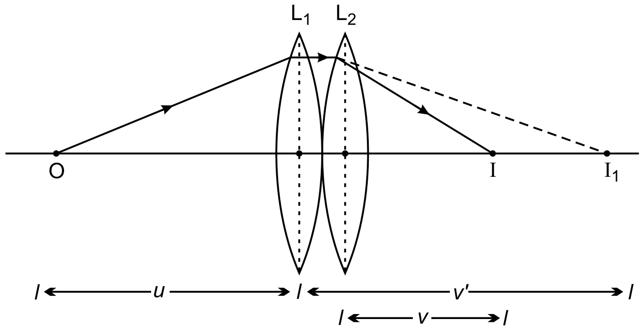


Formation of Primary Rainbow : Rainbows are formed by the dispersion of sunrays in raindrops. The primary rainbow is formed when sunrays, after suffering one internal reflection in the raindrops, emerge at minimum deviation and enters the observer's eye. In figure, P_1 and P_2 are two raindrops, E is the observer's eye and S is the sun. The sunrays fall on the drops parallel to SE. If the rays are deviated (and dispersed) by the drops so as to arrive at the observer, the observer would receive intense light in the those directions in which the rays suffer minimum deviation. It can be shown that he would receive red light in a direction making an angle of 43°, and intense violet light in a direction making an angle of 41° with the line SE produced. The drops sending the intense red and violet light to the observer lie on concentric circles which generate cones of semivertical angles of 43° and 41° respectively with common vertex at E. Thus, the observer sees concentric coloured arcs of which the innermost is violet and the outermost is red. The intermediate colours lie in between. This is the primary rainbow.

Formation of Secondary Rainbow : The secondary fainter rainbow is formed by the sunrays undergoing two internal reflections in the raindrops and emerging at minimum deviation, as occurring in drops S_1 and S_2 in the figure. The semivertical angles for this bow are 51° for the red rays to 54° for the violet rays. As such, the order of colours is reverse of that in the primary rainbow.

OR

(ii) (a) **Both the Lenses are Convex :** Suppose two thin convex lenses L_1 and L_2 of focal lengths f_1 and f_2 are placed in contact in air having a common principal axis. A point object O is placed on the principal axis at a distance u from the first lens L_1. Its image would be formed by the lens L_1 alone at I'. distant v' (say) from L_1. Then, from the lens formula, we have,



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

I′ serves as a virtual object for the second lens L_2 which forms a final image I at a distance v (say) from it.

Then, we have

$$\frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2}. \qquad \text{...(ii)}$$

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

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}. \qquad \text{...(iii)}$$

If we replace these two lenses by a single lens which forms the image of an object placed distant u from it at a distance v, then the focal length F of this equivalent lens would be given by

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{F} \qquad \text{...(iv)}$$

From eq. (iii) and (iv), we get

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

(b) **One lens is convex and the other is concave :** Suppose the focal length of the convex lens is f_1 and that of the concave lens is f_2. If F be the focal length of the equivalent lens, then :

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

or

$$F = \frac{f_1 f_2}{f_2 - f_1}$$

If $f_1 > f_2$, then F is negative and the combination will behave like a concave lens.

If $f_1 < f_2$, then F is positive and the combination will behave like a convex lens.

If $f_1 = f_2$, then F is infinite and the combination will behave like a plane glass plate.

Answer 8.

Let a_1 and a_2 be the amplitudes and I_1 and I_2 the intensities of the light waves emitted from the sources. The intensity ratio is 100 : 1. Then, we have

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{100}{1}$$

or

$$\frac{a_1}{a_2} = \frac{10}{1} \qquad \text{....(i)}$$

In interference, the maximum and minimum resultant amplitudes are $(a_1 + a_2)$ and $(a_1 - a_2)$ respectively.

$$\therefore \quad \frac{\text{Maximum intensity } I_{max}}{\text{Minimum intensity } I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$$

But from equation (i), $a_1 = 10a_2$

$$\therefore \quad \frac{I_{max}}{I_{min}} = \frac{(10a_2 + a_2)^2}{(10a_2 - a_2)^2} = \frac{121}{81}$$

Answer 9.

We know $$\omega = \frac{n_V - n_R}{n_Y - 1}$$

Given $n_V = 1.62$, $n_R = 1.52$ and $n_Y = 1.59$

So, $$\omega = \frac{1.62 - 1.52}{1.59 - 1}$$

$$= 0.1695$$

Angular dispersion between red and violet rays is :

$$\theta = \delta_V - \delta_R$$

$$\theta = \omega \times \delta_Y$$

So, $$\theta = 0.169 \times 40^\circ = 6.78^\circ$$

Answer 10.

