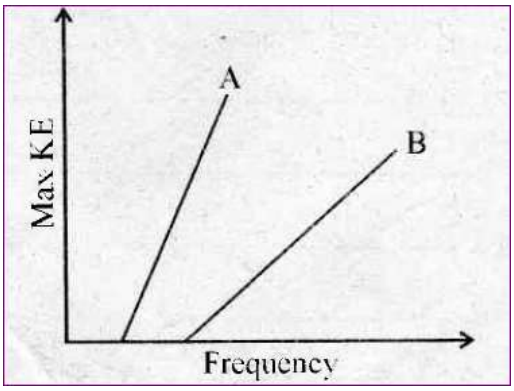
Dual Nature Of Radiation And Matter

Que 1: Momentum of a photon with wavelength λ is……. *Marks :(1)*

Ans: p = h/ λ

Que 2: The graph shows the variation of KE with frequency of incident radiations for two surfaces A and B.



1. **Which of the metal has greater work function? For which of the metals will stopping potential be more for the same frequency of incident radiation?**
2. **The work function of cesium metal is 2.14 eV. When light of frequency 6 x 1014 Hz incident on the metal surface, what is the maximum KE of the photoelectrons and stopping potential? *Marks :(3)***

Ans: 1. B has greater work function – threshold frequency large, material A has more stopping potential since when work function decreases stopping potential increases, $V_s = \frac{h}{e}\nu - \frac{\phi_0}{e}$

2. $K_{max} = h\nu - \phi_0 = (6.625 \times 10^{-34} \times 6 \times 10^{14}) - 2.14 \times 1.6 \times 10^{-19} = 5.5 \times 10^{-20} J$

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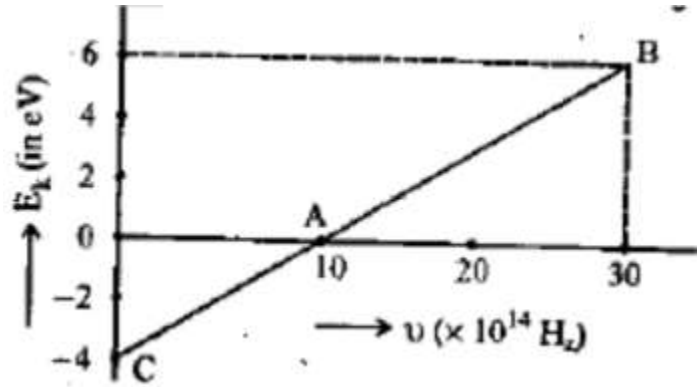
Que 3: Given below is the graph between frequency (υ) of the incident light and maximum kinetic energy (Ek) of emitted photoelectrons. *Marks :(3)*



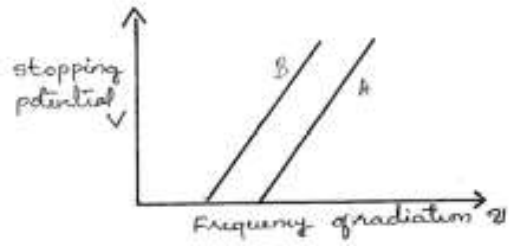
Find the values of i. threshold frequency and ii. Work function from the graph.

Ans:

1. Threshold frequency = 10 x 1014 Hz
2. Work function = - (y intercept) = 4 MeV

Que 4: When photons incident on a metallic surface electric current is produced.

The work function of the metal is given by $\phi = hv_0 = \frac{hc}{\lambda_0}$ **.The graph given below shows the variation in stopping potential V with frequency v0 of the incident radiation of the materials A and B.**



1. **Which of the material has higher work function?**
2. **Which material is more photosensitive?**
3. **What happens to the slope of the graph when intensity of radiation increases? Why?** ***Marks :(5)***

Ans:

1. We have work function = - (y intercept) X charge of electron. Thus material A has high work function.
2. Material B
3. Slope remains the same (slope = h/e is constant) since $V_0 = \frac{h}{e}\nu - \frac{\phi_0}{e}$

Que 5: a) What is de Broglie hypothesis? Write the formula for de Broglie wavelength.

b) Calculate the de Broglie wavelength associated by an electron accelerated through a potential difference of 100 volts. ***Marks :(3)***

Ans:

Particles of matter have wave nature. The waves associated with material particles are called matter waves or De Broglie waves, de Broglie wavelength $\lambda = \frac{h}{mv}$

2. $\lambda = \frac{1.227}{\sqrt{V}}nm = \frac{1.227}{\sqrt{100}}nm = 0.1227nm$

Que 6: All photoelectrons are not emitted with the same energy as the incident photons. Why? ***Marks :(2)***

Ans: A part of the photon energy is used as the work function to eject an electron. So the energy of the electrons emitted will be less than that of incident photon.

