Sample Question Paper - 21
Physics (042)
Class- XII, Session: 2021-22
TERM II

Time : 2 Hours | | *Max. Marks : 35*

General Instructions :

(i) There are 12 questions in all. All questions are compulsory.

(ii) This question paper has three sections: Section A, Section B and Section C.

(iii) Section A contains three questions of two marks each, Section B contains eight questions of three marks each, Section C contains one case study-based question of five marks.

(iv) There is no overall choice. However, an internal choice has been provided in one question of two marks and two questions of three marks. You have to attempt only one of the choices in such questions.

(v) You may use log tables if necessary but use of calculator is not allowed.

SECTION - A

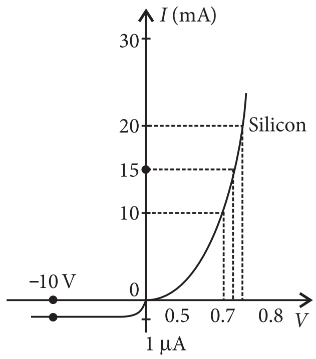
1. Plot V-I characteristics for an illuminated photodiode under reverse bias for three different illumination intensities $I_1 > I_2 > I_3$.

2. You are given two converging lenses of focal lengths 1.25 cm and 5 cm to design a compound microscope. If it is desired to have a magnification of 30, find out the separation between the objective and the eyepiece.

OR

In total internal reflection when the angle of incidence is equal to the critical angle for the pair of media in contact, what will be angle of refraction?

3. The V-I characteristic of a silicon diode is as shown in the figure. Calculate the resistance of the diode at (i) $I = 15$ mA and (ii) $V = -10$ V



SECTION - B

4. (a) Why are Si and GaAs preferred materials for fabrication in solar cells?
(b) Draw V-I characteristic of solar cell and mention its significance.

5. (i) How does one explain the emission of electrons from a photosensitive surface with the help of Einstein's photoelectric equation?

(ii) The work function of the following metals is given : Na = 2.75 eV, K = 2.3 eV, Mo = 4.17 eV and Ni = 5.15 eV. Which of these metals will not cause photoelectric emission for radiation of wavelength 3300 Å from a laser source placed 1 m away from these metals? What happens if the laser source is brought nearer and placed 50 cm away?

6. Calculate the de-Broglie wavelength associated with the electron in the 2^{nd} excited state of hydrogen atom. The ground state energy of the hydrogen atom is 13.6 eV.

OR

The electron in a given Bohr orbit has a total energy of –2.0 eV. Calculate its

(i) kinetic energy. (ii) potential energy.

(iii) wavelength of radiation emitted, when this electron makes a transition to the ground state.

[Given : Energy in the ground state = –13.6 eV and Rydberg's constant = 1.09×10^7 m^{-1}]

7. Two slits in Young's experiment have widths in the ratio 1 : 25. Find the ratio of intensity at the maxima and minima in the interference pattern, $\frac{I_{max}}{I_{min}}$.

OR

Light from a point source in air falls on a spherical glass surface (n = 1.67 and radius of curvature = 25 cm). The distance of the light source from the glass surface is 95 cm. At what position the image is formed?

8. A biconvex lens has a radius of curvature of magnitude 20 cm. Which one of the following options describe best the image formed of an object of height 2 cm placed 30 cm from the lens? [$\mu = 3/2$]

9. Identify the part of the electromagnetic spectrum which is

(a) suitable for radar system used in aircraft navigation,

(b) produced by bombarding a metal target by high speed electrons.

10. In a diffraction pattern due to a single slit of width a, the first minimum is observed at an angle 30° when light of wavelength 5000 Å is incident on the slit. Find the angle at which the first secondary maximum is observed.

11. (a) How are electromagnetic waves produced?

(b) How do you convince yourself that electromagnetic waves carry energy and momentum?

SECTION - C

12. CASE STUDY : NUCLEAR FISSION

In the year 1939, German scientist Otto Hahn and Strassmann discovered that when an uranium isotope was bombarded with a neutron, it breaks into two intermediate mass fragments. It was observed that, the sum of the masses of new fragments formed were less than the mass of the original nuclei. This difference in the mass appeared as the energy released in the process. Thus, the phenomenon of splitting of a heavy nucleus (usually $A > 230$) into two or more lighter nuclei by the bombardment of proton, neutron, α-particle, etc with liberation of energy is called nuclear fission.

$$_{92}U^{235} + {_0}n^1 \rightarrow \underset{\text{Unstable nucleus}}{_{92}U^{236}} \rightarrow {_{56}}Ba^{144} + {_{36}}Kr^{89} + 3\,{_0}n^1 + Q$$

(i) Nuclear fission can be explained on the basis of

(a) Millikan's oil drop method

(b) Liquid drop model

(c) Shell model

(d) Bohr's model.