Let e, m, v be the charge, mass and velocity of the electron and r be the radius of the orbit. Positive charge on the nucleus is Ze. In case of hydrogen atom, Z = 1. Centripetal force is provided by electrostatic force of attraction. Therefore,

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Ze \times e}{r^2}$$

$$mv^2 = \frac{Ze^2}{4\pi\varepsilon_0 r} \quad ...(i)$$

By first postulate : $$mvr = \frac{nh}{2\pi} \quad ...(ii)$$

Where n is the quantum number.

Squaring equation (ii) and dividing by equation (i), we get :

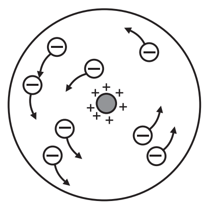
$$\frac{m^2v^2r^2}{mv^2} = \frac{\frac{n^2h^2}{4\pi^2}}{\frac{Ze^2}{4\pi\varepsilon_0 r}}$$

Then, $$r = \frac{n^2h^2\varepsilon_0}{\pi Ze^2 m}$$

Answer 11.

(i) On the basis of the observations of α-particle scattering experiments, Rutherford presented a model of atom, called "Rutherford's model". In this model, the mass of the atom (leaving the mass of its electrons) and its whole positive charge are concentrated at the center of the atom in a nucleus of radius $\approx 10^{-15}$m. Around the nucleus are distributed the electrons in a hollow sphere of radius $\approx 10^{-10}$m.

The total negative charge of the electrons is equal to the positive charge of the nucleus, the atom as a whole being electrically neutral. Rutherford assumed that the electrons in the atom are not stationary (if they were so, they would be pulled into the nucleus due to strong electrostatic attraction), but are revolving around the nucleus in different orbits and the necessary centripetal force is provided by the electrostatic force of attraction between the electrons and the nucleus.



Rutherford's atomic model was supported by the periodic table of elements.

Drawbacks of Rutherford's Model : This model suffers from two drawbacks :

(a) Regarding Stability of Atom : Electrons revolving around the nucleus have centripetal acceleration. According to electrodynamics, accelerated charged particles radiate energy (electromagnetic waves). Hence electromagnetic waves should be continuously radiated out by the revolving electrons. Due to this continuous loss of energy of the electrons, the radii of their orbitals should be continuously decreasing and ultimately the electrons should fall into the nucleus. Thus, atom cannot remain stable.

(b) Regarding Explanation of Line-spectrum : In Rutherford' model, due to continuously changing radii of the circular orbits of electrons, the frequency of revolution of the electrons must also be changing. As a result, electrons will radiate electromagnetic waves of all frequencies, *i.e.*, spectrum of these waves will be 'continuous' in nature. But experimentally the atomic spectra are not continuous; they have many sharp lines and each spectral line corresponds to a particular frequency. So, an atom should radiate waves of some definite frequencies only, not of all frequencies. Thus, Rutherford model was unable to explain the line spectrum.

(ii) Energy given to the atom by radiation of wavelength 975 Å = $(9.75 \times 10^{-10}$ m) is :

$$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})\times(3.0\times10^{8})}{975\times10^{-10}}$$

$$= 20.4\times10^{-19}\text{ J} = \frac{20.4\times10^{-19}}{1.60\times10^{-19}}$$

$$= 12.75\text{ eV}$$

Energy of hydrogen atom in ground state (n = 1) is – 13.6 eV.
Hence energy of the excited atom is :

$$-13.6 + 12.75 = -0.85\text{ eV}$$

Energy of hydrogen atom is given by :

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

If $E_n = -0.85$ eV

then $-\frac{13.6}{n^2} = -0.85$

$$n = 4$$

Now the emitted wavelength is given by :

$$\lambda = \frac{hc}{\Delta E}$$

The longest wavelength will correspond to the transition between the closest energy levels. The longest wavelength will be emitted for transition from 4th orbit to 3rd orbit.

$$E_4 = 0.85\text{ eV}, E_3 = -1.5\text{ eV}$$

The energy difference between the closest level is :

$$\Delta E = E_4 - E_3.$$

$$\Delta E = -0.85\text{ eV} - (-1.51\text{ eV})$$

$$= 0.66\text{ eV} = 0.66 \times 1.6 \times 10^{-19}\text{ J}$$

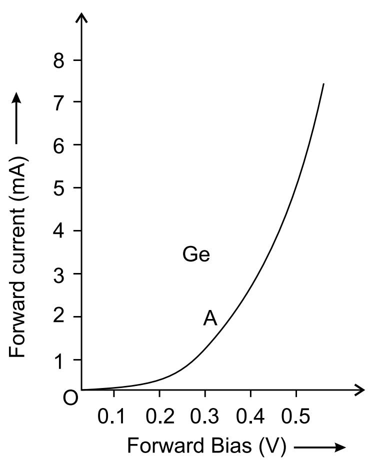
Hence, the longest wavelength emitted is

