# Sample Question Paper - 7
## Physics (042)
## Class- XII, Session: 2021-22
## TERM II

**Time Allowed: 2 hours** **Maximum Marks: 35**

**General Instructions:**

1. There are 12 questions in all. All questions are compulsory.
2. This question paper has three sections: Section A, Section B and Section C.
3. 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.
4. 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.
5. You may use log tables if necessary but use of calculator is not allowed.

**Section A**

1. Draw a circuit diagram for p-n junction diode in forward bias. Sketch the voltage-current graph for the same. **[2]**

2. A photon emitted during the de-excitation of electron from a state n to the first excited state in a hydrogen atom, irradiates a metallic cathode of work function 2 eV, in a photo cell, with a stopping potential of 0.55 V. Obtain the value of the quantum number of the state n. **[2]**

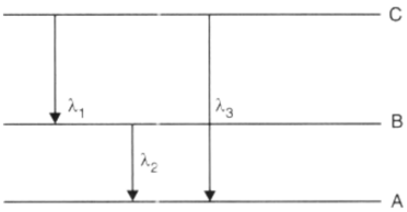
OR

Crystal diffraction experiments can be performed either by using electrons accelerated through appropriate voltage or by using X-rays. If the wavelength of these probes (electrons or X-rays) is 1 $\overset{o}{A}$, estimate which of the two has greater energy.

3. Why can't we take one slab of p-type semiconductor and physically join it to another slab of n-type semiconductor to get a p-n junction? **[2]**

**Section B**

4. **[3]**
   i. State Bohr's quantization condition for defining stationary orbits. How does de-Broglie hypothesis explain the stationary orbits?
   ii. Find the relation between the three wavelengths $\lambda_1, \lambda_2$ and $\lambda_3$ from the energy level diagram shown below:




5. Draw the circuit diagram of a full-wave rectifier using p-n junction diode. Explain its working **[3]**

and show the output input waveforms.

6. Distinguish between nuclear fission and fusion. Show how in both these processes energy is released. Calculate the energy release in MeV in the deuterium-tritium fusion reaction: **[3]**

$_1^2H + \, _1^3H \rightarrow \, _2^4He + _0 n^1$

Using the data:

$m\left(_1^2H\right)$ = 2.014102 u

$m\left(_1^3H\right)$ = 3.016049 u

$m\left(_2^4He\right)$ = = 4.002603 u

$m_n$ = 1.008665 u

1amu = 931.5 $\frac{MeV}{c^2}$

7. What is diffraction of light? Draw a graph showing the variation of intensity with angle in a single slit diffraction experiment. Write one feature which distinguish the observed pattern from the double slit interference pattern. How would the diffraction pattern of a single slit be affected when: **[3]**

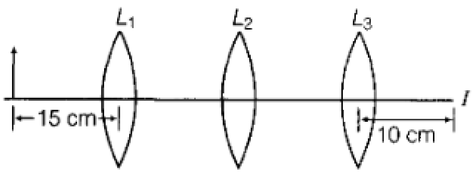
   i. the width of the slit is decreased?
   ii. the monochromatic source of light is replaced by a source of white light?

8. **[3]**
   i. What is the relation between critical angle and refractive index of a material?
   ii. Does critical angle depend on the colour of light? Explain

OR

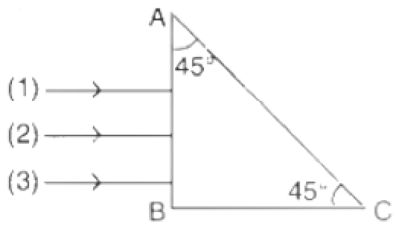
You are given three lenses $L_1$, $L_2$ and $L_3$ each of focal length 10 cm. An object is kept at 15 cm in front of $L_1$ as shown. The final real image is formed at the focus I of $L_3$ .

Find the separation between $L_1$, $L_2$ and $L_3$.




