ISC SEMESTER 2 EXAMINATION

SAMPLE PAPER - 2

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) A monochromatic ray of light falls on a regular prism under minimum deviation condition. What is the relation between angle of incidence and angle of emergence?

(ii) What are matter waves?

(iii) What is the magnitude of the potential barrier across a Ge *p-n* junction?

(iv) In an interference experiment, the ratio of amplitudes of coherent waves is $a_1 : a_2 = 1 : 3$. The ratio of maximum and minimum intensities of fringes will be:

(a) 1 : 9 (b) 4 : 1 (c) 1 : 3 (d) 9 : 1

(v) The ratio of powers of a thin concave and a thin convex lens is 3/2. When they are in contact, their equivalent focal length is 30 cm. Their individual focal lengths are:

(a) 10 cm, – 15 cm (c) 50 cm, – 75 cm
(b) 75 cm, – 50 cm (d) 15 cm, – 10 cm

(vi) Which one of the series of hydrogen spectrum is in the visible region?

(a) Lyman series (c) Paschen series
(b) Balmer series (d) Bracket series

(vii) If the kinetic energy of the particle is increased to 16 times its previous value, the percentage change in the de-Broglie wavelength of the particle is:

(a) 25 (b) 75 (c) 50 (d) 60

Section-B

Question 2.

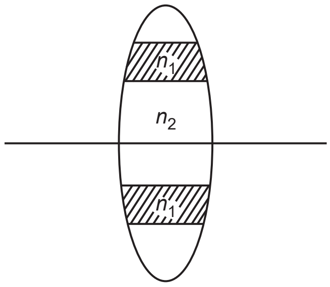
What is the geometrical shape of the wavefront for:

(i) Light diverging from a point source?

(ii) The pattern of wavefront of light from a distant star intercepted by earth?

Question 3.

(i) A lens is made of two different materials of refractive indices n_1 and n_2, as shown. A point object is placed on the principal axis. How many images of the object will be formed by the lens?



OR

(ii) Is it possible that a convex lens may behave as a concave lens in some situation? Explain with an example.

Question 4.

A ray of light is refracted through a prism on the position of minimum deviation. The angle of the prism is 60° and the refractive index of its material is 1.532. Find:

(i) The angle of minimum deviation.

(ii) The corresponding angles of incidence and refraction.

Question 5.

What is the advantage of an LED bulb over the filament electric bulb ?

Question 6.

(i) Calculate the radius of the nucleus of an element whose mass number is 64. ($R_0 = 1.2 \times 10^{-15}$ m)

OR

(ii) Calculate the energy released in the nuclear reaction

$$_1H^2 + {_1H^2} \rightarrow 2He^4 \text{ +Energy}$$

(Mass of $_1H^2$ = 2.0141002 u, Mass of $_2He^4$ = 4.002604 u)

Section-C

Question 7.

(i) A thin convex lens of focal length 10 cm is placed in contact of a thin concave lens of focal length 15 cm. Find:

(a) The focal length

(b) Power, and

(c) The nature of the combined lens system.

OR

(ii) What should be the power of a lens in order to change the reducing distance from 50 cm to 25 cm? Also, name the type of lens used.

Question 8.

Derive the general relation for the magnifying power of an astronomical telescope when image is formed at infinity. State any one advantage of an astronomical of the reflecting type over a refracting type.

Question 9.

For which spectral color of light is:

(i) The speed maximum in glass

(ii) The speed minimum in glass

(iii) What happen to the speed in vacuum?

Question 10.

The energy of an electron in an excited hydrogen atom is – 3.4 eV. Calculate the angular momentum of the electron according to the Bohr's theory. ($h = 6.626 \times 10^{-34}$ Js)

Question 11.

Read the passage given below and answer the questions that follow:

Nuclear binding energy is used to determine whether fission or fusion will be a favourable process. The mass defect of a nucleus represents the mass of the energy binding the nucleus and it is the difference between the mass of a nucleus and the sum of the masses of the nucleons of which it is composed.

(i) Calculate mass defect and binding energy of ${}_{10}Ne^{20}$ = 19.992397 u, $m({}_1H^1)$ = 1.007825 u, $m({}_0n^1)$ = 1.008665 u.

(ii) What is mass defect? and how is it related to binding energy?

Question 12.

(i) What is meant by doping in semiconductors? What are p-type semiconductors? Draw the circuit diagram of reverse biasing of a semiconductor diode.

OR

(ii) What is a photodiode? Explain in brief. Mention some uses of photodiode.