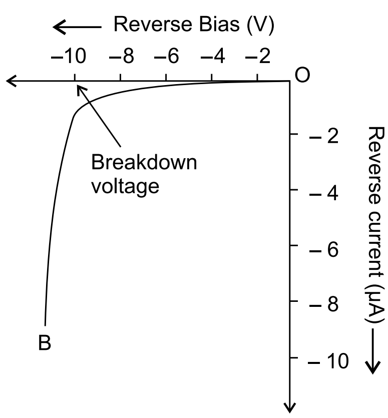
$$\lambda = \frac{(6.63\times10^{-34})\times(3\times10^{8})}{0.66\times1.6\times10^{-19}}$$

$$= 18.835 \times 10^{-7}\text{ m} = 18835\text{ Å}.$$

Answer 12.

(i)

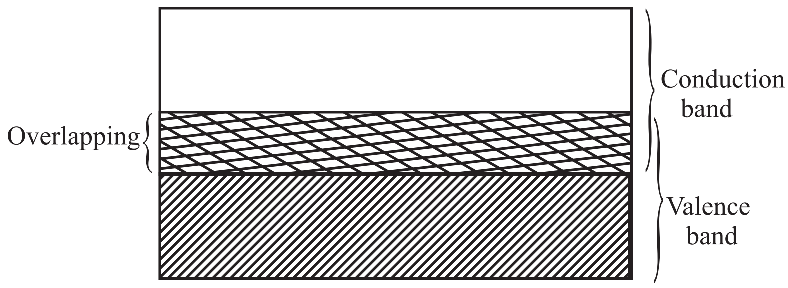




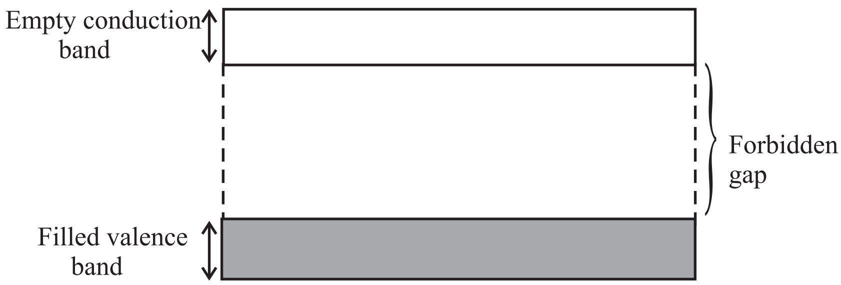
OR

(ii) **Formation of energy bands in solids :** An isolated atom has well defined energy levels. When large number of such atom get together to form a real soild, their individual energy levels overlap and get completely modified. Instead of discrete value of energy of electrons, the value lies in a certain range. The collection of these closely packed energy levels are said to form an energy band. Two type of such bands formed in solid are called valence band and conduction band. The band formed by filled energy levels is known as valence band, whereas partially filled or unfilled band is known as conduction band. The two bands are generally separated by a gap called energy gap or forbidden gap.

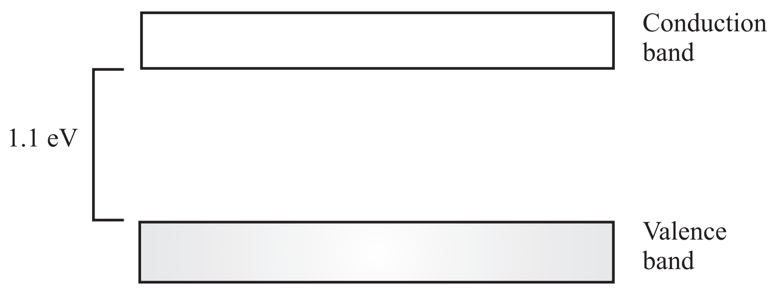
Conductors : In case of conductors, electrons fill the conduction band, partially the overlapping of both the bands *i.e.,* valence and conduction band also take place. This shows that no forbidden gap is present.



Insulators : In case of insulator, forbidden gap is very large. On the other hand, its valence band is fully filled with the electrons, whereas its conduction band is empty.



Semiconductor : In case of semiconductors the conduction band is empty and valence band is filled with electrons. Like insulators, forbidden energy gap is not so large in case of semiconductors. The gap is very small. The energy gap is nearly of 1 eV.



❑❑