ISC SEMESTER 2 EXAMINATION

SAMPLE PAPER - 3

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) What are the applications of $p-n$ Junction diode?

(ii) Calculate the de-Broglie wavelength of a proton of kinetic energy 500 eV. The mass of proton is 1.67×10^{-27} kg.

(iii) What is the magnitude of the potential across a Si $p-n$ Junction?

(iv) A beam of electrons is used in Young's double slit experiment. If the speed of electrons is increased then the fringe width will :

(a) increase
(b) decrease
(c) remains same
(d) fringes will not be seen

(v) A double convex lense of glass ($n = 1.5$) has a focal length of 10 cm in air. When immersed in a liquid of refractive index 3.0, the lens will behave as :

(a) converging lens of focal length 10 cm.
(b) converging lens of focal length 30 cm.
(c) diverging lens of focal length 10 cm.
(d) converging lens of focal length $\frac{10}{3}$ cm.

(vi) A hydrogen atom (ionisation potential 13.6 V) makes a transition from third excited state to second excited state. The energy of the photon emitted in the process is:

(a) 0.66 eV
(b) 2.55 eV
(c) 12.09 eV
(d) 12.75 eV

(vii) The wevelength of de-Broglie waves associated with a moving particle is independent of its:

(a) velocity
(b) charge
(c) momentum
(d) mass

Section-B

Question 2.

(i) State one assumption made in deriving the formula $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ for refraction at a spherical interface.

(ii) Can the optical centre of a lens be situated outside the lens?

Question 3.

(i) Light of wevelength 5100 Å from a narrow slit is incident an a double slit. It the overall separation of 10 fringes on a screen 0.2m away is 2×10^{-2} m, find the slit separation.

OR

(ii) State one similarity and one difference between interference and diffraction of light.

Question 4.

(i) What is the angle of refraction made by a ray of light inside a regular (that is, an equilateral) glass prism in the minimum deviation case?

(ii) State one condition for observing a sustained interference of light.

Question 5.

Distinguish between intrinsic and extrinsic semiconductors.

Question 6.

(i) The threshold wavelength for tungsten is 2400 Å. When tungsten is illuminated with light of wavelength 1600 Å, find : (a) work function, (b) maximum kinetic energy of emitted electrons.

OR

(ii) Monochromatic light of wavelength 198 nm is incident on the surface of a metallic cathode, whose work function is 2.5 eV. How much potential difference must be applied between the cathode and the anode of a photocell to just stop the photo-current from flowing?

Section-C

Question 7.

(i) Laser light of wevelength 720 mm is incident on a pair of slits which are separated by 1.8 mm. If the screen is kept 100 cm away from the two slits. Calculate.

(a) Fringe separation (fringe-with).

(b) Distance of 10^{th} bright fringe from the centre of the interference pattern.

OR

(ii) Draw a labelled ray diagram showing the formation of an image by a refracting telescope when the final image lies at infinity.

Question 8.

A compound microscope consists of two convex lenses having focal length of 1·5 cm and 5 cm. When an object is kept at a distance of 1·6 cm from the objective, the final image is virtual and lies at a distance of 25 cm from the eyepiece. Calculate magnifying power of the compound microscope in this set-up.

Question 9.

The refractive indices of silicate flint glass for wavelength 400 nm and 700 nm are 1.66 and 1.61 respectively. Find the minimum angle of deviation of an equilateral prism made of this glass for light of wavelength 400 nm and 700 nm.

Question 10.

What do you mean by the distance of the closest approach of an α-particle in Rutherford experiment ? Derive its expression.

Question 11.

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

A neutron is absorbed by a $_3Li^6$ nucleus with subsequent emission of an α-particle. Alpha (α) particles are composite particles consisting of two protons and two neutron highly bound together.

Given:

$$m(_0n^1) = 1.00865\ u$$
$$m(_3Li^6) = 6.015126\ u$$
$$m(_2He^4) = 4.002603\ u$$
$$m(_1H^3) = 3.016049\ u$$
$$1\ u \times c^2 = 931.5\ MeV$$

(i) Write the corresponding nuclear reaction.

(ii) Calculate the energy released in the reaction.

Question 12.

(i) Distinguish between n-type and p-type semiconductors.

OR

(ii) Draw the circuit diagram of a full wave rectifier. Draw the input and output wave forms.

Answers

Section-A

Answer 1.

