DRGP Institute

Chapter 11

Dual Nature of Radiation and Matter

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BOARD:- 2013

1. (a) Define the following in the phenomenon of PEE-
   (i) work function
   (ii) Stopping potential
   (b) Calculate the energy of a photon of wavelength 3.31A.

⇒

(a) (i) **work function**- The minimum amount of energy required to remove e^- from metal surface is called work function.

$$\phi = \omega_0 = h\nu_0$$

(ii) **Stopping potential**- -ve potential of anode which can reduce PE current to the zero is called stopping potential.

$$eV_0 = \frac{1}{2}mV_{max}^2$$

(b) $\lambda = 3.31A^0$

$E = ?$

$$E = h\nu$$

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

$$E = \frac{6.62\times10^{-34}\times3\times10^{8}}{3.31\times10^{-10}}$$

$$E = 6\times10^{-16}\ J$$

BOARD:- 2013 (Supp)

2. The work function of Cs metal is 2.12 ev when light of frequency 7×10^{14} Hz is incident on a metal surface e^- are emitted for emitted e^- ⇒ (i) Find out max K.E
   (ii) Find out max. speed

⇒

$$\omega_0 = 2.12eV = 2.12\times1.6\times10^{-19} = 3.424\times10^{-19}\ J$$

$$\nu = 7\times10^{14}\ Hz$$

(i) $K.E_{max} = h\nu - \omega_0$

$$K.E_{max} = (6.62\times10^{-34}\times7\times10^{14}) - (3.424\times10^{-19})$$

$$K.E_{max} = 1.21\times10^{-19}\ J$$

$$= \frac{1.21\times10^{-19}}{1.6\times10^{-19}} = 0.756\ eV$$

(ii) $V_{max} = ?$ $\quad \frac{1}{2}mV_{max}^2 = 1.2\times10^{-19}$

$$V_{max} = \sqrt{\frac{1.2\times10^{-19}\times2}{9.1\times10^{-31}}}$$

$$V_{max} = 5.16\times10^{3}\ m/s$$

BOARD:- 2014

3. A ball of mass 0.12 kg is moving with a speed of 20 m/s find its de Broglie wavelength (plank's constant $h = 6.62\times10^{-34}$ JS).

⇒ $m = 0.12$ Kg $\quad v = 20$ m/s $\quad \lambda = ?$

$h = 6.62\times10^{-34}$ JS

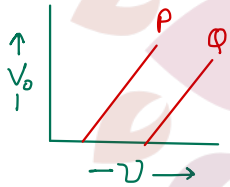
wavelength $\lambda = \frac{h}{P} = \frac{h}{mv}$

$$\lambda = \frac{6.62\times10^{-34}}{0.12\times20}$$

$$\lambda = 2.8\times10^{-34}\ m$$

4. Which metal will have higher wavelength & work function?

⇒



Threshold frequency will be higher for metal φ. Due to it

P = Have higher wavelength

φ = Have higher workfunction

5. A monochromatic light source of frequency 6×10^{14} Hz emits 2×10^{-3} J of energy per second. Find the number of photons emitted by the source per second.

⇒ $V = 6\times10^{14}$ Hz

$P = 2\times10^{-3}$ J/s or W

$n = ?$

for one photon

$$P = \frac{E}{t}$$

for n photon

$$P = \frac{nE}{t}$$

$$n = \frac{Pt}{E}$$

$$n = \frac{2\times10^{-3}\times1}{6.62\times10^{-34}\times6\times10^{14}}$$

$$n \simeq 5\times10^{15}\ \text{photon/s}$$

BOARD:- 2015

6. Define stopping potential.

7. If the work function of a metal is $3.31 \times 1.6 \times 10^{-19}$ Joule, then calculate its threshold frequency in Hz.

⇒ $\omega_0 = h\nu_0$

$\nu_0 = \omega_0/h$

$\nu_0 = \frac{3.31 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}}$

$\nu_0 = 8 \times 10^{14}$ Hz

8. Write deBrogli's hypothesis. Obtain formula for deBrogli wavelength of an electron which is accelerated from rest through a potential V.

