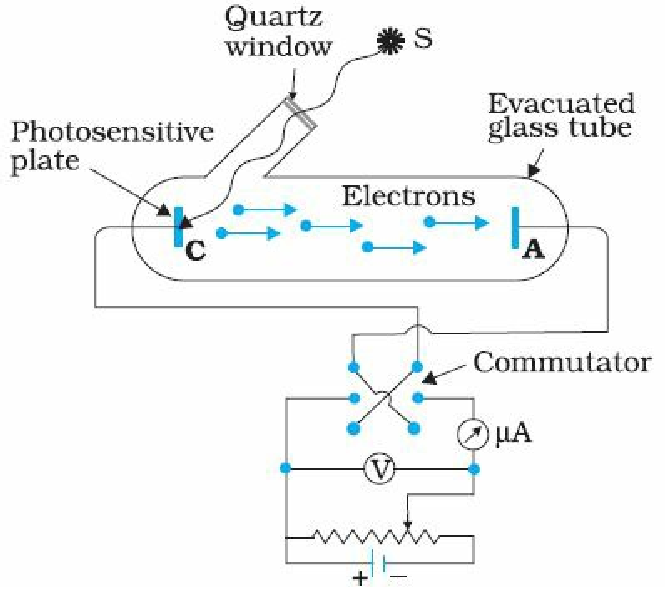
CBSE Test Paper-01

Class - 12 Physics (Dual Nature of Radiation and Matter)

1. Stopping potential in the experimental set up shown in figure is



   a. positive potential V_0 given to the plate A for which the photocurrent stops or becomes zero
   b. positive potential V_0 given to the plate A for which the photocurrent stops increasing
   c. negative potential V_0 given to the plate A for which the photocurrent stops or becomes zero
   d. positive potential V_0 given to the plate A for which the photocurrent saturates

2. Photons can be
   a. deflected by electric fields
   b. scattered
   c. deflected by magnetic fields
   d. deflected by magnetic fields

3. If an electron moving with a speed of $2.5 \times 10^7 \mathrm{ms}^{-1}$ is deflected by an electric field of 1.6 k V m^{-1} perpendicular to its circular path, then e/m for the electron will be (given radius of circlar path = 2.3 m)

   a. $1.7 \times 10^{11} \mathrm{Ckg}^{-1}$
   b. $1.8 \times 10^{11} \mathrm{Ckg}^{-1}$
   c. $1.9 \times 10^{11} \mathrm{Ckg}^{-1}$

   d. $1.85\times10^{11}\mathrm{Ckg}^{-1}$
4. If the threshold wavelength of radiations required to eject a photoelectron from a metal surface is 6 $\times10^{-7}$ m, then work function of the metal is
   a. 3.4 $\times10^{-19}$ J
   b. 3.5 $\times10^{-19}$ J
   c. 3.3 $\times10^{-19}$ J
   d. 3.6 $\times10^{-19}$ J

5. According to the Einstein's model stopping potential for a metal having work function ϕ_0 is given by

   a. $V_0=\left(\frac{h}{e}\right)\nu+\frac{\phi_0}{e}$
   b. $V_0=\left(\frac{h}{e}\right)\nu+2\frac{\phi_0}{e}$
   c. $V_0=\left(\frac{h}{e}\right)\nu-2\frac{\phi_0}{e}$
   d. $V_0=\left(\frac{h}{e}\right)\nu-\frac{\phi_0}{e}$

6. Why is photoelectric emission not possible at all frequencies?

7. Ultraviolet light is incident on two photosensitive materials having work functions W_1 and W_2(W_1 > W_2). In which case will the kinetic energy of the emitted electrons be greater? Why?

8. The stopping potential in an experiment on photoelectric effect is 1.5 V. What is the maximum kinetic energy of the photoelectrons emitted?

9. An electron is revolving around the nucleus with a constant speed of 2. 2 $\times$ 10^8 m/s. Find the de-Broglie wavelength associated with it.

10. A 100 W sodium lamp radius energy uniformly in all directions. The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it. The wavelength of the sodium light is 589 nm.

    a. What is the energy per photon associated with the sodium light?
    b. At what rate are the photons delivered to the sphere?

11. The maximum kinetic energy of a photoelectron is 3eV. What is its stopping potential?

12. Explain. Given $m_n = 1.675 \times 10^{-27} kg$(b) Obtain the de-Broglie wavelength associated with thermal neutrons at room temperature (27°C). Hence explain why a fast neutron beam needs to be thermalised with the environment before it can be used for neutron diffraction experiments.

