ISC SEMESTER 2 EXAMINATION
SAMPLE PAPER - 5
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) On what factor does the maximum kinetic energy of the photoelectrons in a photo cell depend?

(ii) What is forbidden band?

(iii) What should be the order of obstacle or aperture for diffraction of light?

(iv) The angle of minimum deviation for a prism is 30° and the angle of prism is 60°. The refractive index of the prism material is :

(a) $\sqrt{2}$ (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{\sqrt{3}}{2}$ (d) $\frac{3}{\sqrt{2}}$

(v) When an extended white object is placed before a convex lens, coloured images are formed. The image of the smallest size is of the colour :

(a) violet (b) green (c) yellow (d) red

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

(a) $3r$ (c) $9r$

(b) $2.25r$ (d) $\frac{r}{3}$

(vii) The work function of a surface of photosensitive material is 6·2 eV. The wavelength of the incident radiation for which the stopping potential is 5 V lies in the :

(a) UV region (c) Infra-red region

(b) Visible region (d) X-ray region

Section-B

Question 2.

Where will you keep an object in front of a:

(i) Convex lens in order to get a virtual and magnified image?

(ii) Concave lens to get a virtual and diminished image?

Question 3.

(i) A parallel beam of light of wavelength 5890 Å falls normally on a slit of width 0.2 mm. Find the distance between the first minima on the two sides of the central maximum of the diffraction pattern observed on a screen placed in the focal plane of a convex lens of focal length 50 cm. The lens is placed quite close to the slit.

OR

(ii) How will the interference pattern of Young's double slit change if one of the two slits is covered by a paper which transmits only half of the light intensity?

Question 4.

(i) In Young's experiment, the fringe width with light of wavelength = 6500 Å is 2 mm. What will be the fringe width if the entire apparatus is immersed in liquid of refractive index 1.33 ?

(ii) Show graphically the intensity distribution in a single slit diffraction pattern.

Question 5.

Why is the resistance of a *p-n* junction low when forward biased and high when reverse-biased? Explain.

Question 6.

(i) Light of wavelength 4000 Å is incident on two metals A and B. Which metal will emit photoelectrons, if their work functions are 3.8 eV and 1.6 eV respectively?

OR

(ii) Plot a labelled graph of $|V_s|$ where V_s is stopping potential versus frequency f of the incident radiation. State how will you use this graph to determine the value of Planck's constant?

Section-C

Question 7.

(i) In Young's double slit experiment the slits are 0.589 mm apart and the interference is observed on a screen placed at a distance of 100 cm from the slits. It is found that the 9^{th} bright fringe is at a distance of 7.5 mm from the dark fringe which is second from the center of the fringe pattern. Find the wavelength of the light used.

OR

(ii) In a Young's double slit experiment, the distance between the slit and screen is 1.6 m. When light of wavelength 5.89×10^{-7} m falls on the slits, distance between the centre of the interference pattern and the fourth fringe on either side is found to be 1.60 mm. What is the slit separation?

Question 8.

There is small air bubble inside a glass sphere of radius 10 cm. The bubble is 4.0 cm below the surface and is viewed normally from the outside. Find the apparent depth of the bubble.

Question 9.

The image of a small electric bulb fixed on the wall of a room is to be obtained on the opposite wall 3.0 m away by means of a convex lens. What is the maximum focal length of the required lens?

Question 10.

The energy of an electron in the first Bohr orbit of an atom is – 27·2 eV. What will be the energy in the third orbit ?

Question 11.

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

Nuclear energy is the energy in the nucleus, or core, of an atom. Atoms are tiny units that make up all matter in the universe, and energy is what holds the nucleus together. There is a huge amount of energy in an atom's dense nucleus.

(i) How is nuclear energy created? How does it work?

(ii) How does nuclear energy impact the environment?

Question 12.

(i) Draw the circuit diagram for reverse biasing of a diode using proper symbol for diode. Also draw the V-I characteristics of the reverse biased diode.

OR

(ii) What is LED? Explain how radiations are given out by LED?

Answers

Section-A

Answer 1.

(i) It depends upon the frequency of incident radiation and work function of the material.

(ii) The interval between the valence band and conduction band is called forbidden band or energy gap.

(iii) The order of size should be equal to the order of wavelength of light used.

(iv) (a) $\sqrt{2}$

Explanation :

$$n = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\frac{A}{2}} \qquad [\because \delta_m = 30°, A = 60°]$$

$$= \frac{\sin(45°)}{\sin 30°} = \frac{1}{\sqrt{2}} \cdot 2$$

$$n = \sqrt{2}$$

(v) (a) violet

Explanation :

Since the wavelength of violet is largest. It shows less deviation and the image formed is the smallest.