Que 7: Write Einstein's photoelectric equation and explain the terms involved in it ***Marks :(3)***

Ans: $K_{max} = h(\nu - \nu_0)$

v –photon frequency, v0- threshold frequency, minimum frequency of photon required to eject an electron from a metal surface, Kmax – maximum kinetic energy of ejected electrons

Que 8: Work function of a metal is the ***Marks :(1)***

(a) Energy required by an electron to get absorbed in the metal surface.

(b) Minimum energy required by an electron to escape from the metal surface

(c) Energy required by an electron to be retained by a metal surface.

(d) Maximum energy required by an electron to escape from the metal surface.

Ans: (b) minimum energy required by an electron to escape from the metal surface

Que 9: When light falls on a certain metals photo electrons are generated.

1. **Express the phenomenon in terms of equation.**
2. **Explain the terms used.** ***Marks :(4)***

Ans: 1. $h\nu = \phi_0 + K_{max}$

2. hv –photon energy, φ0- work function, minimum energy required to eject an electron from a metal surface, Kmax – maximum kinetic energy of ejected electrons

Que 10: Electron can undergo diffraction just like waves. What is the wavelength of an electron accelerating in a potential difference of 54 V? ***Marks :(2)***

Ans: $\lambda = \frac{1.227}{\sqrt{V}} nm = \frac{1.227}{\sqrt{54}} nm = 0.167 nm$

Que 11: (a) The work function a metal is 6eV.If two photons each having energy 4 eV strike with the metal surface.

(i) will the emission be possible? (ii) Why?

(b) The waves associated with matter is called matter waves. Let λe and λp be the de Broglie wavelengths associated with electron and proton respectively. If they are accelerated by same potential, then ***Marks :(4)***

λe> λp ii) λp> λe iii) λp= λe iv) $\lambda_e = \frac{1}{\lambda_p}$

Ans: i) No ii) For photoelectric effect to occur minimum energy is required. Here the energy of one photon is less than work function. So emission will not be possible.

2. λe> λp , since $\lambda = \frac{h}{\sqrt{2mqV}}$

Que 12: Photoelectric current depends on the intensity of incident light.

1. The maximum current emitted by a photoelectric material is called.....

(i) Emitter current (ii) Collector current (iii) Saturation current (iv) Peak current

2. Work function of cesium and platinum are 2.14 eV and 5.65 eV respectively. Which one of the metals has higher threshold wavelength? Justify.
Marks :(3)

Ans: 1. (iii) Saturation current

2. Platinum, since $\nu_0 = \frac{\phi}{h}$

Que 13: The wavelength of matter waves is called de Broglie Wavelength.

An α -particle, a proton and an electron having de Broglie wavelengths λα , λp and λe respectively are moving with the same momentum. Then

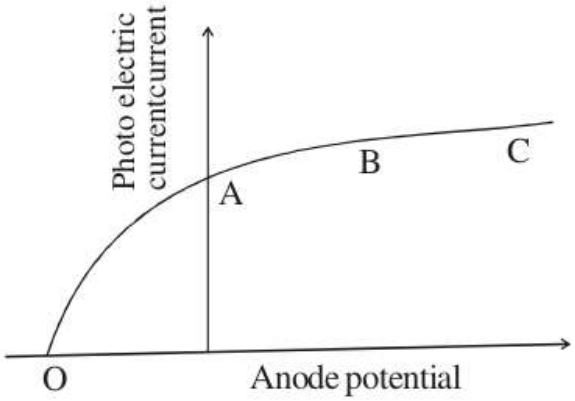
i. λα> λp> λe ii) λp> λe> λα iii) λα= λp = λe iv) λp= λe ≠ λα

b) The de Broglie wavelength of a ball of mass 0.12 Kg is 2.76 x 10-34 m. Calculate the speed of the ball. [h= 6.625 x 10-34 Js] ***Marks :(4)***

Ans: a) λα= λp = λe

b) m = 0.12 kg, λ = 2.76 x 10-34 m, we have $v = \frac{h}{m\lambda} = \frac{6.625 \times 10^{-34}}{0.12 \times 2.76 \times 10^{-34}} = 20 m/s$