9. Plot a graph showing variation of de Broglie wavelength ($\lambda$) associated with a charged particle of mass m, versus $1\sqrt{V}$, where V is the potential difference through which the particle is accelerated. How does this graph give us the information regarding the magnitude of the charge of the particle? **[3]**

10. Three rays (1, 2, 3) of different colours fall normally on one of the sides of an isosceles right-angled prism as shown. The refractive index of prism for these rays is 1.39, 1.47, and 1.52 respectively. Find which of these rays get internally reflected and which get only refracted from AC. Trace the paths of rays. Justify your answer with the help of necessary calculations. **[3]**




11. State clearly how a microwave oven works to heat up a food item containing water molecules. Why are microwaves found useful for the raw systems in aircraft navigation? **[3]**

OR

In Young's double slit experiment, the two slits 0.15 mm apart are illuminated by monochromatic light of wavelength 450 nm. The screen is 1.0 m away from the slits.

i. Find the distance of the second

   a. bright fringe

   b. dark fringe from the central maximum.

ii. How will the fringe pattern change if the screen is moved away from the slits?

**CASE STUDY**

12. **Read the source given below and answer the following questions:** **[5]**

A compound microscope is an optical instrument used for observing highly magnified images of tiny objects. Magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final image to the angle subtended at the eye by the object, when both the final image and the object are situated at the least distance of distinct vision from the eye. It can be given that : $m = m_e \times m_o$, where $m_e$ is magnification produced by eye lens and $m_o$ is magnification produced by objective lens.

Consider a compound microscope that consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm.

i. The object distance for eye-piece, so that final image is formed at the least distance of distinct vision, will be

   a. 3.45 cm

   b. 5 cm

   c. 1.29 cm

   d. 2.59 cm

ii. How far from the objective should an object be placed in order to obtain the condition described in part (i)?

   a. 4.5 cm

   b. 2.5 cm

   c. 1.5 cm

   d. 3.0 cm

iii. What is the magnifying power of the microscope in case of least distinct vision?

   a. 20

   b. 30

   c. 40

   d. 10

iv. The intermediate image formed by the objective of a compound microscope is

   a. real, inverted and magnified

   b. real, erect, and magnified

   c. virtual, erect and magnified

   d. virtual, inverted and magnified

v. The magnifying power of a compound microscope increases with

   a. the focal length of objective lens is increased and that of eye lens is decreased

   b. the focal length of eye lens is increased and that of objective lens is decreased

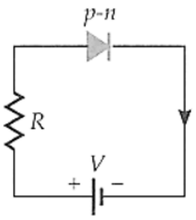
c. focal lengths of both objects and eye-piece are increased
d. focal lengths of both objects and eye-piece are decreased.

## Solution

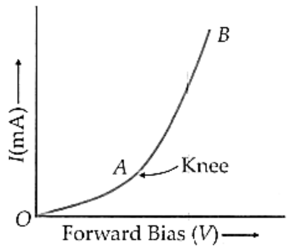
**PHYSICS - 042**

**Class 12 - Physics**

### Section A

1. 


The figure shows a forward-biased p-n junction diode in which p-side is connected to the +ve terminal and n-side is connected to the -ve terminal of the battery and shows its voltage-current graph.




2. Given: Work function $\phi$ = 2eV, Stopping potential $V_0$ = 0.55 V

Thus, Stopping potential energy = $eV_0$ = 0.55 eV = K.E.

Applying Einstein photoelectric equation,

E = $\phi$ + K.E

h$\nu$ = 2 + 0.55 = 2.55 eV

Also, $E_n = -\frac{13.6}{n^2}$, and we know $E_2 = \frac{-13.6}{2^2} = -3.4eV$

The energy difference $\Delta E = -3.4 - (-2.55)\text{eV} = -0.85\text{eV}$

$\therefore \quad \frac{-13.6}{n^2} = -0.85$

$\Rightarrow n = 4$

OR

de-Broglie matter wave equation states that

$\lambda = h/\sqrt{2emV} = h/\sqrt{2mK}$

$\Rightarrow \quad K = h^2/2m\lambda^2$.........(i)

For X-ray of same wavelength = $1\overset{o}{A}$

$E' = h\nu = \frac{hc}{\lambda}$........(ii)

$\frac{K}{E'} = \frac{h^2}{2m\lambda^2} \times \frac{\lambda}{hc} = \frac{h}{2mc\lambda}$

where, h = 6.6 $\times$ $10^{-34}$ J-s, c = 3 $\times$ $10^8$ m/s, m = 9.1 $\times$ $10^{-31}$kg, $\lambda = 1\dot{A} = 1 \times 10^{-10}\text{m}$

$\frac{K}{E'} = \frac{6.6 \times 10^{-34}}{2 \times 9.1 \times 10^{-31} \times 3 \times 10^8 \times 1 \times 10^{-10}}$

$\frac{K}{E'} = 0.012 \Rightarrow \frac{K}{E'} < 1$

Thus, K < E'

i.e. Energy possess by X-ray is more than electron.

