One Two Academy | Dual Nature of Radiation and Matter

Maximum Marks : 25 **PHYSICS** **Time: 50 Minutes**

Choose the correct answer :- **3x1=3**

1. The wave associated with a moving particle of mass 3×10^{-6} g has the same wavelength as an electron moving with a velocity 6×10^{6} m s^{-1} . The velocity of the particle is
(a) $1.82 \times 10^{-18}\ m\ s^{-1}$ (b) $9 \times 10^{-2}\ m\ s^{-1}$
(c) $3 \times 10^{-31}\ m\ s^{-1}$ (d) $1.82 \times 10^{-15}\ m\ s^{-1}$

2. The work functions for metals *A*, *B* and *C* are 1.92 eV, 2.0 eV and 5.0 eV respectively. The metal/metals which will emit photoelectrons for a radiation of wavelength 4100Å is/are
(a) *A* only (b) both *A* and *B*
(c) all these metals (d) none

3. The Work function of Ni is
(a) 4.70 (b) 5.15 (c) 5.65 (d) 4.28

Answer the following :- **3x2=6**

4. Define stopping potential.
5. A proton and an electron have same kinetic energy. Which one has greater de Broglie wavelength? Justify
6. Find the de Broglie wavelength associated with an alpha particle which is accelerated through a potential difference of 400 V. Given that the mass of the proton is 1.67×10^{-27} kg.

Answer any two of the following:- **2x3=6**

7. What is a photo cell? Mention the different types of photocells.
8. Write the expression for the de Broglie wavelength associated with a charged particle of charge q and mass m, when it is accelerated through a potential *V*.
9. Calculate the cut-off wavelength and cutoff frequency of x-rays from an x –ray tube of accelerating potential 20,000 V.

Answer the following :- **2x5=10**

10. (a) Obtain Einstein's photoelectric equation with necessary explanation..

(OR)

(b) (b) Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.

11. i) Define work function of a metal. Give its unit.
ii) When a light of frequency 9×10^{14} Hz is incident on a metal surface, photoelectrons are emitted with a maximum speed of 8×10^{5} ms^{-1} . Determine the threshold frequency of the surface.

ALL THE BEST

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Answer key attached in next page!!!

This page is to prevent seeing answer key

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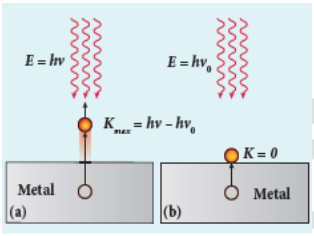
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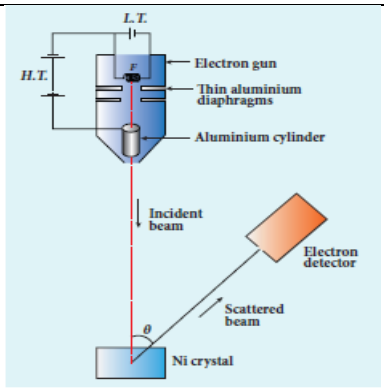
ANSWER KEY

Q NO	ANSWERS	MARKS
1.	(D) 1.82 x 10^{-15} m s^{-1}	**1**
2.	(B) both A and B	**1**
3.	(B) 5.15	**1**
4.	Stopping potential is that the value of the negative (retarding) potential given to the collecting electrode *A* which is just sufficient to stop the most energetic photoelectrons emitted and make the photocurrent zero.	**2**
5.	The electron is much lighter than a proton which implies that the particle with smaller mass result in larger wavelength. Hence, the electron has the greater wavelength.	**2**
6.	$\lambda = \frac{h}{\sqrt{2MqV}} = 0.00507$ Å	**2**
7.	Photo electric cell or photo cell is a device which converts light energy into electrical energy. It works on the principle of photo electric effect. When light is incident on the photosensitive materials, their electric properties will get affected, based on which photo cells are classified into three types.They are, i) **Photo emissive cell:** Its working depends on the electron emission from a metal cathode due to irradiation of light or other radiations. ii) **Photo voltaic cell:** Here sensitive element made of semiconductor is used which generates voltage proportional to the intensity of light or other radiations. iii) **Photo conductive cell:** In this, the resistance of the semiconductor changes in accordance with the radiant energy incident on it.	**3**
8.	Let an electron of mass *m* be accelerated through a potential difference of *V* volt. The kinetic energy acquired by the electron is given by $\frac{1}{2}mv^2 = eV$ Therefore, the speed υ of the electron is, $v = \sqrt{\frac{2eV}{m}}$ Hence, the de Broglie wavelength of the matter waves associated with electron is, $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2emV}}$ $\lambda = \frac{12.27}{\sqrt{V}}$ Å	**3**

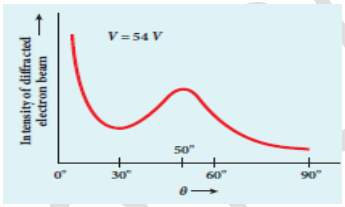
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9.	$\lambda = \frac{12400}{V}$ Å $= 0.62$ Å $v_0 = \frac{c}{\lambda_0} = 4.84 \times 10^{18}\ Hz$	**3**
10. a	When a photon of energy hv is incident on a metal surface, it is completely absorbed by a single electron and the electron is ejected. In this process, a part of the photon energy is used in overcoming the potential barrier of the metal surface (photoelectric work function ϕ_0)and the remaining energy as the kinetic energy of the ejected electron. From the law of conservation of energy, $hv = \phi_0 + \frac{1}{2}mv^2$ where m is the mass of the electron and v its velocity.  If we reduce the frequency of the incident light, the speed or kinetic energy of photo electrons is also reduced. At some frequency v_0 of incident radiation, the photo electrons are just ejected with almost zero kinetic energy. Then the equation becomes $hv_o = \phi_0$ where v_0 is the threshold frequency. $\therefore hv = hv_0 + \frac{1}{2}mv^2$ This equation is called Einstein's photoelectric equation. If the electron does not lose energy by internal collisions, then it is emitted with maximum kinetic energy K_{max}. Then $K_{max} = hv - \phi_0$	**5**
10. b	The filament F is heated by a low tension (L.T.) battery. Electrons are emitted from the hot filament by thermionic emission. They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery. Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.	**5**

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The electrons scattered by Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam. The detector is capable of rotation in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will. The intensity of the scattered electron beam is measured as a function of the angle θ.
the variation of intensity of the scattered electrons with the angle θ for the accelerating voltage of $54V$. For a given accelerating voltage V,



Hence,The scattered wave shows a peak or maximum at an angle of 50° to the incident electron beam. This peak in intensity is attributed to the constructive interference of electrons diffracted from various atomic layers of the target material. From the known value of interplanar spacing of Nickel, the wavelength of the electron wave was experimentally calculated as 1.65A. The wavelength can also be calculated from de Broglie relation for $V = 54$ V,

$\lambda = \frac{12.27}{\sqrt{V}}$ Å $= 1.67$Å

This value agrees very well with the experimentally observed wavelength of 1.65A. Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.

11	i) The minimum energy needed for an electron to escape from the metal surface is called work function of that metal. The work function of the metal is denoted by ϕ_0 and is measured in eV. ii) $K_{max} = \frac{1}{2}mv^2$ $K_{max} = 2.912 \times 10^{-19}$ J $F_0 = 4.61 \times 10^{14}$ Hz	**5**

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