ISC SEMESTER 2 EXAMINATION
SPECIMEN QUESTION PAPER
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***

The intended marks for questions are given in brackets [ ].

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 – 7 MARKS

Question 1

(i) What is meant by a *wavefront*? **[1]**

(ii) Find the de Broglie wavelength of electrons moving with a speed of 7×10^{6} ms^{-1}. **[1]**

(iii) State how a p-type semiconductor will be obtained from a pure crystal of a semiconductor. **[1]**

(iv) In case of a **regular** prism, **in minimum deviation** position, angle made by the refracted ray (inside the prism) with the normal drawn to the refracting surface is: **[1]**

(a) 90°

(b) 60°

(c) 45°

(d) 30°

(v) In **Young's double slit experiment**, what is the effect on fringe pattern if the slits are brought closer to each other? **[1]**

(a) Fringes disappear.

(b) Fringe width increases.

(c) Fringe width decreases.

(d) Fringe width remains unaltered.

(vi) First line of **Balmer** series (H_α) in the spectrum of hydrogen is obtained when an electron of hydrogen atom goes from: **[1]**

(a) 2^{nd} orbit to 1^{st} orbit

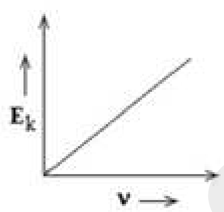
(b) 2^{nd} orbit to 3^{rd} orbit

(c) 3^{rd} orbit to 2^{nd} orbit

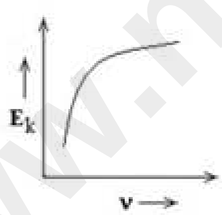
(d) 3^{rd} orbit to 1^{st} orbit

(vii) Which of the following graphs correctly represents the variation of maximum kinetic energy (E_k) of photoelectrons with the frequency (ν) of the incident radiation? **[1]**

(a)



(b)



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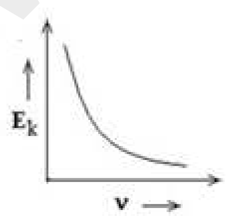

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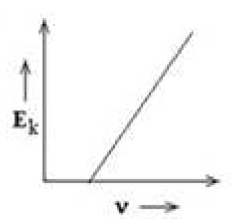


SECTION B – 10 MARKS

Question 2 **[2]**

(i) What is meant by *Constructive interference*?

(ii) In Young's double slit experiment, what should be the phase difference between the two overlapping waves to obtain 5^{th} dark band/fringe on the screen?

Question 3 **[2]**

(i) A thin converging lens of focal length 5cm is used as a **simple microscope**. Calculate its **magnifying power** when image formed lies at:

(a) Infinity.

(b) Least distance of distinct vision (D = 25 cm).

OR

(ii) A thin **converging** lens of focal length 12cm is kept in contact with a thin **diverging** lens of focal length 18cm. Calculate the **effective/equivalent** focal length of the combination.

Question 4 **[2]**

(i) Define *angular dispersion*.

(ii) State *any one* difference between a *primary rainbow* and a *secondary rainbow*.

Question 5 **[2]**

Explain the following terms:

(i) Intrinsic semiconductor.

(ii) Extrinsic semiconductor.

Question 6 **[2]**

(i) Calculate **maximum kinetic energy** of photoelectrons emitted by a metal (work function = $1 \cdot 5$eV) when it is illuminated with light of wavelength 198 nm.

OR

(ii) Calculate the minimum amount of energy which a gamma ray photon should have for the production of an electron and a positron pair.

SECTION C – 18 MARKS

Question 7 **[3]**

(i) In a single slit diffraction experiment, how does the angular width of the central maxima change when:

(a) screen is moved away from the plane of the slit?

(b) width of the slit is increased?

(c) light of larger wavelength is used?

OR

(ii) Using Huygen's wave theory of light, prove Snell's law of refraction of light.

Question 8 **[3]**

Draw a ray diagram of a refracting astronomical telescope when final image is formed at infinity. Also write the expression for its angular magnification (magnifying power).

Question 9 **[3]**

Radius of curvature of an equi – convex lens of glass ($n = 1{\cdot}5$) is 30 cm. Find its focal length. An object of height 5·0 cm is placed at a distance of 60 cm from the optical centre of the lens. Find the position and the height of the image formed.