(i) It can be used as a solar cell when diode is forward-biased. It is used in LED lighting applications. It is used as rectifiers in many electric circuits.

(ii) We know de-Broglie wavelength is given by :

$$\lambda = \frac{h}{\sqrt{2mK}}$$

Given :

$$m = 1.67 \times 10^{-27}\ kg$$
$$K = 500\ eV$$
$$= 500 \times 1.6 \times 10^{-19}\ J$$

$$\therefore \quad \lambda = \frac{6.67 \times 10^{-34}}{\sqrt{2 \times (1.67 \times 10^{-27})(500 \times 1.6 \times 10^{-19})}} = 1.28 \times 10^{-12}\ m.$$

(iii) The potential difference across the junction or diode by the action of the depletion layer at approximately 0.7V for silicon.

(iv) (b) decrease

Explanation :

For electron $\quad \lambda = \frac{h}{p} = \frac{h}{mv}$

Fringe width $\quad \beta = \frac{\lambda D}{d} = \frac{hD}{mvd}$

$\Rightarrow \quad \beta \ \alpha \ \frac{1}{v}$

Hence speed increased then fringe width will decrease.

(v) (c) diverging lense of local length 10 cm

Explanation :

By $$\frac{1}{f} = \left(\frac{n_g}{n_l} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ [When lens is immersed in medium]

and $$\frac{1}{F} = (n_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ [When lens in air]

Now $$\frac{F}{f} = \frac{\left(\frac{n_g}{n_l} - 1\right)}{(n_g - 1)}$$

$\Rightarrow$ $$\frac{10}{f} = \left[\frac{1.5/3 - 1}{0.5}\right]$$

$\Rightarrow$ $$f = \frac{5}{-0.5}$$

$$= -10 \text{ cm} = -ve$$

Hence, focal length of lens is negative and it behave as concave lens.

(vi) (a) 0.66 eV

Explanation :

$$\Delta E = E_3 - E_4$$ ($\because$ For 2nd excited state $n = 3$, for 3rd. $n = 4$)

$$= 13.6\left[\frac{1}{3^2} - \frac{1}{4^2}\right]$$

$$= 13.6\left[\frac{1}{9} - \frac{1}{16}\right]$$

$$= 13.6 \times \left[\frac{16-9}{16 \times 9}\right] = 0.66 \text{ eV}$$

(vii) (b) charge

de-Broglie wavelength is given by, $\lambda = \frac{h}{mv} = \frac{h}{p}$

Section-B

Answer 2.

(i) The aperture of the spherical surface is small.

(ii) Yes, for concavo-convex and convexo-concave lenses the optical centre will be outside the lens.

Answer 3.

(i) Given : $D = 0.2\text{m}, \lambda = 5100 \text{ Å} = 5.1 \times 10^{-7}$ m

$$\beta = \frac{2 \times 10^{-2}}{10} = 0.2 \times 10^{-2} \text{ m}$$

Slit separation, $$d = \frac{D\lambda}{\beta} = \frac{0.2 \times 5.1 \times 10^{-7} \text{ m}^2}{0.2 \times 10^{-2} \text{ m}}$$

$$= 5.1 \times 10^{-5}\text{m}$$

(ii) **Similarity :** Both interference and diffraction demonstrate the wave nature of light.

Difference : In interference the bright and dark bands (fringes) are of uniform intensity, but same is not true for diffraction.

Answer 4.

(i) For minimum deviation,

r = A/2, where A is angle of prim

(ii) The two light sources must be coherent.

Answer 5.

(i)	It is a pure, natural semiconductor, such as pure Ge and pure Si.	It is prepared by adding a small quantity of impurity to a pure semiconductor, such as *n*-type and *p*-type semiconductors.
(ii)	Intrinsic charge carriers like electrons and holes have equal concentration.	In *p*-type semiconductor majority charge carriers are holes and minority charge carriers are electrons, while *vice-versa* in *n*-type semiconductor.
(iii)	Its electrical conductivity is very low.	Its electrical conductivity is significantly high.
(iv)	Its conductivity cannot be controlled.	Its conductivity can be controlled by adjusting the quantity of the impurity added.
(v)	Its conductivity increases exponentially with temperature.	Its conductivity also increases with temperature but not exponentially.

Answer 6.