3. A p-n junction cannot be obtained by physically joining the slabs of p-type and n-type semiconductors. The reason is that the surfaces of the two slabs may appear flat to the naked eye, but infact the size of irregularities on their surfaces is very large as compared to the interatomic spacing. When two such slabs are put together, a continuous contact at atomic level is not achieved. Due to this, there will be discontinuity at the junction of the two slabs and as a result, the charge carriers cannot flow from one slab to the other.

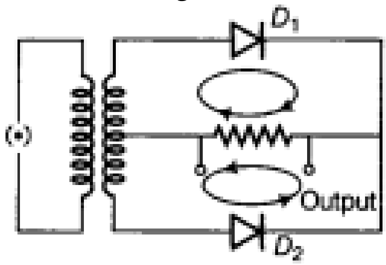
### Section B

4. i. Only those orbits are stable for which the angular momentum, of revolving electron, is an integral multiple of h/2$\pi$. $L = \frac{nh}{2\pi}$ i.e., angular momentum of orbiting electron is quantized.

According to de-Broglie hypothesis
Linear momentum
$p = \frac{h}{\lambda}$
And for a circular orbit, L = $r_n$p where '$r_n$' is the radius of $n^{th}$ orbit
$= \frac{r_n h}{\lambda}$
Also, $\mathrm{L} = \frac{nh}{2\pi}$
$\therefore \frac{r_n h}{\lambda} = \frac{nh}{2\pi}$
$\Rightarrow \quad 2\pi r_n = n\lambda$
$\therefore$ Circumference of permitted orbits are integral multiples of the wave-length $\lambda$

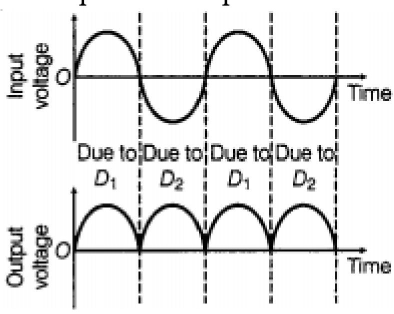
ii. $E_C - E_B = \frac{hc}{\lambda_1}$ ...(i)
$E_B - E_A = \frac{\hbar c}{\lambda_2}$ ...(ii)
$E_C - E_A = \frac{hc}{\lambda_3}$ ...(iii)
Adding (i) & (ii)
$E_C - E_A = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$ ...(iv)
Using equation (iii) and (iv)
$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$
$\Rightarrow \quad \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

5. A rectifier which rectifies both halves of each a.c. input cycle is called a full wave rectifier. To make use of both the halves of input cycle, two junction diodes are used.
The circuit diagram of full-wave rectifier is shown below:




Circuit diagram of full wave rectifier

During the first half of input cycle, the upper end of the coil is at positive potential and lower end at negative potential. This provides forward bias to diode $D_1$ and reverse bias to diode $D_2$. So diode $D_1$ conducts only and diode $D_2$ does not conduct. Current flows in output load in the direction shown in figure.
During the second half of input cycle, $D_2$ is forward biased and conducts. In this way, current flows in the load in the single direction in both the half of the input wave as shown in figure.
The input and output wave forms are given below:

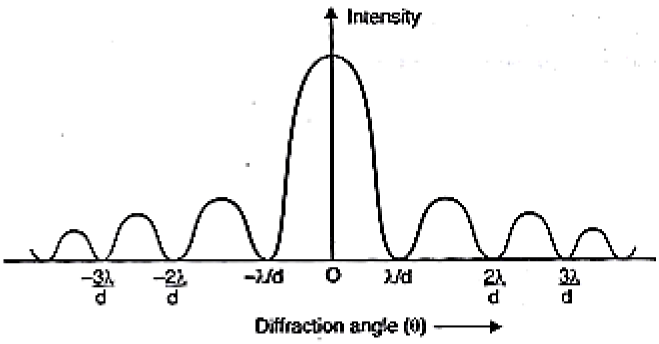



6. Nuclear fission is a process of splitting of a heavier nucleus into two lighter nuclei. It generally occurs in elements of high atomic mass.
Nuclear fusion is a process of a combination of two light nuclei to form heavier nuclei. It generally occurs in elements of low atomic mass. This process releases a tremendous amount of energy because some mass is converted into energy.
In both processes, the total mass of the products is slightly less than the mass of the original nuclei. This difference in mass is converted to energy.
In the given problem, mass defect is