Answers

Section-A

Answer 1.

(i) Angle of incidence is equal to the angle of emergence under the condition of minimum deviation.

(ii) The waves associated with the moving particles of matter are called matter waves.

(iii) For a germanium p-n junction, the magnitude of potential barrier is about 0.3V.

(iv) (b) 4 : 1

Explanation :

$$a_1 : a_2 = 1 : 3$$
$$I_1 : I_2 = (a_1 + a_2)^2 : (a_1 - a_2)^2$$
$$= 4^2 : 2^2 = 16 : 4$$
$$= 4 : 1.$$

(v) (a) 10 cm, – 15 cm

Explanation :

Let focal length of thin concave lens and convex lens are f_1 and f_2 respectively.

Given: $$\frac{f_1}{f_2} = \frac{3}{-2}$$

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{30}$$

$$\frac{-2}{3f_2} + \frac{1}{f_2} = \frac{1}{30}$$

$$\frac{1}{3f_2} = \frac{1}{30}$$

$$f_2 = 10 \text{ cm}$$

$$\because \quad \frac{f_1}{f_2} = \frac{-3}{2}$$

$$f_1 = -15 \text{ cm}$$

(vi) (b) Balmer Series

Explanation :

Balmer series lies in visible region of hydrogen spectrum.

(vii) (b) 75

Explanation :

de-Broglie wavelength of the particle $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}}$

where E_k is the kinetic energy of the particle.

If E_k increases to 16 times, then

New wavelength $\lambda' = \sqrt{\frac{2mE_k}{2mE_k.16}} \times \lambda = \sqrt{\frac{1}{16}}\lambda$

$$= \frac{\lambda}{4} = 25\%\ \lambda$$

Hence percentage change in de-Broglie wavelength is 75%.

Section-B

Answer 2.

(i) Light diverging from a point source will have a spherical wavefront.

(ii) The portion of wavefront of light from a distant star intercepted by the earth will be a plane wavefront.

Answer 3.

(i) There will be two different focal lengths of the lens because of the two materials of different refractive indices. Hence, there will be two images that will be formed.

OR

(ii) Yes, a convex lens can behave as a concave lens when it is placed in a medium of refractive index greater than that of the material of the lens. Example, if a convex lens of glass ($n = 1.50$) is immersed in carbon disulphide ($n = 1.63$) then it will behave as concave lens.

Answer 4.

(i) If A be the refracting angle of the prims and δ_m the minimum deviation produced, then the refractive index of its material is given by:

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

Here given: $n = 1.532$, $A = 60°$, $\delta_m = ?$

$$1.532 = \frac{\sin\left[\frac{60°+\delta_m}{2}\right]}{\sin\left(\frac{60°}{2}\right)}$$

$$\sin\left[\frac{(60^\circ+\delta_m)}{2}\right] = 1.532 \times \sin 30^\circ = 1.532 \times 0.5$$

$$= 0.766$$

Thus, $$\frac{60^\circ+\delta_m}{2} = \sin^{-1}(0.766) = 50^\circ$$

$\therefore$ $$\delta_m = 100^\circ - 60^\circ = 40^\circ.$$

(ii) The corresponding angle of incidence is given by:

$$i = \frac{A+\delta_m}{2} = \frac{(60^\circ+40^\circ)}{2} = 50^\circ$$

And the angle of refraction, $$r = \frac{A}{2} = \frac{60^\circ}{2} = 30^\circ.$$

Answer 5.

LEDs are energy saving, operating at low voltage, less energy dissipating (heating) and with much longer life compared to ordinary filament lamps.

Answer 6.

(i) The radius of the nucleus of the atom is

$$R = R_0A^{1/3}, \text{ where A is mass number}$$
$$= 1.2 \times 10^{-15} \times (64)^{1/3} \text{ m}$$
$$= 4.8 \times 10^{-15} \text{ m}$$
$$= 4.8 \text{ fermi}$$

OR

(ii) $$\text{Mass of } {}_1H^2 + {}_1H^2 = (2.014102 + 2.014102)\ u$$
$$= 4.028204\ u$$
$$\text{Mass defect, } \Delta m = (4.028204 - 4.002604)\ u$$
$$= 0.0256u$$

Its equivalent energy is,

$$\Delta E = (\Delta m) \times c^2$$
$$= (0.0256) \times c^2$$

But $$1\ u \times c^2 = 931.5 \text{ MeV}$$

$\therefore$ $$\Delta E = 0.0256 \times 931.5 \text{ MeV} = 23.8464 \text{ MeV}.$$

Section-C

Answer 7.