Question 10 **[3]**

On the basis of Bohr's theory, derive an expression for the radius of the nth orbit of an electron of hydrogen atom.

Question 11 **[3]**

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

Mr. Ravi had been living in a small town with his family for many years. He decided to shift to a city when he learnt that a nuclear power plant would be built in his town. His son Prakash, who was a science teacher, did not agree with his father's decision.

Prakash explained to his father how mass defect during nuclear fission released energy. He assured his father that the authorities were taking all the possible safety measures to avoid any kind of nuclear mishap. Mr. Ravi understood the scientific explanation given by his son and decided not to shift to another place.

(i) What is the **cause** of energy generation of a nuclear reactor during nuclear fission?

(ii) Write one nuclear reaction for **nuclear fission** that takes place in a nuclear reactor.

(iii) Give the formula for the energy generation that takes place in the nuclear reactor.

Question 12 **[3]**

(i) Answer the following questions.

(a) Draw the circuit diagram of a *full wave rectifier*.

(b) Draw labelled graphs showing the input and output voltages.

OR

(ii) With reference to Semiconductor Physics,

(a) Name the diode that emits spontaneous radiation when forward biased.

(b) Draw a labelled energy band diagram for a *semiconductor.*

(c) Name the process that causes depletion region in a p-n junction.

Useful Constants & Relations:

1	Mass of electron/positron	m	$9{\cdot}1 \times 10^{-31}$ kg
2	Charge of an electron	e	$1{\cdot}6 \times 10^{-19}$ C
3	Speed of light in vacuum	c	$3{\cdot}0 \times 10^{8}$ ms^{-1}
4	Planck's constant	h	$6{\cdot}6 \times 10^{-34}$ Js
5	1nm	=	1×10^{-9} m
6	1eV	=	$1{\cdot}6 \times 10^{-19}$ J

Answers

Section-A

Answer 1.

(i) Wavefront is defined as the imaginary surface in a medium such that all the medium particles lying on the surface are in the same phase of oscillation. It propagates along the direction of propagation of the wave with the same velocity as that of the wave.

(ii) De Broglie wavelength of electron,

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

Here, $h = 6.6 \times 10^{-34}$ Js, $m = 9.1 \times 10^{-31}$ kg

$v = 7 \times 10^{6}\ \text{ms}^{-1}$

$$\therefore \quad \lambda = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 7 \times 10^{6}}$$

$$= 1.03 \times 10^{-10} \text{ m.}$$

(iii) A p-type semiconductor can be obtained by adding a trivalent impurity such as aluminium with a pure crystal of a semiconductor (silicon or germanium).

(iv) (d) 30°

Explanation :

In the position of minimum deviation,

$$2r = A$$

or $$r = \frac{A}{2} = \frac{60°}{2} = 30°$$

(v) (b) Fringe with increases.

Explanation :

Fringe width, $\beta = \dfrac{D\lambda}{d}$

On decreasing d, the fringe width increases

(vi) (c) 3rd orbit to 2nd orbit.

Explanation :

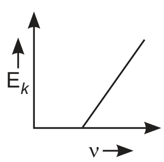
For balmer series

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

where $n = 3, 4, 5, ...$

For first line of balmer series (H_α), $n = 3$.

(vii) (d)



Explanation :

According to Einstein's photo-electric equation $E_k = h\nu - w$, hence option (d) is correct.

Section-B

Answer 2.

(i) When two waves meet at a point with phase difference $(\phi) = 2m\pi$, where $m = 0, 1, 2, ...$ or a path difference $(x) = m\lambda$, where $m = 0, 1, 2, ...$ then we obtain constructive interference.

(ii) For 5th dark fringe,

phase difference $(\phi) = (2m - 1)\pi$

Here, $m = 5$

$\therefore \quad \phi = (2m - 1)\pi = 9\pi.$

Answer 3.

(i) The magnifying power of simple microscope is $M = \frac{D}{f}$ when image lies at infinity and $M = 1 + \frac{D}{f}$ when image is at the least distance of distinct vision. Here, D = 25 cm and f = 5 cm.