$\Delta m = 2.014102 + 3.016049 - 4.002603 - 1.008665$
$\Delta m = 0.018883$ u

Energy released, $\Delta E = \Delta mc^2$
$\Delta E = 0.018883 \times 931.5 = 17.589$ MeV

7. Diffraction of light: Phenomenon of bending of light around the corners of an obstacle or aperture is called diffraction.
The intensity distribution wave for diffraction is shown in the diagram below:




In interference, by 2 slits all bright fringes are of same intensity. In diffraction, the intensity of bright fringes decreases with the increase in distance from the central bright fringe.

i. The diffraction pattern becomes narrower if the width of the slit is decreased.
ii. When the monochromatic source is replaced by a white light source, we get a coloured diffraction pattern. The central band is white, but the other bands are coloured. As bandwidth is proportional to λ, the red band of higher wavelength is wider than the violet band with smaller wavelength.

8. i. $\mu = \sin i_c$ or $n_{21} = \sin i_c$
where $n_{21}$ is the refractive index of rarer medium 1 with respect to denser medium 2.
ii. As $\mu$ depends on wavelength, therefore, critical angle for the same pair of media in contact will be different for different colours.

OR

For lens $L_1$, u = -15cm, v = ?, f = +10 cm

Now, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
$\frac{1}{10} = \frac{1}{v} + \frac{1}{15}$
$\Rightarrow \quad v = 30\text{cm}$
Distance of image from lens $L_1$ is 30 cm.

For lens $L_3$, distance of image from lens $L_3$, v'' = 10 cm

Now, $\frac{1}{f''} = \frac{1}{v''} - \frac{1}{u''}$
$\frac{1}{10} = \frac{1}{10} + \frac{1}{u''} \Rightarrow u'' = \infty$
The refracted rays from lens $L_1$ become parallel to principal axis. It is possible only when image formed by $L_1$ lies at first focus of $L_2$ i.e at a distance of 10 cm from $L_2$.

Therefore, separation between $L_1$ and $L_2$ = 30 + 10 = 40 cm

Now $L_2$ makes image at infinity, thus any distance between $L_2$ and $L_3$ will make the object for $L_3$ as infinity.

Therefore, separation between $L_2$ and $L_3$ = any length

9. Consider a particle of mass m, charge q . Let it be accelerated through a potential difference V to gain speed v and Kinetic energy KE.
KE = qV = $\frac{1}{2}mv^2$
Now, we can rearrange the expression to get
$v = \sqrt{\frac{2qV}{m}}$
The de-Broglie wavelength is given by the equation:
$\lambda = \frac{h}{mv}$
Substituting the value of v, we get

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

This is analogous to the equation of a straight line passing through the origin: y = mx where m is the slope of the line.

Hence, we can see that if we plot the graph of $\lambda$ vs V, we would get a straight line with slope:

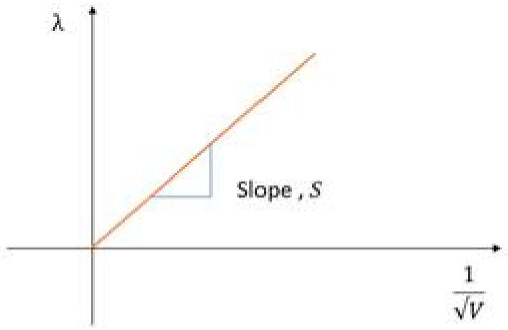
$S = \frac{h}{\sqrt{2mq}}$

On rearranging,

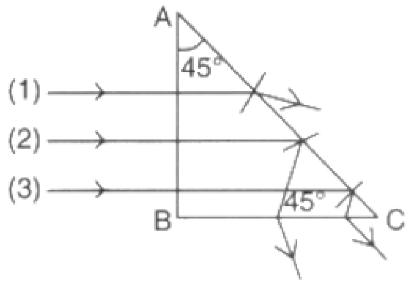
$q = \frac{h^2}{2mS^2}$

Hence, as we know q, h and we can determine S from the graph, we can calculate the magnitude of charge on the particle.