(ii) For sustaining the nuclear fission chain reaction in a sample (of small size) of $^{235}_{92}U$, it is desirable to slow down fast neutrons by

(a) friction
(b) elastic damping/scattering
(c) absorption
(d) none of these.

(ii) Which of the following is/are fission reaction(s)?

(I) $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{236}_{92}U \rightarrow ^{133}_{51}Sb + ^{99}_{41}Nb + 4^{1}_{0}n$

(II) $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{1.40}_{54}Xe + ^{94}_{38}Sr + 2^{1}_{0}n$

(III) $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$

(a) Both II and III
(b) Both I and III
(c) Only II
(d) Both I and II

(iv) On an average, the number of neutrons and the energy of a neutron released per fission of a uranium atom are respectively

(a) 2.5 and 2 keV
(b) 3 and 1 keV
(c) 2.5 and 2 MeV
(d) 2 and 2 keV

(v) In any fission process, ratio of mass of daughter nucleus to mass of parent nucleus is

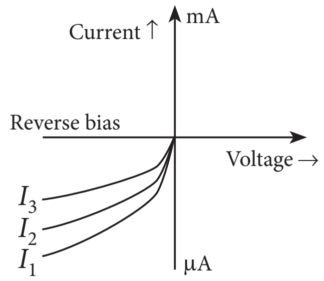
(a) less than 1
(b) greater than 1
(c) equal to 1
(d) depends o the mass of parent nucleus.

Solution

PHYSICS - 042

Class 12 - Physics

1.



$I_1 > I_2 > I_3$

2. Maximum magnification of a compound microscope is

$$m = \frac{v_0}{u_0}\left[1 + \frac{D}{f_e}\right]$$

So, for m to be 30,

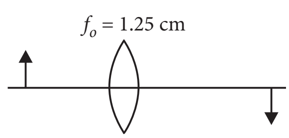
$$30 = \frac{v_0}{u_0}\left[1 + \frac{25}{5}\right] \quad \text{or} \quad 30 = \frac{v_0}{u_0}[6]$$

$v_0 = 5u_0$ ... (i)

For objective of focal length 1.25 cm,

$$\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_o}$$

$$\frac{1}{5u_o} - \frac{1}{-u_o} = \frac{1}{1.25}$$



$$\frac{1+5}{5u_o} = \frac{1}{1.25}$$

$5u_o = +7.5$ cm or $u_o = 1.5$ cm. So, $v_o = +7.5$ cm

Now u_e for required magnification,

$$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e} \quad \text{or} \quad \frac{1}{-25} - \frac{1}{-u_e} = \frac{1}{5}$$

$$\frac{1}{u_e} = \frac{1}{5} + \frac{1}{25} = \frac{5+1}{25} \quad \text{or} \quad u_e = \frac{25}{6} \text{ cm}$$

Hence, separation between two lenses should be

$$v_o + u_e = 7.5 \text{ cm} + \frac{25}{6} \text{ cm} = 11.67 \text{ cm}$$

OR

When the angle of refraction is equal to 90°, the angle of incidence is called the critical angle.

3. (i) From the given curve, we have

Voltage, $V = 0.8$ volt for current, $I = 20$ mA

Voltage, $V = 0.7$ volt for current, $I = 10$ mA

$\Rightarrow \Delta I = (20 - 10)\text{mA} = 10 \times 10^{-3}$ A

$\Rightarrow \Delta V = (0.8 - 0.7) = 0.1$ V

$\therefore$ Resistance, $R = \dfrac{\Delta V}{\Delta I}$

$$\Rightarrow R = \frac{0.1}{10 \times 10^{-3}} \Rightarrow R = 10\ \Omega$$

(ii) For $V = -10$ V, we have

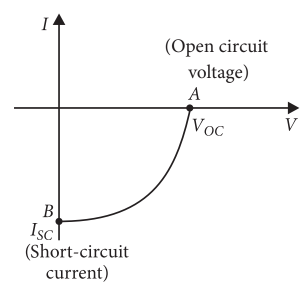
$I = -1\ \mu\text{A} = -1 \times 10^{-6}$ A

$$\Rightarrow R = \frac{-10}{-1 \times 10^{-6}} = 1.0 \times 10^{7}\ \Omega$$

4. (a) The energy for the maximum intensity of the solar radiation is nearly 1.5 eV. In order to have photo excitation the energy of radiation ($h\upsilon$) must be greater than energy band gap (E_g), *i.e.*, $h\upsilon > E_g$. Therefore, the semiconductor with energy band gap about 1.5 eV or lower and with higher absorption coefficient, is likely to give better solar conversion efficiency.