(i) (a) Let threshold wavelength be λ_0, then

$$W = \frac{hc}{\lambda_0}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{2400 \times 10^{-10}}$$

$$= 8.25 \times 10^{-19}\ \text{J}$$

(b) Maximum kinetic energy of emitted electrons is given by :

$$E_k = h\nu - W$$

$$= \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$= hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

$$= 6.6 \times 10^{-34} \times 3 \times 10^{8}\left[\frac{(2400 - 1600) \times 10^{-10}}{1600 \times 10^{-10} \times 2400 \times 10^{-10}}\right]$$

$$= 4.125 \times 10^{-19}\ \text{J.}$$

OR

(ii) $$eV_0 = \frac{hc}{\lambda} - W$$

or Stopping potential $$V_0 = \frac{hc}{e\lambda} - \frac{W}{e}$$

Here, $\lambda = 198 \text{ nm} = 198 \times 10^{-9} \text{ m}$

$$W = 2.5\ eV = 2.5 \times 1.6 \times 10^{-19} \text{J}$$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$V_0(\text{stop potential}) = \left(\frac{hc}{\lambda} - W\right)\frac{1}{e}$$

$$V_0 = \left(\frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times198\times10^{-9}} - \frac{2.5\times1.6\times10^{-19}}{1.6\times10^{-19}}\right)\text{V}$$

$$= 3.75\text{V}$$

Section-C

Answer 7.

(i) (a) The fringe width is given by

$$\beta = \frac{D\lambda}{d}$$

$$D = 100 \text{ cm} = 1 \text{ m}$$

$$\lambda = 720 \text{ nm} = 720 \times 10^{-9}\text{m}$$

$$d = 1.8 \text{ mm} = 1.8 \times 10^{-3} \text{ m}$$

$$\therefore \quad \beta = \frac{1\times720\times10^{-9}}{1.8\times10^{-3}} = 4\times10^{-4}\text{ m}$$

$$= 0.4 \text{ mm}$$

(b) The distance of n^{th} order bright fringe from the centre is given by

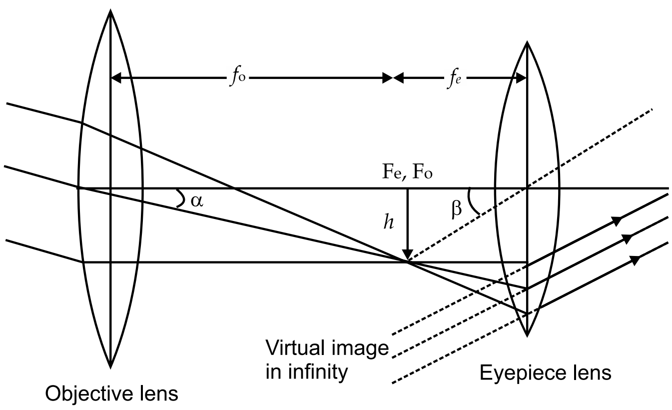
$$x = \frac{mD\lambda}{d} \qquad [\because m = 10]$$

$$= 10 \times 0.4 \text{ mm}$$

$$= 4 \text{ mm}$$

OR

(ii)



When final image forms at infinity $u_e = f_e$

Magnifying power of telescope $m = \frac{-f_0}{f_e}$

Answer 8.

D = 25 cm

$u_0 = -1.6$ cm, $f_0 = 1.5$ cm, $f_e = 5$ cm, M = ?

For objective :

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

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

$$\Rightarrow \quad \frac{1}{v_0} = \frac{1}{1.5} + \frac{1}{-1.6}$$

$$10\left[\frac{1}{15} - \frac{1}{16}\right] = \frac{10}{15 \times 16}$$

$$\Rightarrow \quad v_0 = \frac{16 \times 15}{10} = 1.6 \times 15 \text{ cm} = 24 \text{ cm}$$

Answer 9.

Angle of minimum deviation is given by,

$$\mu = \frac{\sin\frac{(A + \delta_m)}{2}}{\sin\frac{A}{2}}$$

$$= \frac{\sin\frac{(60^\circ + \delta_m)}{2}}{\sin\left(\frac{60^\circ}{2}\right)} = \frac{\sin\left(30^\circ + \frac{\delta_m}{2}\right)}{\sin 30^\circ}$$

$$= 2\sin\left(30^\circ + \frac{\delta_m}{2}\right)$$

For 400 mm light, $$1.66 = 2\sin\left(30^\circ + \frac{\delta_m}{2}\right)$$

or $$\sin\left(30^\circ + \frac{\delta_m}{2}\right) = 0.83$$

$$30^\circ + \frac{\delta_m}{2} = 56^\circ$$

$$\delta_m = 52^\circ$$

For 700 nm light, $$1.61 = 2\sin\left(30^\circ + \frac{\delta_m}{2}\right)$$

Similarly, $$\delta_m = 47.22^\circ$$

Answer 10.

