Sample Question Paper - 22
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. An LED is constructed from a *p-n* junction based on a certain Ga-As-P semiconducting material whose energy gap is 1.9 eV. Identify the colour of the emitted light.

2. Which of the following electromagnetic waves has (a) minimum wavelength, and (b) minimum frequency? Write one use of each of these two waves.
Infrared waves, Microwaves, γ-rays and X-rays.

OR

Identify the electromagnetic waves whose wavelengths vary as
(a) 10^{-11} m < λ < 10^{-14} m
(b) 10^{-4} m < λ < 10^{-6} m
Write one use of each.

3. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 600 nm is incident on it. Find the energy band gap (in eV) for the semiconductor.

SECTION - B

4. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. Upto which energy level the hydrogen atoms would be excited?
Calculate the wavelengths of the first member of Lyman and first member of Balmer series.

5. (a) Draw a ray diagram showing the path of a ray of light entering through a triangular glass prism.
(b) Deduce the expression for the refractive index of glass prism in terms of the angle of minimum deviation and angle of the prism.

6. In a YDSE, $D = 1$ m, $d = 1$ mm, and $\lambda = 1/2$ mm.
(i) Find the distance between the first and central maxima on the screen.
(ii) Find the number of maximum and minimum obtained on the screen.

7. Answer the following questions:

(a) Show, by giving a simple example, how *e.m.* waves carry energy and momentum.

(b) How are microwaves produced? Why is it necessary in microwave ovens to select the frequency of microwaves to match the resonant frequency of water molecules?

(c) Write two important uses of infrared waves.

8. (a) An electron and a proton are accelerated through the same potential. Which one of the two has

(i) greater value of de-Broglie wavelength associated with it, and

(ii) lesser momentum?

Justify your answer in each case.

(b) How is the momentum of a particle related with its de-Broglie wavelength? Show the variation on a graph.

OR

Write Einstein's photoelectric equation. Mention the underlying properties of photons on the basis of which this equation is obtained. Write two important observations of photoelectric effect which can be explained by Einstein's equation.

9. Dictate the important process that involved during the formation of a *p-n* junction. Explain briefly, with the help of a suitable diagram, how a *p-n* junction is formed. Also define the term 'barrier potential'.

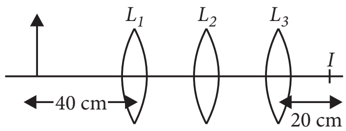
10. White light is used in a Young's double slit experiment. Find the minimum non-zero order of the red fringe (λ = 700 nm) which overlaps with a blue fringe (λ = 500 nm).

11. (a) Write two important advantage justifying why reflecting type telescopes are preferred over refracting telescopes.

(b) The objective of a telescope is of larger focal length and of larger aperture (compared to the eyepiece). Why? Give reasons.

OR

You are given three lenses L_1, L_2 and L_3 each of focal length 20 cm. An object is kept at 40 cm in front of L_1, as shown. The final real image is formed at the focus 'I' of L_3. Find the separations between L_1, L_2 and L_3.



SECTION - C

12. CASE STUDY : NUCLEAR ENERGY

A heavy nucleus breaks into comparatively lighter nuclei which are more stable compared to the original heavy nucleus. When a heavy nucleus like uranium is bombarded by slow moving neutrons, it splits into two parts releasing large amount of energy. The typical fission reaction of $_{92}U^{235}$.

$_{92}U^{235} + {_0}n^1 \rightarrow {_{56}}Ba^{141} + {_{36}}Kr^{92} + 3{_0}n^1 + 200$ MeV

The fission of $_{92}U^{235}$ approximately released 200 MeV of energy.

(i) If 200 MeV energy is released in the fission of a single nucleus of $^{235}_{92}U$, the fissions which are required to produce a power of 1 kW is

(a) 3.125×10^{13} (b) 1.52×10^{6} (c) 3.125×10^{12} (d) 3.125×10^{14}

(ii) The release in energy in nuclear fission is consistent with the fact that uranium has
(a) more mass per nucleon than either of the two fragments
(b) more mass per nucleon as the two fragment
(c) exactly the same mass per nucleon as the two fragments
(d) less mass per nucleon than either of two fragments.

