Sample Question Paper - 11
Physics (042)
Class- XII, Session: 2021-22
TERM II

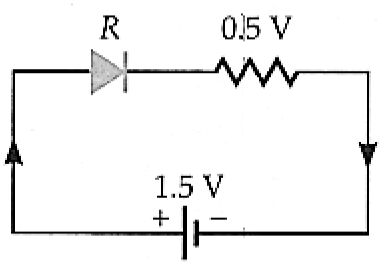
Time Allowed: 2 hours **Maximum Marks: 35**

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. A p-n junction diode when forward biased has a drop of 0.5 V which is assumed to be independent of the current. The current in excess of 10 mA through the diode produces a large Joule heating which damages (burns) the diode. If we want to use a 1.5 V battery to forward bias the diode, what should be the value of the resistor used in series with the diode so that the maximum current does not exceed 5 mA? **[2]**



2. Determine the speed of electron in n = 3 orbit of He^{+}. Is the non-relativistic approximation valid? **[2]**

OR

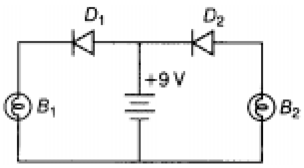
Write Einstein's photoelectric equation. State clearly the three salient features observed in photoelectric effect which can be explained on the basis of above equation.

3. Distinguish between the light-emitting diode and the photodiode. **[2]**

Section B

4. Using Bohr's postulates of the atomic model, derive the expression for radius of nth electron orbit. Hence, obtain the expression for Bohr's radius. **[3]**

5. i. In the following diagram, which bulb out of B_1 and B_2 will glow and why? **[3]**



ii. Draw a circuit diagram of an illuminated p-n junction solar cell.

iii. Explain briefly the three processes due to which generation of emf takes place in a solar cell.

6. Define the terms (i) mass defect (ii) binding energy for a nucleus and state the relation between the two for a given nuclear reaction for which the B.E. / nucleon of the product nucleus/nuclei is more than that for the original nucleus/nuclei. Is this nuclear reaction exothermic or endothermic in nature? Justify your choice. **[3]**

7. i. Define wavefront. Use Huygens' principle to verify the laws of refraction. **[3]**

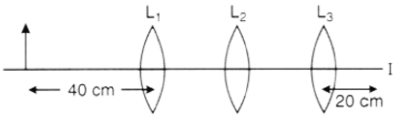
ii. In a single slit diffraction experiment, the width of the slit is made double of the original width. How does this affect the size and intensity of the central diffraction band? Explain.

iii. When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the center of obstacle. Explain why?

8. When viewing through a compound microscope, our eyes should be positioned not on the eyepiece but a short distance away from it for best viewing. Why? How much should be that short distance between the eye and eyepiece? **[3]**

OR

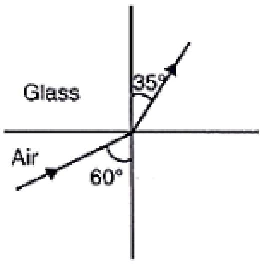
You are given three lenses L_1, L_2 and L_3 each of focal length 20 cm. An object is kept at 40 cm in front of L_1. The final real image is formed at the focus I of L_3. Find the separations between L_1, $L_2$and L_3.



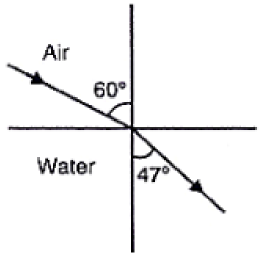
9. Write Einstein's photoelectric equation and point out any two characteristic properties of photons on which this equation is based. Briefly explain three observed features which can be explained by this equation. **[3]**

10. Refraction of a ray in air incident at 60° with the normal to a glass air and water air interface, respectively. Predict the angle of refraction in glass when the angle of incidence in water is 45° with the normal to a water glass interface. **[3]**

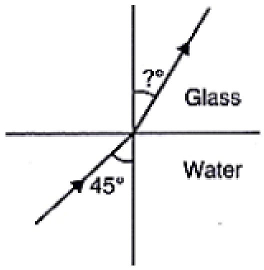
a.



b.



c.