⇒ De-Brogli's hypothesis - Just like light, small moving particles like e^- also act as both particle and wave. wave associated with these particle known as matter wave.

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

$\lambda = \frac{h}{mv}$ - (1)

$E_K = \frac{1}{2}mv^2$

$E_K = \frac{1}{2}\frac{m^2v^2}{m}$

$m^2v^2 = 2mE_K$

$p^2 = (mv)^2 = 2mE_K$

p or $mv = \sqrt{2mE_K}$

put $p = mv = \sqrt{2mE_K}$

$\lambda = \frac{h}{\sqrt{2mE_K}}$ - (2)

$E_K = qV$

$\lambda = \frac{h}{\sqrt{2mqV}}$

for e^- { $h = 6.62 \times 10^{-34}$ JxS, $m = 9.1 \times 10^{-31}$ Kg, $q = 1.6 \times 10^{-19}$ C }

$\lambda = \frac{12.27}{\sqrt{V}}$ A°

↳ Potential for acceleration

BOARD:- 2015 (Supp)

9. The K.E of proton and α-particle is same which of these particles will have the smallest de-Broglie wavelength?

⇒ $\lambda = \frac{h}{\sqrt{2mE_K}}$

K.E is same then

$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_p}} = \sqrt{\frac{4m_p}{m_p}}$

$\frac{\lambda_p}{\lambda_\alpha} = \frac{2}{1}$

$\lambda_p : \lambda_\alpha = 2:1$

↳ Smallest λ.

10. The threshold frequency of a metal is 2.2×10^{14}. If a light of 7.2×10^{14} Hz is incident on the metal then find the stopping potential for PEE.

⇒

$$\frac{1}{2}mv_{max}^2 = eV_0 = h\nu - h\nu_0$$

$$V_0 = \frac{h}{e}(\nu - \nu_0)$$

$$V_0 = \frac{6.62 \times 10^{-34}}{1.6 \times 10^{-19}}(7.2 \times 10^{14} - 2.2 \times 10^{14})$$

$$V_0 = 2.06 \text{ volt.}$$

BOARD:- 2016

11. The threshold frequency for Cs metal is 5.16×10^{14} Hz. Find It's work function in eV.

⇒

$$\phi \text{ or } \omega_0 = h\nu_0$$

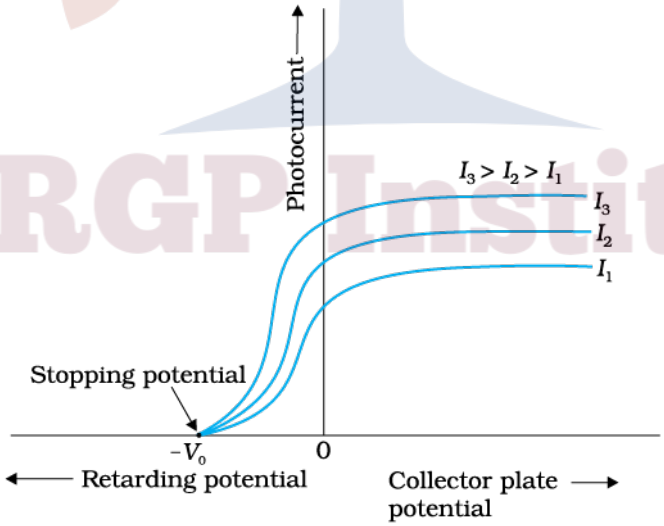
$$= 6.62 \times 10^{-34} \times 5.16 \times 10^{14} \text{ J}$$

$$= \frac{6.62 \times 10^{-34} \times 5.16 \times 10^{14}}{1.6 \times 10^{-19}}$$

$$= 2.13 \text{ eV}$$

12. What is stopping potential or cut voltage? Draw a graph of PE current variation with collector plate potential for two incident radiation of same frequency & different intensity. [1+1=2]

⇒



BOARD:- 2017

13. What is PEE? on which two PE current depends?

⇒ When radiation of suitable frequency incident on metal surface then e⁻ comes out from the surface of metal. This emitted e⁻ is called photoelectron & current flowing due to these e⁻ is called photoelectric current & this effect is called PEE.