13. Monochromatic light of wavelength 632.8 nm is produced by a helium neon laser. The power emitted is 9.42 mW.

    a. Find the energy and momentum of each photon in the light beam.
    b. How many photons per second, on the average, arrive at a target irradiated by this beam? (assume the beam to have uniform cross-section which is less than the target area), and
    c. How fast does a hydrogen atom have to travel in order to have the same momentum as that of the photon?

14. The work function for the following metals is given: Na : 2.75 eV K : 2.30 eV M_0 4.17 eV Ni : 5.15 eV, Which of these metals will not give photoelectric emission for a radiation of wavelength $3300\overset{o}{A}$ from a He-Cd laser placed 1m away from the photocell? What happens if the laser is brought nearer and placed 50 cm away?

15. When a surface is irradiated with light of $\lambda = 4950\overset{\text{o}}{\text{A}}$, a photocurrent appears which vanishes if a retarding potential greater than 0.6 V is applied across the photo tube. When a different source of light is used, it is found that the critical retarding potential is changed to 1.1 V. What is the work function of the surface and the wavelength of the second source? If the photoelectrons (after emission from the source) are subjected to a magnetic field of 10 tesla what changes will be observed in the above two retarding potentials?

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Answers

1. c. negative potential V_0 given to the plate A for which the photocurrent stops or becomes zero

   Explanation: The negative potential of the plate at which the photo electric current becomes zero is called stopping potential or cut-off potential. Its value is negative because some electron reach to the plate with their kinetic energy at zero potential.

2. b. scattered

   Explanation: If photon strike with loosely bound electron then photoelectric effect takes place. Collision of photon with completely free electron give rise to Compton effect or Compton scattering.

3. a. $1.7 \times 10^{11} \mathrm{Ckg}^{-1}$

   Explanation: Electric field provide required centripetal force for circular motion

   $eE = \frac{mv^2}{r}$

   $\frac{e}{m} = \frac{v^2}{rE} = \frac{\left(2.5\times10^7\right)^2}{2.3\times1.6\times10^3} = 1.7 \times 10^{11} C\ Kg^{-1}$

4. c. 3.3 $\times 10^{-19}$ J

   Explanation: $\phi_0 = \frac{hc}{\lambda_0} = \frac{6.6\times10^{-34}\times3\times10^8}{6\times10^{-7}} = 3.3 \times 10^{-19} J$

5. d. $V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi_0}{e}$

   Explanation: $eV_0 = K_{\max}$

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

   $eV_0 = h\nu - \phi_0$

   $V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi_0}{e}$

6. Photoelectric emission is not possible at all frequencies because below the threshold frequency for photosensitive surface of different atoms emission is not possible.

7. K.E. of photoelectron = hv - W

   As given, $W_1 > W_2$

   Since, W_2 is lesser than W_1 thus the kinetic energy of the emitted electrons for the photoelectric material having work function W_2 will be greater.

8. Given, stopping potential, V = 1.5V

   $KE_{max} = eV_0$ where, V_0 = cut-off potential

   KE_{max} = 1.5 eV

9. Given, v = 2.2×10^8 m/s

   Here, m = 9.1×10^{-31} kg

   h = 6.63×10^{-34} kg-m^2-s

   de-Broglie wavelength is given by

   λ= h/mv..............................(i)

   Substituting all values in Eq. (i), we get

   $\lambda = \frac{6.63\times10^{-34}}{9.1\times10^{-31}\times2.2\times10^8}$

   $\lambda = 3.31 \times 10^{-12}\mathrm{m}$

10. Given,

    P (power) = 100 W

    $\lambda = 589 \times 10^{-9}m$

    a. Energy of each photon

       $E = h\nu = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^8}{589\times10^{-9}}J$

       $\Rightarrow E = 3.38 \times 10^{-19}J$

    b. Number of photons delivered to sphere per second

       $n = \frac{Energy\ radiated\ per\ \sec ond}{Energy\ of\ each\ photon}$

       P = nE

       or $n = \frac{100}{3.38\times10^{-19}} = 3 \times 10^{20}$photons/s

11. Given, maximum kinetic energy of photoelectron = 3eV

    Therefore, Maximum KE = eV_0

    V_0 = stopping potential

    3eV= eV_0

    Hence, stopping potential

    V_0 = 3V

12. (b) Here, T = 27 + 273 = 300 K

Boltzmann's constant, k $= 1.38 \times 10^{-23} J\ mol^{-1} K^{-1}$

We know, average K.E. of neutron at absolute temperature T is given by $E = \frac{3}{2} kT$.