11. i. It is necessary to use satellites for long distance TV transmissions. Why? **[3]**

ii. If the earth did not have an atmosphere, would its average surface temperature be higher or lower than what it is now?

iii. Some scientists have predicted that a global nuclear war on the earth would be followed by a severe 'nuclear winter' with a devastating effect on life on earth. What might be the basis of this prediction?

OR

In Young's double-slit experiment, the intensity of light at a point on the screen where the path difference is λ is k units. Find the intensity at a point where the path difference is

i. $\frac{\pi}{4}$

ii. $\frac{\pi}{3}$

iii. $\frac{\pi}{2}$

CASE STUDY

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

The lens maker's formula relates the focal length of a lens to the refractive index of the lens material and the radii of curvature of its two surfaces. This formula is called so because it is used by manufacturers to design lenses of required focal length from a glass of given refractive index.

If the object is placed at infinity, the image will be formed at focus for both double convex lens and double concave lens.

Therefore, lens maker's formula is, $\frac{1}{f}=\left[\frac{\mu_2-\mu_1}{\mu_1}\right]\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

When lens is placed in air, $\mu_1=1$ and $\mu_2=\mu$. The lens maker formula takes the form,

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

i. The radius of curvature of each face of biconcave lens with refractive index 1.5 is 30 cm. The focal length of the lens in air is

a. 12 cm

b. 10 cm

c. 20 cm

d. 30 cm

ii. The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If focal length is 12 cm, then refractive index of glass is

a. 1.5
b. 1.78
c. 2.0
d. 2.52

iii. An under-water swimmer cannot see very clearly even in absolutely clear water because of

a. absorption of light in water
b. scattering of light in water
c. reduction of speed of light in water
d. change in the focal length of eye-lens

iv. A thin lens of glass (μ = 1.5) of focal length 10 cm is immersed in water (μ = 1.33). The new focal length is

a. 20 cm
b. 40 cm
c. 48 cm
d. 12 cm

v. An object is immersed in a fluid. In order that the object becomes invisible, it should

a. behave as a perfect reflector
b. absorb all light falling on it
c. have refractive index one
d. have refractive index exactly matching with that of the surrounding fluid.

Solution

PHYSICS - 042

Class 12 - Physics

Section A

1. Here V_D = 0.5 V, V = 1.5 V, I = 5 mA = 5 $\times$ 10^{-3}, R = ?

   The voltage equation for the diode circuit is

   IR + V_D = V

   or 5 $\times$ 10^{-3} A $\times$ R + 0.5 V = 1.5 V

   or R = 200 Ω

2. The speed of electron in nth orbit is given by

   $v = \frac{2\pi KZe^2}{nh}$

   For He, Z = 2, n = 3

   $v = \frac{2\pi K2e^2}{3h}$

   $= \frac{4\times3.14\times9\times10^9(1.6\times10^{-19})^2}{3\times6.6\times10^{-34}}$

   $v = 1.46 \times 10^6 m/s$

   Now, $\frac{v}{c} = \frac{1.46\times10^6}{3\times10^8}$ = 0.048

   which is much less than 1.

   Hence non-relativistic approximation is true.

   OR

   Einstein's photoelectric equation is given as,

   $(K.E.)_{max}$ = hν - hν_0.

   The three salient features which can be explained on the basis this equation are as follows:

   i. If $\nu_0 < \nu$, $K.E._{max}$ is negative since K.E. can never be negative, ν_0 can never be less than ν during photoelectric emission. This brings forward the concept of threshold frequency.

   ii. There is a linear dependency of $K.E_{max}$ and ν.

   iii. $K.E_{max}$ is independent of the intensity of incident radiation.

3. Difference between light-emitting diode and photodiode:

	Light Emitting Diode(LED)	Photodiode
1	It is forward biased.	It is reverse biased.
2	Recombination of electrons and holes takes place at the junction and emits e.m. radiation.	Energy (hv) is supplied by light to take an electron from the valence band to the conduction band.