The graph is drawn below:




10. Three rays (1, 2, 3) of different colours fall normally on one of the sides of an isosceles right-angled prism as shown. At plane AC, the incident angle for ray 1, ray 2 and ray 3 = 45°




Let critical angle for total internal reflection for ray 1 = $C_1$

$1.39 = \frac{1}{\sin C_1}$

$\Rightarrow \quad \sin C_1 = \frac{1}{1.39}$

= 0.719

Hence $C_1$ > 45° (sin $45^0$ = 0.707)

Let critical angle for total internal reflection for ray 2 = $C_2$

$1.47 = \frac{1}{\sin C_2}$

$\Rightarrow \quad \sin C_2 = \frac{1}{1.47} = 0.68$

Hence $C_2$ < 45°

Let critical angle for total internal reflection for ray 3 = $C_3$

$1.52 = \frac{1}{\sin C_3}$

$\Rightarrow \quad \sin C_3 = \frac{1}{1{\cdot}52} = 0.657$

Hence $C_3$ < 45°

As in the case of ray 1, the incident angle is less than the critical angle, it would emerge out from AC. In the figure path of the ray 1 is shown.

In the case of ray 2, ray 3, incident angle is greater than the critical angle, they would get total internal reflection at AC and emerge from BC. In the figure path of the rays, 2 and 3 are shown.

11. In a microwave oven, the frequency of the microwaves is selected to match the resonant frequency of water molecules. This leads to the vibrations of these water molecules. As these vibrations increase with time, the temperature increases leading to the production of heat and this is the heat that is responsible for the cooking

of food in the oven. So any food containing water molecules inside can be heated by a microwave oven. Microwaves are short-wavelength radio waves, with the frequency of the order of 300 MHz to 300 GHz. Due to the short wavelengths, they have high penetrating power with respect to the atmosphere and less diffraction in the atmospheric layers. So, these waves are suitable for the RADAR (Radio Detection And Ranging) systems used in aircraft navigation.

OR

d = 0.15mm $= 15 \times 10^{-4}$m
$\lambda = 450\text{nm} = 4.5 \times 10^{-7}\text{m}$
D = 1m

i. a. The distance of nth order bright fringe from central fringe is given by
$y_n = \frac{Dn\lambda}{d}$
For second bright fringe,
$y_2 = \frac{2D\lambda}{d} = \frac{2\times1\times4.5\times10^{-7}}{1.5\times10^{-4}}$
$y_2 = 6 \times 10^{-3}\text{m}$
The distance of the second bright fringe,
$y_2$ = 6mm

b. The distance of nth order dark fringe from central fringe is given by
$y_n' = (2n-1)\frac{D\lambda}{2d}$
For second dark fringe, n = 2
$y_n' = (2\times2-1)\frac{D\lambda}{2d} = \frac{3D\lambda}{2d}$
$y_n' = \frac{3}{2} \times \frac{1\times45\times10^{-7}}{1.5\times10^{-4}}$
The distance of the second dark fringe,
$y_n' = 45\text{mm}$

ii. With increase of D, fringe width increases as
$\beta = \frac{D\lambda}{d}$ or $\beta \propto D$

**CASE STUDY**

12. i. (i) (b): Here $f_0$ = 2.0, $f_e$ = 6.25 cm, $u_0$ = ?
When the final image is obtained at the least distance of distinct vision :
$v_e$ = -25 cm
As $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$
$\therefore \frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{6.25}$
$= \frac{-1-4}{25} = \frac{-5}{25} = -\frac{1}{5}$
or $u_e$ = -5 cm

ii. (b): Distance between objective and eye-piece = 15 cm
$\therefore$ Distance of the image from objective is
$v_0$ = 15 - 5 = 10 cm
$\therefore \frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{1}{10} - \frac{1}{2} = \frac{1-5}{10} = -\frac{2}{5}$
or $u_0 = -\frac{5}{2} = -2.5cm$
$\therefore$ Distance of object from objective = 2.5 cm

iii. (a): Magnifying power
m = $m_0 \times m_e = \frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right) = \frac{10}{2.5}\left(1+\frac{25}{6.25}\right) = 20$

iv. (a): The intermediate image formed by the objective of a compound microscope is real, inverted and magnified.

v. (d)