Where k is the Boltzmann's constant.

Now, $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{3mkT}}$

$\therefore \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{3 \times 1.675 \times 10^{-27} \times 1.38 \times 10^{-23} \times 300}} = 1.45 \times 10^{-10} m$

Since this wavelength is comparable to interatomic spacing $(\sim 1\overset{o}{A})$ in a crystal, therefore, thermal neutrons are suitable probe for diffraction experiments: so a high energy neutron beam should be first thermalised before using it for diffraction.

13. Given,

Wavelength, $\lambda = 632.8 nm = 632.8 \times 10^{-9} m$

Frequency, $\nu = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{632.8 \times 10^{-9}} Hz$

$= 4.74 \times 10^{14} Hz$

a. E = hv

$= 6.63 \times 10^{-34} \times 4.74 \times 10^{14} J$

$= 3.14 \times 10^{-19} J$

p (momentum) $= \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{632.8 \times 10^{-9}} = 1.05 \times 10^{-27} kg\ ms^{-1}$

b. Power emitted, P = 9.42 mW $= 9.42 \times 10^{-3} W$

P = nE

$n = \frac{P}{E} = \frac{9.42 \times 10^{-3} W}{3.14 \times 10^{-19} J} = 3 \times 10^{16} photons/\sec$

c. Velocity of hydrogen atom

$= \frac{Momentum\ 'p'\ of\ H_2\ atom\ (mv)}{Mass\ of\ H_2\ atom\ (m)}$

$\Rightarrow v = \frac{1.05 \times 10^{-27}}{1.673 \times 10^{-27}} ms^{-1}$ = 0.63ms^{-1}

14. (i) Work function of Na is

$\phi_{Na} = 1.92 eV = 1.92 \times 1.6 \times 10^{-19} J$

$\lambda = 3300\overset{o}{A} = 3300 \times 10^{-10} m$

$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{3300 \times 10^{-10}}$

$E = \frac{6.6 \times 3 \times 10^{-34+8+10-2}}{33 \times 10} J$

$= \frac{6 \times 10^{-18-1}}{1.6 \times 10^{-19}} J$

$= \frac{60}{16} eV$

E = 3.75 eV

It is observed that energy of incident radiation is less than Ni and Mo but larger than Na and K. So photoemission current take place from Na and K but not from Mo and Ni. Therefore, Mo and Ni will not give photoelectric emission. If the laser is brought closer the intensity of radiation increases without any change in frequency. This therefore, will not affect the result. However, photoelectric current from Na and K will increase.

15. According to Einstein's equation of photo electricity

$\frac{1}{2} m v_{\max}^2 = eV_0 = hv - v_0$

or $eV_0 = \frac{hc}{\lambda} - \phi_0$

where ϕ_0 is the work function, λ wavelength of incident light and V_0 is the stopping potential.

For the first source,

$\lambda_1 = 4950 \overset{\circ}{A} = 4950 \times 10^{-10} m$

V_0 = 0.6 V

$\therefore 1.6 \times 10^{-19} \times 0.6 = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{495 \times 10^{-9}} - \phi_0$

or $0.96 \times 10^{-19} = 4 \times 10^{-19} - \phi_0$

$\therefore \phi_0 = 3.04 \times 10^{-19} J$ .....(i)

$= \frac{3.04 \times 10^{-19}}{1.6 \times 10^{-19}} eV$ = 1.9 eV

Let λ_2 be the wavelength of the second source.

Given, $V_0' = 1.1 V$

Therefore,

$1.6 \times 10^{-19} \times 1.1 = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda_2} - 3.04 \times 10^{-19} J$(from I)

or $1.76 \times 10^{-19} = \frac{19.8 \times 10^{-26}}{\lambda_2} - 3.04 \times 10^{-19}$

or $\frac{19.8 \times 10^{-26}}{\lambda_2} = 4.8 \times 10^{-19}$

$\therefore \lambda_2 = \frac{19.8 \times 10^{-26}}{4.8 \times 10^{-19}} m = 4.125 \times 10^{-7} m = 4125 \overset{\circ}{A}$

When the ejected photoelectrons are subjected to the action of a magnetic field no change in retarding potential will be observed. This is because a magnetic field does not alter the kinetic energy of the photoelectrons. The magnetic field only changes the direction of motion.