(a) $$M = \frac{D}{f} = \frac{25}{5} = 5$$

(b) $$M = 1 + \frac{D}{f} = 1 + 5 = 6$$

OR

(ii) $$f_1 = 12 \text{ cm}$$
$$f_2 = -18 \text{ cm}$$

The effective focal length of the combination is,

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{12} - \frac{1}{18} = \frac{3-2}{36} = \frac{1}{36}$$

$\therefore \quad f = 36$ cm (converging lens).

Answer 4.

(i) The angle between the emergent rays of any two colours is called angular dispersion between those colours.

(ii) Primary rainbow is formed due to single total internal reflection whereas secondary rainbow is formed after double total internal reflection.

Answer 5.

(i) An intrinsic semiconductor is a pure semiconductor which is free from any impurity. Pure germanium and pure silicon are examples of intrinsic semiconductors.

(ii) When pure germanium or silicon crystal is mixed with some trivalent or pentavalent impurity to improve their conductivity then such type of semiconductor is known as an extrinsic semiconductor.

Answer 6.

(i) According to Einstein's photoelectric equation,

$$E_k = h\nu - w = \frac{hc}{\lambda} - w$$

Here $h = 6.6 \times 10^{-34}$ Js

$c = 3.0 \times 10^{8}\ ms^{-1}$

$\lambda = 198 \times 10^{-9}$ m

$w = 1.5 \times 1.6 \times 10^{-19}$ J

$$\therefore \quad E_k = \left(\frac{6.6 \times 10^{-34} \times 3.0 \times 10^{8}}{198 \times 10^{-9}} - 1.5 \times 1.6 \times 10^{-19}\right) J$$

$$= (10 \times 10^{-19} - 2.4 \times 10^{-19}) J$$

$$= 7.6 \times 10^{-19}\ J$$

OR

(ii) The rest mass energy of electron is,

$$E_0 = m_0c^2 = 9.1 \times 10^{-31} \times (3.0 \times 10^{8})^2\ J$$

$$= \frac{8.2 \times 10^{-14}}{1.6 \times 10^{-13}}\ MeV = 0.51\ MeV$$

For production of an electron and a positron pair, the minimum energy of gamma ray photon must be 2×0.51 MeV = 1.02 MeV.

Section-C

Answer 7.

(i) The angular width of central maximum $\propto \frac{\lambda}{e}$:

(a) Angular width remains unchanged when the screen is moved away from plane of the slit.

(b) The angular width decreases when the width of slit (e) is increased.

(c) The angular width will increase if light of larger wavelength (λ) is used.

OR

(ii) **Snell's law of refraction using Huygen's Principle :**

Consider a plane wavefront AB incident on a surface PQ separating two medium 1 and 2.

The medium 1 is a rarer medium of refractive index n_1 in which light travels with a velocity c_1. The medium 2 is denser medium of refractive index n_2 in which light travels with a velocity c_2.

The angle between the incident ray FA and the normal NA at the point of incidence A is equal to i.

The angle is also equal to the angle between the incident plane wavefront AB.

Similarly, the angle between the refracted wavefront and the surface of separation PQ is equal to the angle of refraction r.

i.e., $\angle ADC = r$

Consider the triangles ΔBAD, ΔACD figure below.

$$\sin i = \sin \angle BAD = \frac{BD}{AD} = \frac{c_1 t}{AD}$$

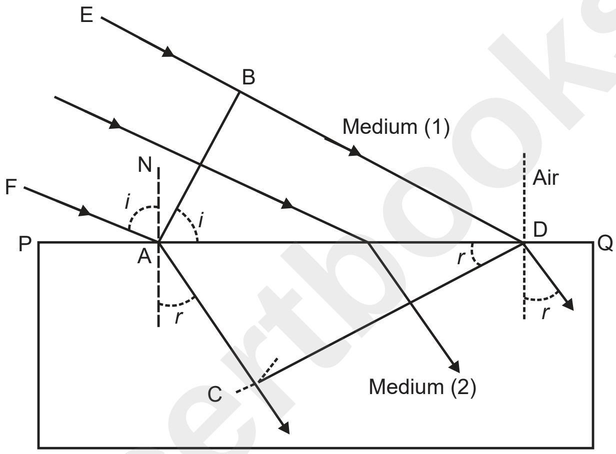
$$\sin r = \sin \angle ADC = \frac{AC}{AD} = \frac{c_2 t}{AD}$$

$$\frac{\sin i}{\sin r} = \frac{c_1 t}{c_2 t} = \frac{c_1}{c_2} = \text{constant}$$