(iii) When $_{92}U^{235}$ undergoes fission, about 0.1% of the original mass is converted into energy. The energy released when 1 kg of $_{92}U^{235}$ undergoes fission is
(a) 9×10^{11} J (b) 9×10^{13} J (c) 9×10^{15} J (d) 9×10^{18} J

(iv) A nuclear fission is said to be critical when multiplication factor or K
(a) $K = 1$ (b) $K > 1$ (c) $K < 1$ (d) $K = 0$

(v) Einstein's mass-energy conversion relation $E = mc^2$ is illustrated by
(a) nuclear fission (b) β-decay (c) rocket propulsion (d) steam engine

Solution

PHYSICS - 042

Class 12 - Physics

1. As $E_g = \frac{hc}{\lambda}$ $\therefore$ $\lambda = \frac{hc}{E_g}$

Here, E_g = 1.9 eV; hc = 1240 eV nm

$\therefore$ $\lambda = \frac{1240 \text{ eV nm}}{1.9 \text{ eV}} = 652.6$ nm

Hence, the emitted light is of red colour.

2. (a) γ rays (b) Microwaves

(i) X-rays are used as a diagnostic tool in medicine.

(ii) Microwaves : These are used in Radar system for aircraft navigation.

(iii) Infra-red rays : These are used to treat muscular pain.

(iv) Gamma rays : These are used for the treatment of cancer.

OR

(a) Gamma rays lie between 10^{-11} m to 10^{-14} m. These rays are used in radiotherapy to treat certain cancers and tumors.

(b) Infrared waves lie between 10^{-4} m to 10^{-6} m. These waves are used in taking photographs during conditions of fog, smoke etc., as these waves are scattered less than visible rays.

3. The energy band gap for the semiconductor is,

$E_g = \frac{hc}{\lambda}$

Here, λ = 600 nm, hc = 1240 eV nm

$\therefore$ $E_g = \frac{1240 \text{ eV nm}}{600 \text{ nm}} = 2.06$ eV

4. Here, ΔE = 12.5 eV

Energy of an electron in n^{th} orbit of hydrogen atom is,

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

In ground state, n = 1

E_1 = −13.6 eV

Energy of an electron in the excited state after absorbing a photon of 12.5 eV energy will be

E_n = −13.6 + 12.5 = −1.1 eV

$\therefore$ $n^2 = \frac{-13.6}{E_n} = \frac{-13.6}{-1.1} = 12.36 \Rightarrow n = 3.5$

Here, state of electron cannot be fraction.

So, $n = 3$ (2^{nd} exited state).

The wavelength λ of the first member of Lyman series is given by

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

$$\Rightarrow \lambda = \frac{4}{3R} = \frac{4}{3 \times 1.097 \times 10^7}$$

$\Rightarrow \lambda = 1.215 \times 10^{-7}$ m

$\Rightarrow \lambda = 121 \times 10^{-9}$ m $\Rightarrow \lambda = 121$ nm

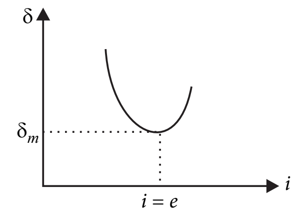
The wavelength λ' of the first member of the Balmer series is given by

$$\frac{1}{\lambda'} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5}{36}R$$

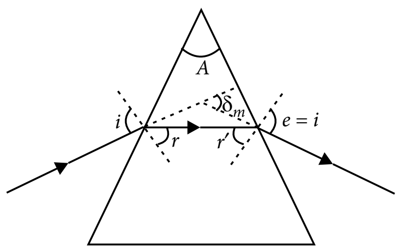
$$\Rightarrow \lambda' = \frac{36}{5R} = \frac{36}{5 \times (1.097 \times 10^7)}$$

$= 6.56 \times 10^{-7}$ m $= 656 \times 10^{-9}$ m = 656 nm

5. (a) If graph is plotted between angle of incidence i and angle of deviation δ, it is found that the angle of deviation δ first decreases with increase in angle of incidence i and then becomes minimum 'δ_m' when $i = e$ and then increases with increase in angle of incidence i. Figure shows the path of a ray of light suffering refraction through a prism of refracting angle 'A'.