(vi) (b) $2.25r$

Explanation :

Radius of third orbit of hydrogen atom $r_3 = \frac{r \times 9}{4} = 2.25r$

(vii) (a) UV region

Explanation :

$$eV_0 = h\nu - h\nu_0$$
$$5 \text{ eV} = h\nu - 6.2 \text{ eV}$$
$$h\nu = 11.2 \text{ eV}$$
$$\frac{hc}{\lambda} = 11.2 \text{ eV}$$
$$\lambda = \frac{hc}{11.2} \text{eV} = 1.104 \times 10^{-7} \text{ m}$$

∴ The wavelength lies in the ultraviolet region.

Section-B

Answer 2.

(i) In order to get a virtual and magnified image with a convex lens, the object should be placed within the focus (between the principal focus and the lens).

(ii) In order to get a virtual and diminished image using a concave Lens, the object should be placed anywhere as concave lens always give virtual and small image.

Answer 3.

(i) We know
$$\sin\theta = \frac{\lambda}{e}$$
or
$$\theta = \frac{\lambda}{e} \text{ radian}$$

If x be the linear distance of the first minimum from the central maximum on the screen and f be the focal length of the lens.

Then,
$$\theta = \left(\frac{x}{f}\right) \text{ radian.}$$
$$x = \frac{f\lambda}{e}$$

The linear distance between the two minima on the two sides of the central maximum is :

∴
$$2x = \frac{2f\lambda}{e} = \frac{2\times 0.5\times(5890\times 10^{-10})}{0.2\times 10^{-3}}$$
$$= 2.945 \times 10^{-3} \text{ m} = 2.945 \text{ mm}$$

OR

(ii) Let 'a' be the initial amplitude and I the intensity of the light wave from each slit. Then
$$I_{max} = (a + a)^2$$
$$= (\sqrt{I} + \sqrt{I})^2 = 4 I$$
$$I_{min} = (\sqrt{I} - \sqrt{I})^2 = 0$$

When one of slits is covered by paper, the intensity of light wave from this slit is $\frac{I}{2}$. While that of the wave from the other slit is still I. Now we have,
$$I_{max}' = \left(\sqrt{I} + \sqrt{\frac{I}{2}}\right)^2 = 2.914 I$$
$$I_{min}' = \left(\sqrt{I} - \sqrt{\frac{I}{2}}\right)^2 = 0.086 I$$

The intensity of maxima will decrease from 4 I to 2.914 I and that of minima will increase from zero to 0.086 I.

Answer 4.

(i) We know, fringe width is given by,

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

When apparatus is immersed in liquid then wavelength decreases to λ',

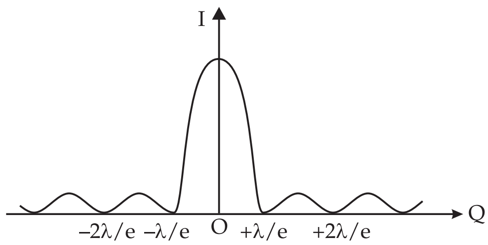
Such that, $$\lambda' = \frac{\lambda}{n}$$

Let β' be the new fringe width,

Then $$\beta' = \frac{D\lambda'}{d} = \frac{D}{d}\frac{\lambda}{n} = \frac{\beta}{n}$$

$$\beta' = \frac{2}{1.33} = 1.5 \text{ mm}$$

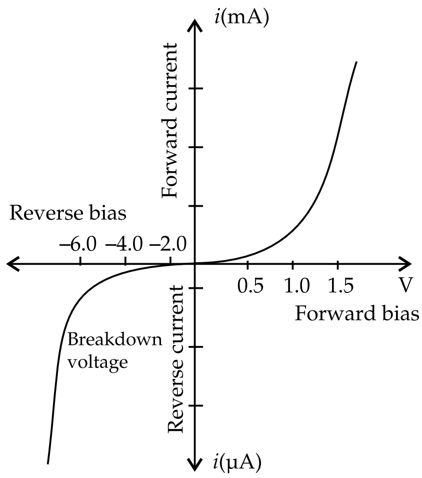
(ii) The graph shown below:



Answer 5.

The thickness of depletion layer decreases with increase in forward bias.

The V-I characteristics curve of *p-n* junction shows that a small increase in forward voltage results in a large increase in forward current while a large increase in reverse voltage results in very little increase in reverse current which means that forward biased *p-n* junction has a low resistance and the reverse biased junction has a high resistance.



Answer 6.