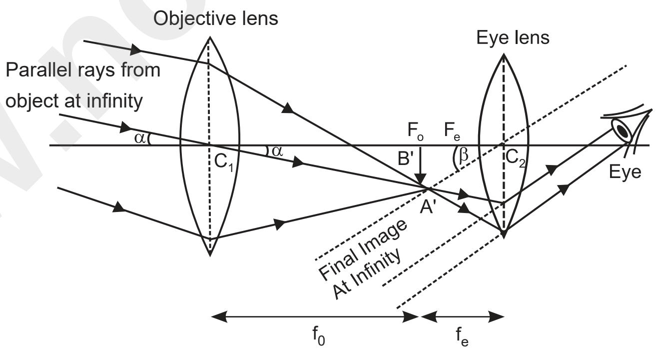
This constant is called the refractive index of the second medium (2) with respect to the first medium (1).

$$\frac{c_1}{c_2} = \frac{n_2}{n_1} = 1n_2$$

This equation proves the Snell's law.



Answer 8.



Magnifying power of a refracting astronomical telescope when final image is formed at infinity is,

$$M = -\frac{f_0}{f_e}$$

when image is formed at least distance D then,

$$M = -\frac{f_0}{f_e}\left(1+\frac{f_e}{D}\right)$$

Answer 9.

Given :

$$n = 1.5$$
$$R_1 = +30 \text{ cm}$$
$$R_2 = -30 \text{ cm}$$
$$u = -60 \text{ cm}$$

Using lens maker's formula,

$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$$

$$= (1.5-1)\left(\frac{1}{30}+\frac{1}{30}\right)$$

$$= \frac{0.5\times 2}{30} = \frac{1}{30}$$

$\therefore$ $f = 30$ cm

Linear magnification,

$$m = \frac{f}{f+u} = \frac{30}{30-60} = \frac{30}{-30} = -1$$

and $m = \frac{v}{u}$

$$-1 = \frac{v}{-60}$$

$$v = 60$$

image will be formed at 60 cm from lens.

Also, $m = \frac{\text{height of image}}{\text{height of object}}$

or, $-1 = \frac{\text{height of image}}{5}$

$\therefore$ height of image = – 5 cm.

Negative sign indicates that the image is inverted.

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,

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

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

By first postulate :

$$mvr = \frac{nh}{2\pi} \quad \text{...(ii)}$$

Where n is the quantum number.

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

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

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

For, hydrogen atom, Z = 1,

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

Answer 11.

(i) Loss in mass (or mass defect) gets converted into energy according to the formula,

$$\Delta E = (\Delta m)\, c^2$$

ΔE is the energy produced, (Δm) is mass defect and c is the speed of light.

(ii) $^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3\, ^{1}_{0}n + \text{Energy}$

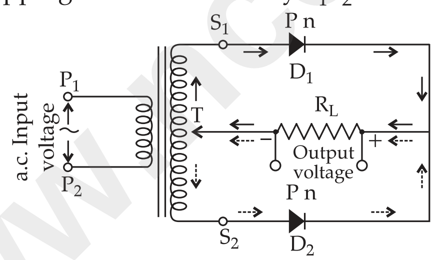
(iii) $$\Delta E = (\Delta m)\, c^2$$

ΔE is energy produced, (Δm) is mass defect and c is the speed of light.

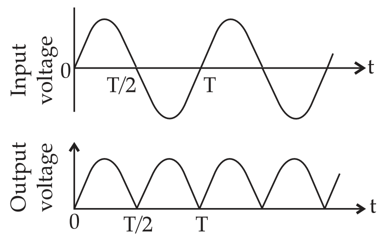
Answer 12.

(i) ***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.



(a)

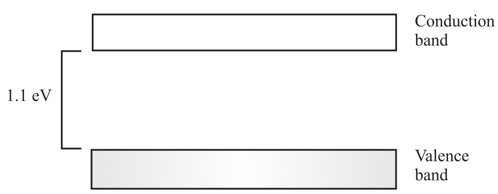


(b)

OR

(ii) (a) Light emitting diode (LED)

(b) **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.



(c) The diffusion of electrons from *n*-region to the *p*-region of the diode causes depletion region in a *p-n* junction.

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