



SELF ASSESSMENT PAPER - 7

SOLUTIONS

I. Multiple Choice Questions

[1 × 4 = 4]

1. Option (C) is correct.

Explanation: $KE = h\nu - \phi_0$

So, KE is independent of intensity of incident light.

2. Option (A) is correct.

Explanation: When a photon strikes a metal surface, the surface electrons come out with maximum speed and maximum kinetic energy. But if the electron emission takes place from inner side of metal, then some energy of the electron is lost due to collision with other electrons and so their speed becomes less. So, ultimately the electrons come out with different speeds.

3. Option (D) is correct.

Explanation: Velocity v , of freely falling body after falling from a height H , will be:

$$v = \sqrt{2gH}$$

We know that de-Broglie wavelength, $\lambda = \frac{h}{p}$

$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{2gH}}$$

h , m , and g are constant

$$\therefore \frac{h}{m\sqrt{2g}} \text{ is constant} \Rightarrow \lambda \propto \frac{h}{\sqrt{H}} \Rightarrow \lambda \propto H^{-1/2}$$

4. Option (D) is correct.

Explanation: $\lambda \propto 1/\sqrt{V}$

$$\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \frac{6}{5}$$

II. Assertion and Reason

[1 × 2 = 2]

1. Option (A) is correct.

Explanation: Energy = $E = \frac{hc}{\lambda}$

$$\text{Momentum} = p = \frac{h}{\lambda}$$

$$\text{So, } p = \frac{E}{c}$$

This is true only when photon has a particle nature. So, assertion and reason both are true and reason properly explains the assertion.

2. Option (A) is correct.

Explanation: de-Broglie wavelength, $\lambda = \frac{h}{mv}$

h and v remaining constant, $\lambda \propto \frac{1}{m}$

So, as the mass of the particle becomes smaller and smaller, the de-Broglie wavelength of the particle becomes more and more significant.

Hence, assertion and reason both are true and reason explains the assertion properly.

III. Competency Based Questions

[1 × 4 = 4]

1. (i) Option (B) is correct.

Explanation: Photocell is a technological application of the photoelectric effect.

(ii) Option (A) is correct.

Explanation: Photosensitive material used as emitter should be connected to $-ve$ terminal of the battery so that the emitted electrons are repelled by emitter and collected by collector.

(iii) Option (B) is correct.

Explanation: A part of the bulb is left clean for the light to enter in it.

(iv) Option (C) is correct.

Explanation: Photocurrent of the order of a few microampere can be normally obtained from a photocell.

(v) Option (D) is correct.

Explanation: A photocell converts a change in intensity of illumination into a change in photocurrent. The magnitude of photocurrent depends on the number of photoelectrons which in turn depends on the intensity of the incident light. Hence any change in the light intensity can be converted to a change in photocurrent.

IV. Very Short Answer Type Question

[1 × 4 = 4]

1. Since, the stopping potential is 4 V, the maximum kinetic energy of photo electrons 4eV

2. The total energy falling (or going through) a surface/region per unit area, per unit time and is measured in J/m²s.

$$\begin{aligned} 3. \quad p_1 &= p_2 \\ \therefore \frac{\lambda_1}{\lambda_2} &= 1 : 1 \end{aligned}$$

V. Short Answer Type Question-I

[2 × 3 = 6]

1. If the frequency of light incident on the cathode of a photocell is increased, then

(i) Energy of the photo electron increases as the energy of photon is directly proportional to the frequency.

(ii) rate of electron emission remains same.

Hence, the current remains same.

2. The energy of a photon of incident radiation is given by

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

$$\therefore E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{(412.5 \times 10^{-9}) \times (1.6 \times 10^{-19})} \text{ eV}$$

$$= 3.01 \text{ eV}$$

Hence, only Na and K will show photoelectric emission

3. Work function, $W = \frac{nhc}{\lambda}$

$$n = \frac{W\lambda}{hc}$$

$$= \frac{3 \times 10^{-19} \times 26.52 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^8}$$

$$= 4 \times 10^{-2}$$

VI. Short Answer Type Question-II [3 × 2 = 6]

1. Kinetic energy of an electron is calculated by,

$$K.E. = hv - \phi_0$$

Where work function

$$\phi_0 = hv_0$$

where, v_0 is cutoff frequency.

From the graph $v_0 = 5 \times 10^{14} \text{ Hz}$

So, at this frequency,

$$eV_0 = hv - hv_0$$

So, $h = \frac{eV_0}{\Delta v}$

where, Δv is change in frequency

$$= \frac{1.6 \times 10^{-19} \times 1.23}{3 \times 10^{14}}$$

$$= 0.656 \times 10^{-33} \text{ J-s}$$

$$= 6.56 \times 10^{-34} \text{ J-s.}$$

2.

$$2\pi r = n\lambda$$

$$2\pi(0.53n^2) = n$$

\Rightarrow

$$\lambda \propto n$$

\Rightarrow

$$\frac{\lambda_2}{\lambda_3} = \frac{(n) \text{ for second excited state}}{(n) \text{ for third excited state}}$$

$$\Rightarrow \frac{\lambda \text{ for second excited state}}{\lambda \text{ for third excited state}} = \frac{3}{4}$$

VII. Long Answer Type Question [1 × 5 = 5]

1. (i) Three features of photoelectric effect, which cannot be explained by the wave theory of light, are:

- Maximum kinetic energy of emitted electrons is independent of the intensity of incident light.
- There exists a 'threshold frequency' of each photosensitive material.
- 'Photoelectric effect' is instantaneous in nature.

Einstein's photoelectric equation,

$$K.E._{\text{max}} = hv - \phi_0$$

- (i) From Einstein's photoelectric equation, we find if frequency of incident radiation remains constant, the $K.E._{\text{max}}$ remains constant and does not change with the change of intensity of radiation.

- (ii) From Einstein's photoelectric equation,

if $hv > \phi_0$, the $KE > 0$

if $hv = \phi_0$, the $KE = 0$

if $hv < \phi_0$, the $KE < 0$. This is not possible since KE cannot be negative. Hence, there should be a minimum frequency of radiation below which photoelectric emission does not take place. This is known as threshold frequency.

- (iii) According to Einstein's theory, due to elastic collision of photon with electron, energy transfer takes place and there remains no time gap between the collision and the ejection of electron.

- (ii) (a) Slope of the graph between V_0 and v (from Einstein's equation) equals (h/e) . Hence, it does not depend on the nature of the material.

- (b) Emitted electrons have greater energy for material M_1 . This is because $\phi_0 (= hv_0)$ has a lower value for material M_1 .

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