(b) At minimum deviation, the inside beam travels parallel to base of the prism.



From figure,

$i = e$

$r = r'$

$\delta_m = (i + e) - (r + r')$

$\delta_m = 2i - 2r$ ...(i)

Also $r + r' = A = 2r$ ...(ii)

So, angle of incidence using equation (i)

$$i = \frac{A + \delta_m}{2}, \text{ angle of refraction } r = \frac{A}{2}$$

Now refractive index of the material of prism

$$^{a}\mu_g = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

where A is the "refracting angle" of the prism and $A = 60°$ for an equiangular prism.

6. (i) $D >> d$

Hence, path difference at any angular position θ on the screen

$\Delta x = d\sin\theta$

The path difference for first maxima

$$\Delta x = d\sin\theta = \lambda \Rightarrow \sin\theta = \frac{\lambda}{d} = \frac{1}{2} \Rightarrow \theta = 30°$$

Hence, distance between central maxima and first maxima

$$y = D\tan\theta = \frac{1}{\sqrt{3}}\text{ m}$$

(ii) Maximum path difference, $\Delta x_{max} = d = 1$ mm

$\Rightarrow$ Highest order maxima, $n_{max} = \left[\frac{d}{\lambda}\right] = 2$ and highest

Order minimum $n_{min} = \left[\frac{d}{\lambda} + \frac{1}{2}\right] = 2$

Total number of maxima $= 2n_{max} + 1 = 5$

Total number of minima $= 2n_{min} = 4$

7. (a) Consider a plane perpendicular to the direction of propagation of the wave. An electric charge, on the plane will be set in motion by the electric and magnetic fields of *e.m.* wave, incident on this plane. This illustrates that *e.m.* waves carry energy and momentum.

(b) Microwaves are produced by special vacuum tube like the klystron, magnetron and Gunn diode.

The frequency of microwaves is selected to match the resonant frequency of water molecules, so that energy is transformed efficiently to the kinetic energy of the molecules.

(c) Uses of infra-red waves :

(i) They are used in night vision devices during warfare. This is because they can pass through haze, fog and mist.

(ii) Infra-red waves are used in remote switches of household electrical appliances.

8. (a) de Broglie wavelength is given by

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2m(qV)}}$$

So, $\lambda \propto \frac{1}{\sqrt{m}}$

Mass of a deutron is more than that of a proton. So, proton will have greater value of de-Broglie wavelength.

(b) de-Broglie wavelength of a particle

$$\lambda = \frac{h}{p} \text{ or } \lambda p = h = \text{constant}$$

It shows a rectangular hyperbola.

OR

Einstein's photoelectric equation is given below.

$$h\upsilon = \frac{1}{2}mv_{max}^2 + W_0$$

where υ = frequency of incident radiation

$\frac{1}{2}mv_{max}^2$ = maximum kinetic energy of an emitted electron

W_0 = work function of the target metal

Three salient features observed are

(i) Below threshold frequency υ_0 corresponding to W_0, no emission of photoelectrons takes place.

(ii) As energy of a photon depends on the frequency of light, so the maximum kinetic energy with which photoelectron is emitted depends only on the energy of photon or on the frequency of incident radiation.

(iii) For a given frequency of incident radiation, intensity of light depends on the number of photons per unit area per unit time and one photon liberates one photoelectron, so number of photoelectrons emitted depend only on its intensity.

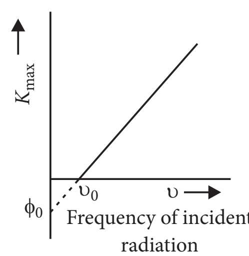
54. Photons : According to Planck's quantum theory of radiation, an electromagnetic wave travels in the form of discrete packets of energy called quanta.

The main features of photons are as follows:

(i) In the interaction of photons with free electrons, the entire energy of photon is absorbed.

(ii) Energy of photon is directly proportional to frequency. Intensity of incident radiation depends on the number of photons falling per unit area per unit time for a given frequency.