Section B

4. Let e, m and v be respectively the charge, mass and velocityof the electron and r the radius of the orbit. The positive charge on the nucleus is Ze, where Z is the atomic number (in case of hydrogen atom, Z = 1). As, the centripetal force is provided by the electrostatic force of attraction, we have

   $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(Ze)\times e}{r^2}$ or $mv^2 = \frac{Ze^2}{4\pi\varepsilon_0 r}$............(i)

   From the first postulate of Bohr's atomic model, the angular momentum of the electron is

   $mvr = n\frac{h}{2\pi}$.............(ii)

   where, n (= 1, 2, 3, ...) is principal quantum number.

   From Eqs. (i) and (ii), we get

   $r = n^2 \frac{h^2\varepsilon_0}{\pi mZe^2}$ ....(iii)

   This is the equation for the radii of the permitted orbits.

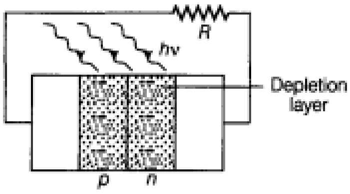
   Bohr's Radius: The radius of the first orbit (n = 1) of hydrogen atom (Z = 1) will be

   $r = \frac{h^2\varepsilon_0}{\pi me^2}$

This is called Bohr's radius and its value is 0.53 $\overset{o}{A}$

Since $r_n \propto n^2$, the radius of the second orbit of hydrogen atom will be $(4 \times 0.53)\overset{o}{A}$ and that of the third orbit $(9 \times 0.53)\overset{o}{A}$ and can be extended for other orbits according to formula.

5. i. The bulb B_1 will glow because the diode D_1 is forward biased.
   ii. The diagram of illuminated p-n junction solar cell is given below



   iii. The generation of emf by a solar cell, when light falls on, it is due to the following three basic processes: generation, separation and collection—
   (a) generation of e-h pairs due to light (with $h\nu > E_g$) close to the junction;
   (b) separation of electrons and holes due to electric field of the depletion region. Electrons are swept to n-side and holes to p-side;
   (c) the electrons reaching the n-side are collected by the front contact and holes reaching p-side are collected by the back contact. Thus p-side becomes positive and n-side becomes negative giving rise to photovoltage.
6. i. Mass defect (ΔM), of any nucleus $_Z^AX$ is the difference in the mass of the nucleus (= M) and the sum of masses of its constituent nucleons (= M').
   $\Delta M = M' - M$
   $= [Zm_p + (A - Z)m_n] - M$
   where m_p and m_n denote the mass of the proton and the neutron respectively.
   ii. Binding energy is the energy required to separate a nucleus into its constituent nucleons. Or Nuclear binding energy is the minimum energy that would be required to disassemble the nucleus of an atom into its component parts. These component parts are neutrons and protons, which are collectively called nucleons. The relation between the two is
   B.E. = ΔMc^2
   iii. There is a release of energy, i.e., the reaction is exothermic.
   Reason: Increase in B.E/nucleon implies that mass has been converted into energy. This would result in the release of energy.
7. i. Wavefront is the locus of all points in which light waves are in the same phase. The propagation of wave energy is perpendicular to the wavefront. Or A wavefront is defined as the continuous locus of all the particles which are vibrating in the same phase.
   ii. The angular width of the central fringe = $\frac{2D\lambda}{a}$ where, a is the width of the slit. Hence if the width of the slit is made double, then fringe width becomes half. The intensity of the central fringe becomes four times. This is because the area of central diffraction band would become $(\frac{1}{4})$th.
   iii. This is because of diffraction. The diffraction of waves from the edges of the circular obstacle interferes constructively at the center of the shadow. It results in the formation of a bright spot at the center of the obstacle.
8. The image of the objective lens in the eyepiece is known as the 'eyering'. All the rays from the object refracted by the objective go through the eye ring. Therefore, it is an ideal position for our eyes for viewing. If we place our eyes too close to the eyepiece, we shall not collect much of the light and also reduce our field of view. If we position our eyes on the eye ring and the area of the pupil of our eye is greater or equal to the area of the eyering, our eyes will collect all the light refracted by the objective.
The precise location of the eye ring naturally depends on the separation between the objective and the eyepiece and the focal length of the eyepiece. When we view through a microscope by placing our eyes on one end, the ideal distance between the eye and the eyepiece is usually built in the design of the instrument.