The energy band gap for Si is about 1.1 eV, while for GaAs, it is about 1.53 eV. The gas GaAs is better inspite of its higher bandgap than Si because it absorbs relatively more energy from the incident solar radiations being of relatively higher absorption coefficient.

(b)



(i) *V-I* curve is drawn in the fourth quadrant, because a solar cell does not draws current but supply current to the load.

(ii) In V-I curve, the point *A* indicates the maximum voltage V_{OC} being supplied by the given solar cell when no current is being drawn from it. V_{OC} is called the open circuit voltage.

(iii) In *V-I* curve, the point *B* indicates the maximum current I_{SC} which can be obtained by short circuiting the solar cell without any load resistance. I_{SC} is called the short circuit current.

5. (i) The Einstein's photoelectric equation is given as

$K_{max} = h\upsilon - \phi_0$

Since K_{max} must be non-negative implies that photoelectric emission is possible only if $h\upsilon > \phi_0$

or $\upsilon_f > \upsilon_0$ where $\upsilon_0 = \dfrac{\phi_0}{h}$, This shows that the greater the work function ϕ_0, higher the threshold frequency υ_0 needed to emit photoelectrons. Thus, there exists a threshold frequency $\upsilon_0 = \frac{\phi_0}{h}$ for the metal surface, below which no photoelectric emission is possible.

(ii) Condition for photoelectric emission,

$h\upsilon > \phi_0$

or $\frac{hc}{\lambda} > \phi_0$

for λ = 3300 Å

$$\frac{hc}{\lambda} = \frac{1.989\times10^{-25}}{3300\times10^{-10}} = \frac{6.03\times10^{-19}}{1.6\times10^{-19}} = 3.77 \text{ eV}$$

$\therefore$ Mo and Ni will not cause photoelectric emission.

If the laser source is brought nearer and placed 50 cm away, then photoelectric emission will not affect, since it depends upon the work function and threshold frequency.

6. de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$, where K is the kinetic energy.

Now, energy of electron,

$$K = \frac{13.6Z^2}{n^2} = \frac{13.6}{3^2} = 1.51 \text{ eV} = 2.41 \times 10^{-19} \text{ J}$$

$$\therefore \quad \lambda = \frac{h}{\sqrt{2mK}} = \frac{6.63\times10^{-34}}{\sqrt{2\times9\times10^{-31}\times2.41\times10^{-19}}}$$

$\simeq 1 \times 10^{-9}$ m = 1 nm

OR

(i) The kinetic energy (E_k) of the electron in an orbit is equal to negative of its total energy (E)

$E_k = -E = -(-2.0) = 2.0$ eV

(ii) The potential energy (E_p) of the electron in an orbit is equal to twice of its total energy (E)

$E_p = 2E = -2 \times 2 = -4$ eV

(iii) Here, ground state energy of the H-atom = −13.6 eV

When the electron goes from the excited state to the ground state, energy emitted is given by

$E = -2 - (-13.6) = 11.6 \text{ eV} = 11.6 \times 1.6 \times 10^{-19}$ J

Now, $E = \frac{hc}{\lambda}$

$$\lambda = \frac{hc}{E} = \frac{6.62\times10^{-34}\times3\times10^{8}}{11.6\times1.6\times10^{-19}}$$

$\lambda = 1.07 \times 10^{-7}$

λ = 1070 Å

7. As, intensity $I \propto$ width of slit W

Also, intensity $I \propto$ square of amplitude A

$$\therefore \quad \frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{A_1^2}{A_2^2}$$

But $\frac{W_1}{W_2} = \frac{1}{25}$ (given)

$$\therefore \quad \frac{A_1^2}{A_2^2} = \frac{1}{25} \quad \text{or} \quad \frac{A_1}{A_2} = \sqrt{\frac{1}{25}} = \frac{1}{5}$$

$$\therefore \quad \frac{I_{max}}{I_{min}} = \frac{(A_1+A_2)^2}{(A_1-A_2)^2} = \frac{\left(\frac{A_1}{A_2}+1\right)^2}{\left(\frac{A_1}{A_2}-1\right)^2}$$

$$= \frac{\left(\frac{1}{5}+1\right)^2}{\left(\frac{1}{5}-1\right)^2} = \frac{\left(\frac{6}{5}\right)^2}{\left(-\frac{4}{5}\right)^2} = \frac{36}{16} = \frac{9}{4}$$