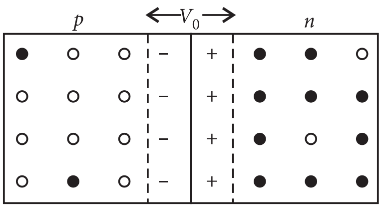
(iii) In photon electron collision, the total energy and momentum remain constant.



Einstein's photoelectric equation is

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

9. Two processes that take place in the formation of a *p-n* junction are diffusion and drift.



When *p-n* junction is formed, then at the junction free electrons from *n*-type diffuse over to *p*-type, thereby filling in the holes in *p*-type. Due to this a layer of positive charge is built on *n*-side and a layer of negative charge is built on *p*-side of the *p-n* junction. This layer sufficiently grows up within a very short time of the junction being formed, preventing any further movement of charge carriers (*i.e.*, electrons and holes) across the junction. Thus a potential difference V_0 of the order of 0.1 to 0.3 V is set up across the *p-n* junction called potential barrier or junction barrier. The thin region around the junction containing immobile positive and negative charges is known as depletion layer.

10. For n^{th} order bright fringe, $Y_n = n\frac{D\lambda}{d}$

Blue fringe is n^{th} bright fringe $Y_n = \frac{nD\lambda_b}{d}$

Red fringe is m^{th} bright fringe $Y_m = \frac{mD\lambda_r}{d}$

They will coincide when $Y_n = Y_m$

$$\therefore \quad n\lambda_b = m\lambda_r \Rightarrow \frac{n}{m} = \frac{7}{5}$$

The first blue and red fringe will coincide for zero order maxima. Then 7^{th} order blue fringe will overlap with 5^{th} order red fringe (Minimum non-zero order).

11. (a) Advantages :

(i) It is free from chromatic aberration.

(ii) Its resolving power is greater than refracting telescope due to larger aperture of mirror.

(b) (i) The objective of a telescope have a larger focal length to obtain large magnifying power and greater intensity of image.

(ii) The aperture of objective lens of a telescope is taken as large because this increases the light gathering capacity of the objective from the distant object. Consequently, a brighter image is formed.

OR

For lens L_1

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$

$$\frac{1}{20} = \frac{1}{v_1} - \frac{1}{-40} \Rightarrow v_1 = 40 \text{ cm}$$

For L_3

$$\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$$

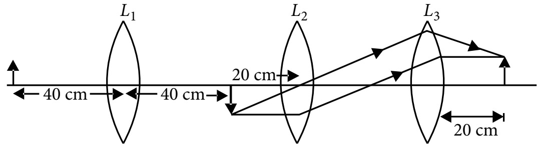
$u_3 = ?, f_3 = +20$ cm, $v_3 = 20$ cm

$$\frac{1}{20} = \frac{1}{20} + \frac{1}{u_3}$$

$u_3 = \infty$

It shows that L_2 must render the rays parallel to the common axis. It means that the image (I_1), formed by L_1, must be at a distance of 20 cm from L_2 (at the focus of L_2).

Therefore, distance between L_1 and L_2 (= 40 + 20) = 60 cm and distance between L_2 and L_3 can have any value.



12. (i) **(a) :** Let the number of fissions per second be *n*.

Energy released per second

$= n \times 200$ MeV $= n \times 200 \times 1.6 \times 10^{-13}$ J

Energy required per second = power × time

= 1 kW × 1 s = 1000 J

$\therefore \quad n \times 200 \times 1.6 \times 10^{-13} = 1000$

or $\quad n = \frac{1000}{3.2\times10^{-11}} = \frac{10}{3.2}\times10^{13} = 3.125\times10^{13}$

(ii) **(a)**

(iii) **(b) :** As only 0.1% of the original mass is converted into energy, hence out of 1 kg mass 1 g is converted into energy.

$\therefore$ Energy released during fission, $E = \Delta mc^2$

$= 1 \text{ g} \times (3 \times 10^8 \text{ m s}^{-1})^2 = 10^{-3} \times 9 \times 10^{16} \text{ J} = 9 \times 10^{13}$ J

(iv) **(a) :** When multiplication factor is equal to 1, then nuclear fission is said to be critical.

(v) **(a) :** $E = mc^2$ is illustrated by nuclear fission.