OR

f_3 = + 20 cm, v_3 = 20 cm

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

$\Rightarrow \quad u_3 = \infty$

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.

Given, $f_1 = f_2 = f_3$ 20 cm

For lens, L_1

u = - 40 cm

f = 20 cm

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

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

$\frac{1}{v} = -\frac{1}{40} + \frac{1}{20}$

$\frac{1}{v} = \frac{1}{40}$

v = 40 cm

(+ ve sign shows it is right hand side of lens L_1)

Now for L_3 the final image is at its focus, that means v_3 = + 20 cm.

Hence $u_3 = \infty$

Now, since image of the object AB formed by convex lens L_2 is virtual object for L_3 therefore $v_2 = \infty$.

Hence for lens L_2, u_2 = ?, f_2 = 20 cm and $u_2 = \infty$.

Using the lens formula,

$\frac{1}{v_2} - \frac{1}{u_2} = \frac{1}{f_2}$

$\Rightarrow \quad \frac{1}{\infty} - \frac{1}{u_2} = \frac{1}{20}$

u_2 = - 20 cm

So, the separation between L_1 and L_2

= 40 + 20 = 60 cm

As $v_2 = \infty$ and $u_3 = \infty$, therefore the distance between L_2 and L_3 does not matter it may take any value because image by L_2 is formed at infinity.

Hence, the distance between $L_2$and L_3 can have any value.

9. Einstein's photoelectric equation is

$eV_0 = K_{max} = h\nu - \phi_0$

Important features of this equation are

i. Photoemission occurs when frequency of incident radiation is more than the threshold frequency, $\nu_0 = \frac{\phi_0}{h}$
ii. Energy of emitted photoelectron is proportional to energy of incident photon.

Three salient features observed in photoelectric effect and their explanation on the basis of Einstein's photoelectric equation is given as below:

i. **Threshold frequency:** For $KE_{max} \geq 0$,

   $\Rightarrow \nu \geq \nu_0$

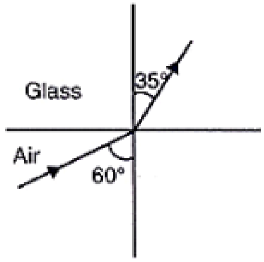
   i.e. the phenomenon of photoelectric effect takes place when incident frequency is greater or equal to a minimum frequency (threshold frequency) ν_0 fixed for given metal.
ii. **KE_{max} of photoelectron:** When incident frequency is greater than threshold frequency, then KE_{max} of photo-electron is directly proportional to ($\nu - \nu_0$) as

   $KE_{max} = h(\nu - \nu_0)$

   $\Rightarrow KE_{max} \propto (\nu - \nu_0)$

iii. **Effect of intensity of incident light:** The number of photons incident per unit time per unit area increases with the increase of intensity of incident light. More number of photons facilitates ejection of more number of photo-electrons from metal surface leads to further increase of photocurrent till its saturation value is reached.

10. a. For the glass-air interface:



Angle of incidence, i = 60°
Angle of refraction, r = 35°
According to Snell's law,

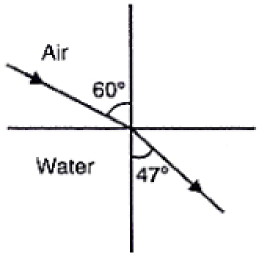
$\mu_g^a = \frac{\sin i}{\sin r}$

$\Rightarrow \mu_g^a = \frac{\sin 60^\circ}{\sin 35^\circ}$

$\Rightarrow \mu_g^a = \frac{0.8660}{0.5736}$

$\Rightarrow \mu_g^a = 1.51$

b. For the water-air interface:



Angle of incidence, i = 60°
Angle of refraction, r = 47°
According to Snell's law,