(i) (a) The focal length of the combination is given by

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

Here, $f_1 = 10$ cm (convex) and $f_2 = -15$ cm (concave)

$\therefore$ $$\frac{1}{f} = \frac{1}{10}-\frac{1}{15} = \frac{3-2}{30} = \frac{1}{30}$$

or $$f = 30 \text{ cm} = 0.3 \text{ m}$$

(b) The power of the combination is

$$P = \frac{1}{f(\textit{in meter})} = \frac{1}{0.3}D = +3.33D$$

(c) The combination is a converging lens of focal length 30 cm.

OR

(ii) The required lens should form the image of an object placed 25 cm away from the lense at a distance 50 cm away.

Here, $u = -25$ cm, $v = -50$ cm, $f = ?$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = -\frac{1}{50} + \frac{1}{25} = \frac{-1+2}{50} = \frac{1}{50}$$

or $$f = 50 \text{ cm}, v = +\,0.5\text{m}$$

The power of the lense

$$P = \frac{1}{f(in\ meter)} = \frac{1}{0.5}D = +2D$$

The required lens is convex.

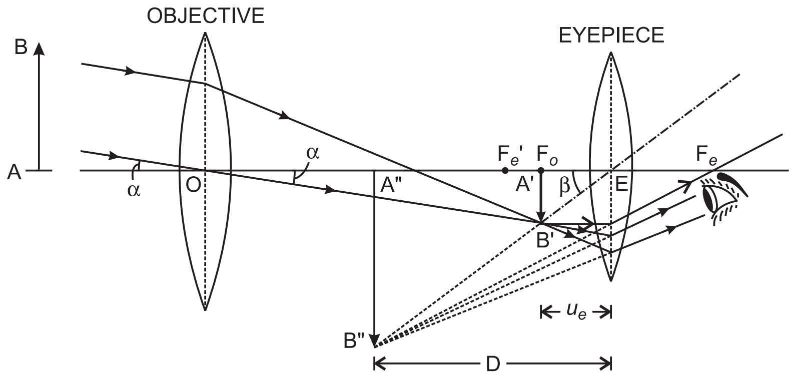
Answer 8.

The magnifying power (angular magnification) of a telescope is defined by

$$M = \frac{\text{Angle subtended by the final image at the eye}}{\text{Angle subtended by the object at the eye when the object is in its actual position}}$$

Since, eye is near the eyepiece E, the angle β subtended by the final A″B″ image at the eyepiece may be taken as the angle subtended at the eye. In the same way, since the object AB is very far from the telescope, the angle subtended by the object at the objective may be taken as the angle subtended at the eye. Then,

$$M = \frac{\beta}{\alpha}$$



Since angles β and α are very small, we may write,

$$\beta = \tan\beta = \frac{A'B'}{EA'}$$

and $$\alpha = \tan\alpha = \frac{A'B'}{OA'}$$

∴ $$M = \frac{\dfrac{A'B'}{EA'}}{\dfrac{A'B'}{OA'}} = \frac{OA'}{EA'}$$

If the focal length of the objective O is f_0 and the distance of A′B′ from the eyepiece E is u_e then, with proper sign, OA′ $= +f_0$ and EA′ $= -u_e$ Thus, by the above equation,

we have $$M = -\frac{f_o}{u_e}$$

Substituting $u_e = f_e$, we get

$$M = -\frac{f_o}{f_e}$$

Advantage of reflecting telescope over refracting type telescope :

1. Chromatic aberration is absent in reflecting type telescope.

2. Image are brighter compared to that in refracting type telescope.

Answer 9.

(i) Red light has maximum speed in glass.

(ii) Violet light has minimum speed in glass.

(iii) The speed of all spectral colors of light is the same in vacuum.

Answer 10.

In Hydrogen atom, the energy of electron in the n^{th} energy level is,

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

Here, $E_n = -3.4\text{eV}$

$\therefore$ $$-3.4 = \frac{13.6}{n^2}$$

or, $$n^2 = \frac{13.6}{3.4} = 4$$

$\therefore$ $n = 2$

According to Bohr's Theory, the angular momentum of the electorns is,

$$\frac{nh}{2\pi} = \frac{2\times 6.626\times 10^{-34}}{2\times 3.14}$$

$$= 2.11 \times 10^{-34}\ \text{Js}$$

Answer 11.

