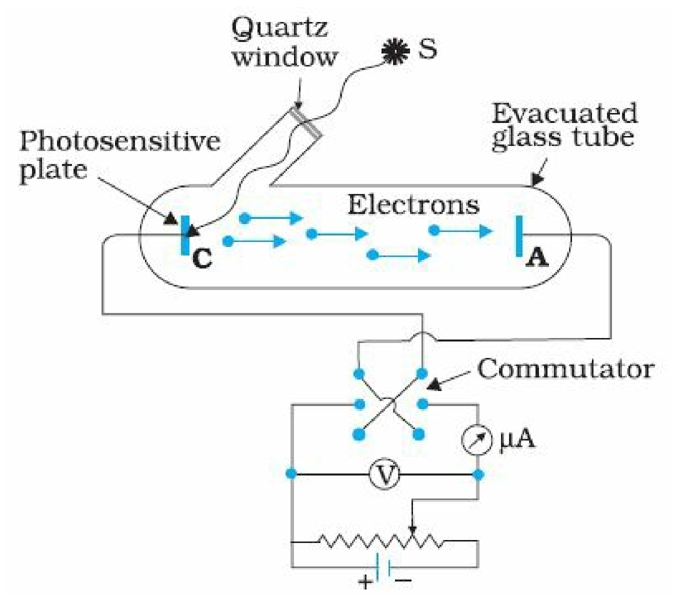
CBSE Test Paper-04
Class 12 Physics (Nature of Radiation & Matter)

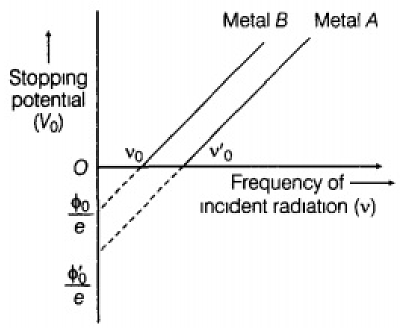
1. According to the Einstein's model minimum energy needed for the electron to escape from a metal surface having work function ϕ_0, the electron is emitted with maximum kinetic energy $\mathrm{K}_{\max}$ =
   a. hν - ϕ_0
   b. hν
   c. hν - 2 ϕ_0
   d. hν + ϕ_0
2. If the energy of a photon corresponding to a wave length of 6000 $\overset{0}{A}$ is 3.32 $\times 10^{19}$ joule, the photon energy for a wavelength of 4000 $\overset{0}{A}$ will be
   a. 6.98 $\times 10^{19}$ joules
   b. 5.98 $\times 10^{19}$ joules
   c. 4.98 $\times 10^{19}$ joules
   d. 2.22 $\times 10^{19}$ joules
3. Work function of a metal is the
   a. energy required by an electron to escape from the metal surface
   b. minimum energy required by an electron to escape from the metal surface
   c. maximum energy required by an electron to escape from the metal surface
   d. energy required by an electron to get absorbed in the metal surface
4. In Photoelectric effect
   a. electrical energy is converted into heat
   b. light is converted into electrical energy
   c. electrical energy is converted into light energy
   d. electrical energy is converted magnetic field energy
5. In the above experimental set up for studying photoelectric effect, if keeping the frequency of the incident radiation and the accelerating potential fixed, the intensity of light is varied, then



a. photocurrent decreases nonlinearly with intensity
b. photocurrent increases linearly with intensity
c. photocurrent remains same with intensity
d. photocurrent decreases linearly with intensity

6. Why should gases be insulators at ordinary pressures and start conducting at very low pressures?

7. The graph shows the variation of stopping potential with frequency of incident radiation for two photosensitive metals A and B. Which one of the two has higher value of work function? Justify your answer.

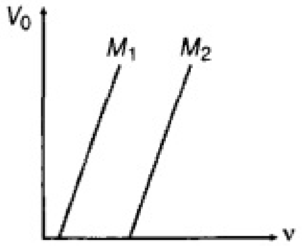


8. Show graphically, the variation of de-Broglie wavelength(λ) with the potential (V) through which an electron is accelerated from rest.