Que 14: The graph shows photoelectric current with anode potential

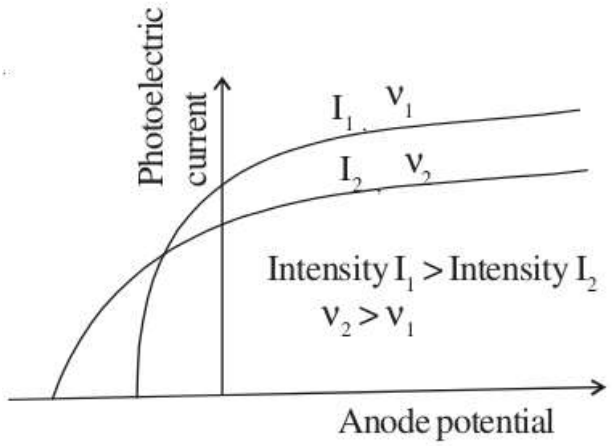


a. The potential at 'O' is called

(i) Accelerating potential (ii) retarding potential (iii) stopping potential (iv) saturation potential

b. Why current becomes constant in the region BC

c. Is the below given graph possible? Justify your answer. ***Marks :(5)***



Ans: a. Stopping potential

b. At a particular anode potential all the electrons from the cathode can reach at anode and the current becomes maximum (saturation) hence the photocurrent will not increase further with increase in anode potential

c. Yes. v 2 >v 1 .Hence stopping potentials are different. The stopping potential of v 2 .must be greater than stopping potential of v 1. This graph agrees with above condition In this I 1 >I 2. Hence photo current corresponding to intensity I 1 must be greater than intensity I 2 this condition also satisfies the above Graph

Que 15: Which of the following element shows lowest work function ?

(a) Cs (b) K (c) Na (d) Ca ***Marks :(1)***

Ans: (a) Cs

Que 16: Is work function is same for all metals ? ***Marks :(1)***

Ans: No, work function is difference for different materials

Que 17: What is work function ? ***Marks :(1)***

Ans: The minimum energy required for an electron to eject from the metal surface.

Que 18: What are the different types of electron emission ? , Explain ***Marks :(3)***

Ans: i) Thermionic emission: By suitably heating, sufficient thermal energy can be imparted to the free electrons to enable them to come out of the metal.

(ii) Field emission : By applying a very strong electric field to a metal, electrons can be pulled out of the metal.

(iii) Photo-electric emission : When light of suitable frequency illuminates a metal surface, electrons are emitted from the metal surface. These photo (light)-generated electrons are called photoelectrons.

Que 19: What do you mean by photo electric emission ? ***Marks :(1)***

Ans: The emission of electrons from the metal surface by indenting light

Que 20: The scientist who succeeded in finding the value of specific charge of an electron? ***Marks :(1)***

Ans: R A Millikan

Que 21: What is the value of e/m of electron ? ***Marks :(1)***

Ans: The value of e/m is 1.76×10^{11} C/kg

Que 22: Which of the following is the representation of specific charge of an electron

(a) e (b) m (c) e/m (d) m/e ***Marks :(1)***

Ans: (c) e/m

Que 23: What do you mean by stopping potential ? ***Marks :(1)***

Ans: The retarding potential applied to a metal surface in order to stop the emitted photo electrons.

Que 24: Which of the following factors depends on kinetic energy of the emitted photoelectron ***Marks :(1)***

(a) Mass of the metal **(b) Intensity of the incident photon**

(c) Nature of the incident photon **(d) Frequency of the incident photon**

Ans: (d) Frequency of the incident photon

Que 25: Explains Einstein's photoelectric equation ? ***Marks :(4)***

Ans: The maximum kinetic energy of the emitted photoelectron is

$K_{max} = h\nu - \varphi_0$

Where h – Plank's constant

Each quantum of radiant energy has energy h ν , where h is Planck's constant and ν the frequency of incident light. In photoelectric effect, an electron absorbs a quantum of energy (h ν) of radiation.

Minimum energy needed for the electron to escape from the metal surface (work function φ_0).

Que 26: Mention some examples of metals showing photoelectric effect. ***Marks :(2)***

Ans: Alkali metals such as lithium, sodium, potassium, caesium and rubidium were sensitive even to visible light.

Que 27: Define photoelectric effect ? ***Marks :(2)***

Ans: The phenomenon of emission of electrons from the surface a metal by the incidence of certain types of radiations called photoelectric effect.