(i) Given: $\lambda = 4000 \text{ Å} = 4000 \times 10^{-10}$ m

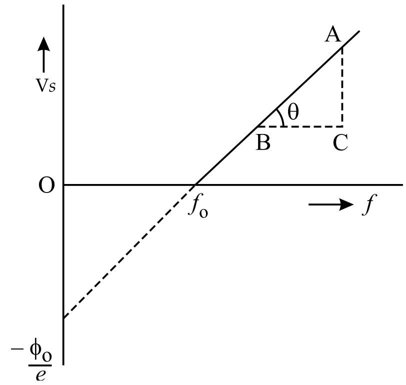
Energy of photon, $$E = h\nu = \frac{hc}{\lambda} = \frac{(6.6\times10^{-34})\times(3.0\times10^{8})}{4000\times10^{-10}}$$

$$= \frac{4.95\times10^{-19}}{1.6\times10^{-19}} \text{ eV} = 3.1 \text{ eV}$$

The incident light will yield photoelectrons if its energy is greater than the work function of the metal. Thus, metal B will emit photoelectrons.

OR

(ii) The graph of stopping potential, $|V_s|$ versus frequency f, of incident radiation is given below:



The value of Plank's constant can be determined, from above graph as :

$h = e$, slope of $(V_s - f)$ graph

Section-C

Answer 7.

(i) In Young's double slit experiment, the distance of the m^{th} bright fringe from the central fringe is given by:

$$x = m\frac{D\lambda}{d} \qquad (m = 0, 1, 2, 3, ...)$$

Here $m = 9$

$\therefore$ $$x = 9\frac{D\lambda}{d}$$

The distance of m^{th} dark fringe from the central fringe

$$x' = \left(m - \frac{1}{2}\right)\frac{D\lambda}{d} \qquad (m = 1, 2, 3, ...)$$

Here $m = 2$

$$x' = \left(2 - \frac{1}{2}\right)\frac{D\lambda}{d} = \frac{3}{2}\frac{D\lambda}{d}$$

According to question, we have:

$$9\frac{D\lambda}{d} - \frac{3}{2}\frac{D\lambda}{d} = 7.5 \times 10^{-3} \text{ m}$$

or $$\frac{15}{2}\frac{D\lambda}{d} = 7.5 \times 10^{-3} \text{ m}$$

$\therefore$ $$\lambda = \frac{2}{15} \times (7.5 \times 10^{-3}) \times \frac{d}{D}$$

$$= \frac{2}{15} \times (7.5 \times 10^{-3}) \times \frac{(0.589 \times 10^{-3})}{1}$$

$$= 0.589 \times 10^{-6} \text{ m}$$

$$= 5890 \times 10^{-10} \text{ m}$$

$$= 5890 \text{ Å}$$

OR

(ii) Given :

$$D = 1.6 \text{ m}$$
$$\lambda = 5.89 \times 10^{-7} \text{ m}$$
$$d = ?$$
$$y_4 - y_0 = \frac{(4-0)\lambda D}{d}$$
$$d = \frac{4 \times 5.89 \times 10^{-7} \times 1.6}{1.60 \times 10^{-3}}$$
$$= 2.356 \times 10^{-3} \text{ m}$$
$$= 2.356 \text{ mm.}$$

Answer 8.

The observe sees the image (I) formed due to refraction at the spherical surface when the light from the bubble (O) goes from glass to air.

Here, $u = -4.0$ cm and R = –10 m

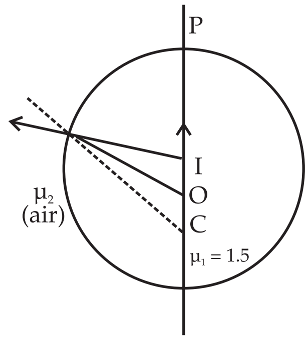
$\mu_1 = 1.5$ and $\mu_2 = 1$

We have,
$$\frac{\infty_2}{v} - \frac{\infty_1}{u} = \frac{\mu_1 - \mu_2}{R}$$

or
$$\frac{1}{v} - \frac{1.5}{-4.0\text{cm}} = \frac{1-1.5}{-10\text{cm}}$$

∴
$$\frac{1}{v} = \frac{0.5}{10\text{cm}} - \frac{1.5}{4.0\text{cm}}$$

$$v = 3.0 \text{ cm}$$



Thus, the bubble will appear 3.0 cm below the surface.

Answer 9.

Let x be the distance between the object and the screen on which a real image of the object is to be obtained by means of a convex lens. Then,

$$x = u + v \qquad \text{...(i)}$$

Where u and v are the numerical values of the object and the image distance respectively for the convex lens.