(i) Mass defect (Δm) = mass of nucleons – mass of nucleus

$$= [10(1.007825 + 1.008665) - 19.992397]u$$

$$= 0.172503u$$

Binding Energy, $\Delta E = 0.172503 \times 931$ MeV

$$= 160.600 \text{ MeV}$$

(ii) The sum of masses of neutrons and protons forming a nucleus is more than the actual mass of the nucleus. This difference of masses is known as mass defect.

$$\Delta m = Zm_p + (A - Z)m_n - M$$

Where, Z = Atomic number, A = mass number, m_p = mass of proton, m_n = mass of neutron, M = mass of nucleus.

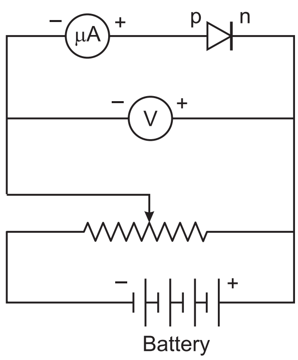
Binding energy, is given by $\Delta E = \Delta m \times c^2$

Answer 12.

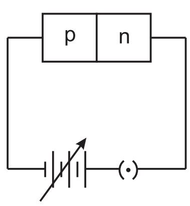
(i) **Doping :** The process of adding a measured quantity of a trivalent or a pentavalent impurity to a pure semiconductor to increase its electrical conductivity is called doping.

***p*-type semiconductor :** When trivalent impurity is added to a pure tetravalent semiconductor in small measured quantity, it gives an excess of majority charge carriers *i.e.,* holes. Such type of semiconductors are called *p*-type semiconductor.

Diagram of the reverse biasing of a semiconductor :



OR



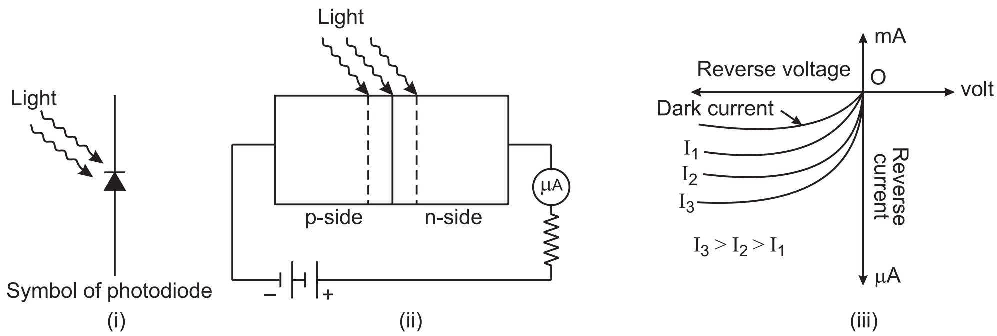
OR

(ii) Photodiode is a *p-n* junction which is an optoelectronic device in which current carriers are generated by photons through photo excitation, *i.e.,* photoconduction by light.

A photodiode is a special *p-n* junction diode made of photosensitive semiconducting material. It is operated under reverse bias below the breakdown voltage. The conductivity of *p-n* junction photodiode is modulated by the absorption of incident light in or near the depletion layer which exists at the *p-n* junction. The conductivity of the *p-n* junction photodiode increases with the increase in intensity of light falling on it.

Symbolically, a photodiode is shown in the figure (i). Figure (ii) shows an experimental arrangement for the study of V-I characteristics of a photodiode in which the photodiode is reverse biased.

When the photodiode is reverse biased with a voltage less than its breakdown voltage and no light is incident on its junction, the reverse current is extremely small (almost negligible). This current is called dark current.



When visible light of energy greater than forbidden energy gap (*i.e.,* $h\nu > E_g$) is incident on a reverse biased *p-n* junction photodiode, additional electron-hole pairs are created in the depletion layer (or near the junction). These charge carriers will be separated by the junction field and made to flow across the junction, creating a reverse current across the junction. The value of reverse saturation current increases with the increase in the intensity of incident light as shown in figure (iii), which is the V-I characteristics of photodiode. It is found that the reverse saturation current through the photodiode varies almost linearly with the light flux or light intensity.

Photodiodes are used for following purposes :

(i) In photodetection of optical signals.

(ii) In demodulation of optical signals.

(iii) In switching the light on and off.

(iv) In optical communication equipments.

(v) In logic circuits that require stability and high speed.

(vi) In reading of computers, punched cards and tapes, etc.

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