9. The ratio between the de-Broglie wavelengths associated with protons, accelerated through a potential of 512 V and α-particles, accelerated through a potential of X volt

is found to be one. Find the value of X.

10. What is the deBroglie wavelength associated with an electron accelerated through a potential of 100 volts?

11. 

    i. Why is the slope same for both lines?
    ii. For which material will the emitted electrons have greater kinetic energy for the incident radiation of the same frequency? Justify your answer.

12. i. State three important properties of photons which describe the particle picture of electromagnetic radiation.
    ii. Use Einstein's photoelectric equation to define the terms : (a) Stopping potential and (b) Threshold frequency

13. Calculate de-Broglie wavelength in nm associated with a ball of mass 66 g moving with a velocity $2.5 \times 10^5 ms^{-1}$. Given $h = 6.6 \times 10^{-34} Js$.

14. a. For what kinetic energy of a neutron will the associated de-Broglie wavelength be $1.40 \times 10^{-10} m$?
    b. Also find the de-Broglie wavelength of a neutron, in thermal equilibrium with matter, having an average kinetic energy of $\frac{3}{2}kT$ at 300 K.

15. Find the maximum velocity of photoelectrons emitted by radiation of frequency 3×10^{15}Hz from a photoelectric surface having a work function 4.0 eV.

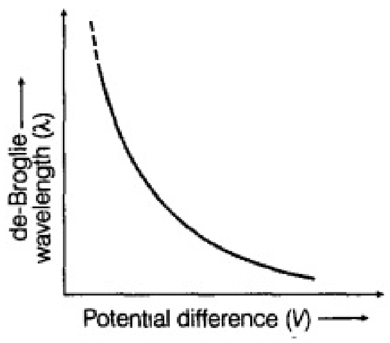
CBSE Test Paper-04
Class 12 Physics (Nature of Radiation & Matter)
Answers

1. a. $\mathrm{hv} - \phi_0$
   Explanation: When any photon is incident on a metal surface it gives its total energy to a electron. Some energy(Work Function) is used up in come out from the metal surface and remaining energy is kinetic energy of electron.
   $E = \phi_0 + K_{\max}$
   $K_{\max} = E - \phi_0$
   $K_{\max} = h\nu - \phi_0$
2. c. 4.98×10^{19} joules
   Explanation: $E = \frac{hc}{\lambda}$
   $\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1}$
   $\frac{3.32 \times 10^{19}}{E_2} = \frac{4000}{6000}$
   $E_2 = \frac{6 \times 3.32 \times 10^{19}}{4} = 4.98 \times 10^{19} J$
3. b. minimum energy required by an electron to escape from the metal surface
   Explanation: When the light strikes on a metal surface, electrons on the surface of the metal get energy from the light and get emitted from the surface. There will be no photo emission from a metal surface below a certain frequency of light. For photo emission minimum frequency of incident light is required. This minimum energy of an electron is called work function.
4. b. light is converted into electrical energy
   Explanation: In photoelectric effect emission of photo-electron takes place, So that photo-current flows in circuit.
5. b. photocurrent increases linearly with intensity
   Explanation: With increase in intensity no. of photon incident increases. So that more electron emitted from metal and photo current increases with increase in intensity.

6. At low pressures, ions have a chance to reach their respective electrodes and constitute a current. At ordinary pressures, ions have no chance to do so because of

collisions with gas molecules and recombination.

7. Metal A has higher value of work function because the threshold frequency is greater for A

8. relation between momentum and energy is
$\Rightarrow \quad p = \sqrt{2mK} = \sqrt{2meV}$
$\therefore$ de-Broglie wavelength
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{V}}$
$\Rightarrow \quad V \cdot \lambda^2$ = constant