OR

Here, $u = -95$ cm, $n_1 = 1$, $n_2 = 1.67$, $R = +25$ cm

As light travels from air (rarer medium) to glass (denser medium), so

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R} \Rightarrow \frac{1.67}{v} - \frac{1}{-95} = \frac{1.67-1}{25}$$

$$\frac{1.67}{v} + \frac{1}{95} = \frac{0.67}{25} \Rightarrow \frac{1.67}{v} = \frac{0.67}{25} - \frac{1}{95}$$

$\Rightarrow$ +102.62 cm

The image is formed at a distance of 102.62 cm from the glass surface in the direction of incident light.

8. As, $\mu = \frac{3}{2}$

According to lens maker's formula

$$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For biconvex lens, $R_1 = +20$ cm, $R_2 = -20$ cm

$$\therefore \quad \frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{20}+\frac{1}{20}\right) = \frac{1}{20} \quad \text{or} \quad f = 20 \text{ cm}$$

According to thin lens formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Here, $u = -30$ cm

$$\therefore \quad \frac{1}{20} = \frac{1}{v} - \frac{1}{-30} \Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{30}$$

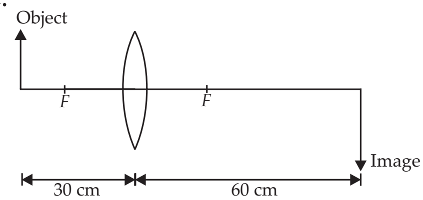
$\therefore \quad v = 60$ cm

The image is formed at a distance of 60 cm on the right hand side of the lens. It is a real image.

Magnification, $m = \frac{v}{u} = \frac{h_I}{h_o}$

$$\frac{60\text{ cm}}{-30\text{ cm}} = \frac{h_I}{2\text{ cm}} \Rightarrow h_I = -4\text{ cm}$$

–ve sign shows that image is inverted.
The image is real, inverted and height of 4 cm as shown in figure.



9. (a) Microwaves are suitable for radar system used in aircraft navigation.

(b) X-rays are produced by bombarding a metal target by high speed electrons.

10. For first minimum, the path difference between extreme waves, $a\sin\theta = \lambda$

Here, $\theta = 30° \Rightarrow \sin\theta = \frac{1}{2} \quad \therefore a = 2\lambda$ ...(i)

For first secondary maximum, the path difference between extreme waves

$$a\sin\theta' = \frac{3}{2}\lambda \text{ or } (2\lambda)\sin\theta' = \frac{3}{2}\lambda \quad \text{[Using eqn (i)]}$$

$$\text{or } \sin\theta' = \frac{3}{4} \quad \therefore \theta' = \sin^{-1}\left(\frac{3}{4}\right)$$

11. (a) An oscillating or accelerated charge is supposed to be source of an electromagnetic wave. An oscillating charge produces an oscillating electric field in space which further produces an oscillating magnetic field which in turn is a source of electric field. These oscillating electric and magnetic field hence, keep on regenerating each other and an electromagnetic wave is produced.

(b) Electromagnetic waves or photons transport energy and momentum. When an electromagnetic wave interacts with a small particle, it can exchange energy and momentum with the particle. The force exerted on the particle is equal to the momentum transferred per unit time. Optical tweezers use this force to provide a non-invasive technique for manipulating microscopic-sized particles with light.

12. (i) **(b)**

(ii) **(b):** Fast neutrons are slowed down by elastic scattering with light nuclei as each collision takes away nearly 50% of energy.

(iii) **(d) :** Reactions I and II represent fission of uranium isotope $^{235}_{92}U$, when bombarded with neutrons that breaks it into two intermediate mass nuclear fragments. However, reaction III represents two deuterons fuses together to from the light isotope of helium.

(iv) **(c) :** On an average 2.5 neutrons are released per fission of the uranium atom.

The energy of the neutron released per fission of the uranium atom is 2 MeV.

(v) **(a):** In fission process, when a parent nucleus breaks into daughter products, then some mass is lost in the form of energy. Thus,

mass of fission products < mass of parent nucleus.

$$\Rightarrow \frac{\text{Mass of fission products}}{\text{Mass of parent nucleus}} < 1$$