$\mu_w^a = \frac{\sin i}{\sin r}$

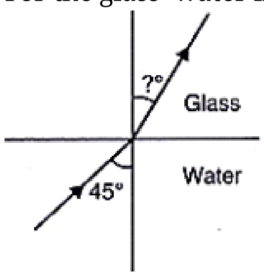
$\Rightarrow \mu_w^a = \frac{\sin 60^\circ}{\sin 47^\circ} = \frac{0.87}{0.73}$

$\Rightarrow \mu_w^a = 1.19$

$\Rightarrow \mu_w^a = \frac{\mu_g^a}{\mu_W^2} = \frac{1.51}{1.19}$

$\Rightarrow \mu_w^a = 1.26$

c. For the glass- water interface:



Angle of incidence, i = 45^0

Angle of refraction, r = $?^0$

According to Snell's law,

$\mu_g^w = \frac{\sin i}{\sin r} = \frac{\sin 45^\circ}{\sin r}$

$\Rightarrow \sin r = \frac{\sin i}{\mu g} = \frac{1/\sqrt{2}}{1.27}$

$\Rightarrow \sin r = 0.6$

$\therefore r = \sin^{-1}(0.6) = 36.87^0$

$\Rightarrow r \approx 37^o$

Therefore, the angle of refraction in glass is 37^o

11. i. TV waves have frequency range 47 MHz-940 MHz. These frequencies are not reflected by the ionosphere. As space wave, they can cover a distance of 50-60 km only. Therefore, for long distance TV transmission, we make use of satellites which reflect the TV signal back towards the earth.

ii. If the earth did not have an atmosphere, then its average surface temperature will be lesser than what it is now because in that case, the greenhouse effect will be absent.

iii. The prediction is based on the assumption that the large dust clouds produced by global nuclear war would perhaps cover substantial part by the global nuclear war would perhaps cover a substantial part of the sky and solar radiations will not be able to reach the earth. It may cause a severe winter on the earth with a devastating effect on life on earth.

OR

Intensity at any point on the screen,

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

Let I_0 be the intensity of either source. Then $I_1 = I_2 = I_0$, and $I = 2I_0(1 + \cos\phi) = 4I_0\cos^2\frac{\phi}{2}$

When $p = \lambda$, $\phi = 2\pi$

$\therefore I = 4I_0\cos^2\frac{\phi}{2} = 4I_0\cos^2\pi = 4I_0 = k$

i. When $p = \frac{\lambda}{4}, \phi = \frac{\pi}{2}$

$\therefore I = 4I_0\cos^2\frac{\pi}{4}, = 4I_0 \times \frac{1}{2} = 2I_0 = \frac{k}{2}$

ii. When $p = \frac{\lambda}{3}, \phi = \frac{2\pi}{3}$

$\therefore I = 4I_0\cos^2\frac{\pi}{3} = 4I_0 \times \frac{1}{4} = I_0 = \frac{k}{4}$

iii. When $p = \frac{\lambda}{2}, \phi = \pi$

$\therefore I = 4I_0\cos^2\frac{\pi}{2} = 0$

CASE STUDY

12. i. (d): Here, = 1.5; R_1 = 30 cm

R_2 = -30 cm

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

$= (1.5 - 1)\left[\frac{1}{30} - \frac{1}{-30}\right] = -0.5 \times \frac{2}{30} = \frac{-1}{30}$

f = -30 cm

ii. (a): Here, f = 12 cm; R_1 = 10 cm; R_2 = -15 cm

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

$\frac{1}{12} = (-1)\left[\frac{1}{10} + \frac{1}{15}\right]$

$\mu = 1.5$

iii. (d): The eye-lens is surrounded by a different medium than air. This will change the focal length of the eye-lens. The eye cannot accommodate all images as it would do in air.

iv. (b): $\frac{1}{f} = (1.5 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

and $\frac{1}{f_w} = \left(\frac{1.5}{1.33} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$= \frac{f_w}{f} = \frac{0.5 \times 1.33}{0.17} = 4$

$f_w = 4f = 4 \times 10 = 40cm$

v. (d): If the refractive index of two media are same, the surface of separation does not produce refraction of reflection which helps in visibility.