An α-particle directed towards the centre of the nucleus will move close up to a distance r_0 where its kinetic energy will appear as potential energy. This distance r_0 is called 'distance of closest approach'.

Kinetic energy of an α-particle is given by,

$$\text{K.E.} = \frac{1}{2}mv^2 \quad \ldots\text{(i)}$$

The electrostatic potential energy of the α-particle of charge $2e$ at a distance r_0 is given by,

$$\text{P.E.} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(Ze)\times 2e}{r_0}$$

Where Z is the atomic number of the atom, so its charge is Ze.

At distance r_0 of closest approach, both P.E. and K.E. are balanced. Thus,

$$\text{P.E.} = \text{K.E.}$$

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{(Ze)\times 2e}{r_0} = \frac{1}{2} mv^2$$

$$r_0 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4Ze^2}{mv^2} = \frac{Ze^2}{\pi\varepsilon_0 mv^2}$$

Answer 11.

(i) The nuclear reaction is

$${}_3\text{Li}^6 + {}_0n^1 \rightarrow {}_1\text{H}^3 + {}_2\text{He}^4 \text{ (α–particle)}$$

(ii) Mass of ${}_3\text{Li}^6 + {}_0n^1$ = 6.015126 u + 1.008665 u = 7.023791 u

Mass of ${}_1\text{H}^3 + {}_2\text{He}^4$ = 3.016049 u + 4.002603 u = 7.018652 u

∴ Mass loss, Δm= 7.023791 – 7.01862 = 0·005139 u

Its energy equivalent is $\Delta E = (\Delta m) \times c^2 = (0.0005139 \text{ u}) \times c^2$

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

∴ $\Delta E = 0.005139 \times 931.5 = 4.787$ MeV

Answer 12.

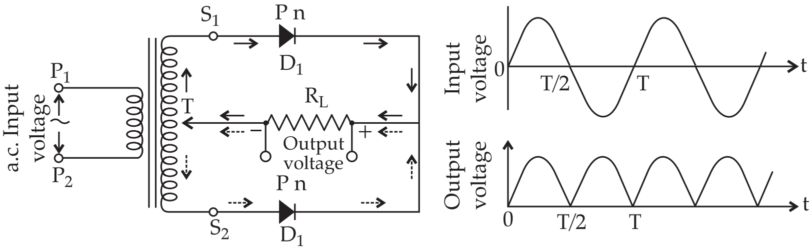
(i)

(i)	It is an extrinsic semiconductor obtained by adding a pentavalent impurity to a pure intrinsic semiconductor.	It is also an extrinsic semiconductor obtained by adding a trivalent impurity to a pure intrinsic semiconductor.
(ii)	The impurity atoms added provide extra free electrons to the crystal lattice and are called donor atoms.	The impurity atoms added create holes in the crystal lattice and are called acceptor atoms because the created holes accept electrons.
(iii)	The electrons are majority carriers and the holes are minority carriers.	The holes are majority carriers and the electrons are minority carriers.
(iv)	The electrons concentration is much more than the hole concentration ($n_e >> n_h$).	The hole concentration is much more than the electron concentration ($n_h >> n_e$).

OR

(ii) ***p-n* Junction Diode as Full-wave Rectifier :** In a full-wave rectifier, a unidirectional, pulsating output current is obtained for both halves of the a.c. input voltage. Essentially, it requires two junction diodes so connected that one diode rectifies one half and the second diode rectifies the second half of the input.

The circuit for a full-wave rectifier is shown in Fig. (a) and the input and the output wave forms in fig. (b). The a.c. input voltage is applied across the primary P_1P_2 of a transformer. The terminals S_1 and S_2 of the secondary are connected to the *p*-type crystals of the junction diodes D_1 and D_2 whose *n*-type crystals are connected to each other. A load resistance R_L is connected across the *n*-types crystals and the central tapping T of the secondary S_1S_2.



S1
P n
D1
P1
a.c. Input voltage
P2
T
RL
− +
Output voltage
S2
P n
D1
Input voltage
0
T/2
T
t
Output voltage
0
T/2
T
t

(a) (b)

❑❑