Now, from the lens formula
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

or
$$u = \frac{vf}{f - v}$$

For a convex lens, f is positive and for a real image v is also positive and u is however, negative. We may, therefore write :

$$-u = \frac{vf}{v - f} \qquad \text{...(ii)}$$

where u is the numerical value of the object distance from the lens. Substituting the value of u from eqn. (ii) in eqn. (i), we have:

$$x = \frac{vf}{v-f} + v$$

$$v^2 - vx + fx = 0$$

$$v = \frac{x + \sqrt{x^2 - 4fx}}{2}$$

for v to be real, we must have $x^2 - 4fx \geq 0$

or $x \geq 4f$

$\therefore$ $f \leq \frac{x}{4}$

Thus, for a fixed distance between the object and the screen, the convex lens should have a maximum focal length of $\frac{x}{4}$ so that a real image is obtained on the screen. Here $x = 3.0$ m.

$$\therefore \quad f_{max} = \frac{x}{4} = \frac{3.0\,\text{m}}{4} = 0.75\text{ m} = 75\text{ cm.}$$

Answer 10.

The energy of the electron in the first orbit = – 27.2 eV

Since, $E_n \propto \frac{1}{n^2}$ (Where n is the principal quantum number)

$$\Rightarrow \quad \frac{E_3}{E_1} = \frac{(1)^2}{(3)^2} = \frac{1}{9}$$

$$\Rightarrow \quad E_3 = \frac{1}{9} E_1$$

$\therefore$ The energy of the electron in the third orbit will be,

$$E_3 = \frac{1}{9}(-27.2)\text{ eV} = -3.02\text{ eV}$$

Answer 11.

(i) Generation of electricity from nuclear power is fundamentally similar to other kinds of traditional power generation like coal, natural gas, and oil. All of these power sources are referred to as "thermal" power sources. Oil, coal, or natural gas is burned to boil water or to make hot gases. The high pressure of the boiled water (steam) or gases is used to turn an electric turbine that generates electricity.

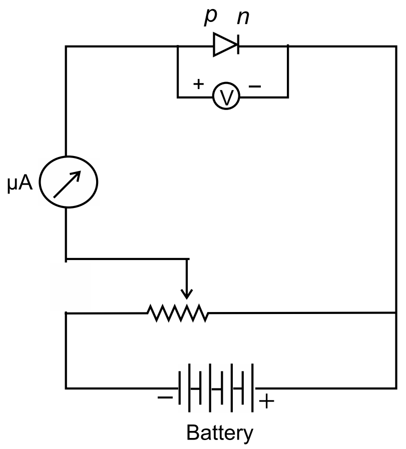
Nuclear power makes electricity in exactly the same way as coal, natural gas, or oil except a nuclear chain reaction is used to create heat, instead of burning fossil fuel. The heat from that nuclear chain reaction, or fission (splitting of atoms), boils the water.

(ii) Nuclear waste, also known as irradiated fuel, as produced by power plants, is only one piece of a very large chain of radioactive waste that nuclear power relies upon. We call this the Nuclear Fuel Chain.

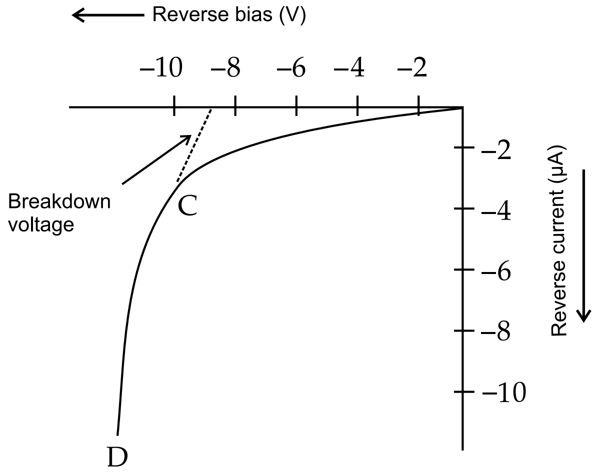
Nuclear energy places on our water supply via consumption and pollution. Nuclear power plants consume more water than any other kind of power plants. These power plant consumed over 2 billion gallons of water per day and it killed about a billion fish and other organisms per year, placing a tremendous burden on the River and on the fish species.

Answer 12.

(i) The circuit diagram and V–I characteristics of a reverse biased diode are:



Reverse bias circuit



Reverse bias characteristics

OR

(ii) LED means light emitting diode. It is a heavily doped *p-n* junction diode, and it converts electrical energy into light energy.

When a *p-n* junction diode is forward biased, both the electrons and the holes move towards opposite side of the junction through it. When they cross the junction, the recombination of electrons and holes takes place. Electrons fall from a higher level in the conduction band to a lower level in the valence band due to which energy is released in the form of electromagnetic radiations (heat and light).

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