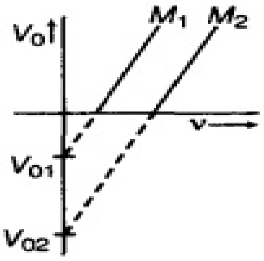
9. de-Broglie wavelength of accelerated charged particle is given by -
$\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mqV}}$
Ratio of wavelengths of proton and α-particle.
$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\left(\frac{m_a}{m_p}\right)\left(\frac{q_a}{q_p}\right)\left(\frac{V_a}{V_p}\right)}$
Here, $\frac{m_\alpha}{m_p} = 4, \frac{q_\alpha}{q_p} = 2$
$\frac{V_\alpha}{V_p} = \frac{X}{512} \frac{\lambda_p}{\lambda_\alpha} = 1$
$\Rightarrow \quad 1 = \sqrt{4 \times 2 \times \left(\frac{X}{512}\right)} = \frac{X}{64}$
X = 64 V

10. de-Broglie wavelength,
$\lambda = \frac{1.227}{\sqrt{V}} nm$
$\Rightarrow \lambda = \frac{1.227}{\sqrt{100}} nm$ = 0.123 nm

11. i. The slope of stopping potential (V_0) versus frequency (v) is equal to (h/e) which is universal constant, so slope is same for both lines.

ii.

K.E. = hv - hv_0As threshold frequency v_0 is lesser for M_1, so K.E. will be greater for M_1/sub>for same frequency v.



12. i. Important properties of photons which are used to establish Einstein's photoelectric equations.
    1. Tiny packet of energy is called one quanta and that one quanta is called photons.
    2. Each photon has energy E (= hv = hc/λ) and momentum p(= hv/c =hc /λ),
    3. All photons of light of a particular frequency v or wavelength /..have the same energy E (= hv =hc /λ) and momentum p (= hv/c - h/λ) whatever the intensity of radiation may be.

    ii. Einstein's photoelectric equation is given by
    $eV_0 = h(v- v_0)$
    a. the potential necessary to stop any electron (or, in other words, to stop even the electron with the most kinetic energy) from reaching the other side is called stopping potential or cut-off potential for the given frequency of the incident radiation.
    b. minimum frequency of the incident radiation below which no emission of photoelectrons take place. This frequency is called the threshold frequency.

13. Given: m = 66g $= 66 \times 10^{-3} kg$
$v = 2.5 \times 10^5 ns^{-1}$
We know, $\lambda = \frac{h}{mv}$
$\Rightarrow \lambda = \frac{6.6\times10^{-34}}{66\times10^{-3}\times2.5\times10^5}$
$= 4 \times 10^{-38} m = \frac{4\times10^{-38}}{10^{-9}} nm$

$\Rightarrow \lambda = 4 \times 10^{-29} nm$

14. a. $m = 1.675 \times 10^{-27} kg$ Here, $\lambda = 1.40 \times 10^{-10} m$

$h = 6.63 \times 10^{-34} Js$

As, $\lambda = \frac{h}{mv}$

$v = \frac{h}{m\lambda}$

or $v = \frac{6.63 \times 10^{-34}}{1.675 \times 10^{-27} \times 1.40 \times 10^{-10}}$

$= 28.28 \times 10^2 m/s$

$K.E. = \frac{1}{2} mv^2 = \frac{1}{2} \times 1.675 \times 10^{-27} \times (28.28 \times 10^2)^2$

$= 6.634 \times 10^{-21} J$

b. $E = \frac{3}{2} kT = \frac{3}{2} \times (1.38 \times 10^{-23}) \times 300 = 6.21 \times 10^{-21} J$

(Here, k is Boltzmann constant. The value of k is $1.38 \times 10^{-38} JK^{-1}$)

As, $\lambda = \frac{h}{\sqrt{2mE}}$

$\Rightarrow \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 6.21 \times 10^{-21} \times 1.675 \times 10^{-27}}}$

or $\lambda = 1.45 \times 10^{-10} m$

15. $\frac{1}{2} mv^2{}_{\max} = hv - \phi_0$

$= 6.63 \times 10^{-34} \times 3 \times 10^{15} - 4 \times 1.6 \times 10^{-19}$

or $v_{\max}^2 = \frac{2\left[19.89 \times 10^{-19} - 6.4 \times 10^{-19}\right]}{9.1 \times 10^{-31}}$

$= \frac{26.98 \times 10^{-19}}{9.1 \times 10^{-31}} = 2.96 \times 10^{12}$

$v_{\max} = 1.72 \times 10^6 ms^{-1}$