→ Photo electric current depends on -
(i) Intensity of light
(ii) Potential difference b/w electrodes

BOARD:- 2018

14. Find de-Broglie wavelength associated with an electron that is accelerated through a potential difference 10^4 volts.

⇒ $$\lambda = \frac{12.27}{\sqrt{10^4}}$$

$$\lambda = 0.1227\ A^\circ$$

15. Einstein's Photoelectric Current. Explain PEE with the help of this eq^n.

⇒ $$\frac{1}{2}mv_{max}^2 = eV_0 = h\upsilon - h\upsilon_0$$

1. If $\upsilon < \upsilon_0$ then

$$\frac{1}{2}mv_{max}^2 = -ve \text{ (which is not possible)}$$

It means PEE only possible when $\upsilon \geq \upsilon_0$.
{ in this case $K.E_{max} \geq 0$ }

2. If we increase frequency of incident light (υ) then K.E of emitted e^- increases.
3. when photon incident on e^- of metal surface then e^- absorbs whole energy of photon in negligible time duration. so there is no time delay b/w incidence of light & emission of e^-.
4. There is no effect of intensity of incident light on K.E of emitted e^-.

BOARD:- 2019

16. Define threshold frequency.

⇒ The minimum frequency required to remove e^- from metal surface is called work function.

17. Find the de-Broglie wavelength associated with an electron that is accelerated through a potential difference 100 volts.

⇒ $$\lambda = \frac{12.27}{\sqrt{V}}\ A^\circ$$

$$\lambda = \frac{12.27}{\sqrt{100}}\ A^\circ$$

$$\lambda = 1.227\ A^\circ$$

BOARD:- 2020

18. Why can't PEE be explained on the basis of wave theory of light ? write any two reasons.

⇒ 1. According to wave theory when we increase intensity of incident light, K.E. of e^- increases. But practically we observe there is no effect of intensity on K.E of e^-.

2. According to wave theory energy is distributed in all surface e^- so, –

(i) Light of any energy can cause PEE.

(ii) There is timedelay b/w incidence of Light and emission of e^-.

[Both are false].

BOARD:- 2021

19. The formula of momentum of photon is -

(a) $h\upsilon$ (b) h/λ (c) $h\lambda/c$ (d) $h/c\lambda$

$$P = h/\lambda$$

$$\text{so, } \lambda = \frac{h}{P}$$

20. The max. K.E of an emitted photo electron by a metal is 2.2 eV. The value of stopping potential will be _____ volt.

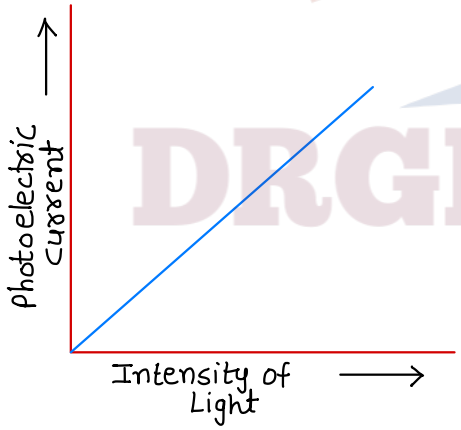
⇒ $K.E_{max} = eV_0$

$2.2\,eV = eV_0$

$V_0 = 2.2$ volt

21. What is PEE? Draw a graph b/w PE current and intensity of incident Light.

⇒



When radiation of suitable frequency incident on metal surface then e^- comes out from the surface of metal. This emitted e^- is called photoelectron & current flowing due to these e^- is called photoelectric current & this effect is called PEE.

BOARD:- 2022

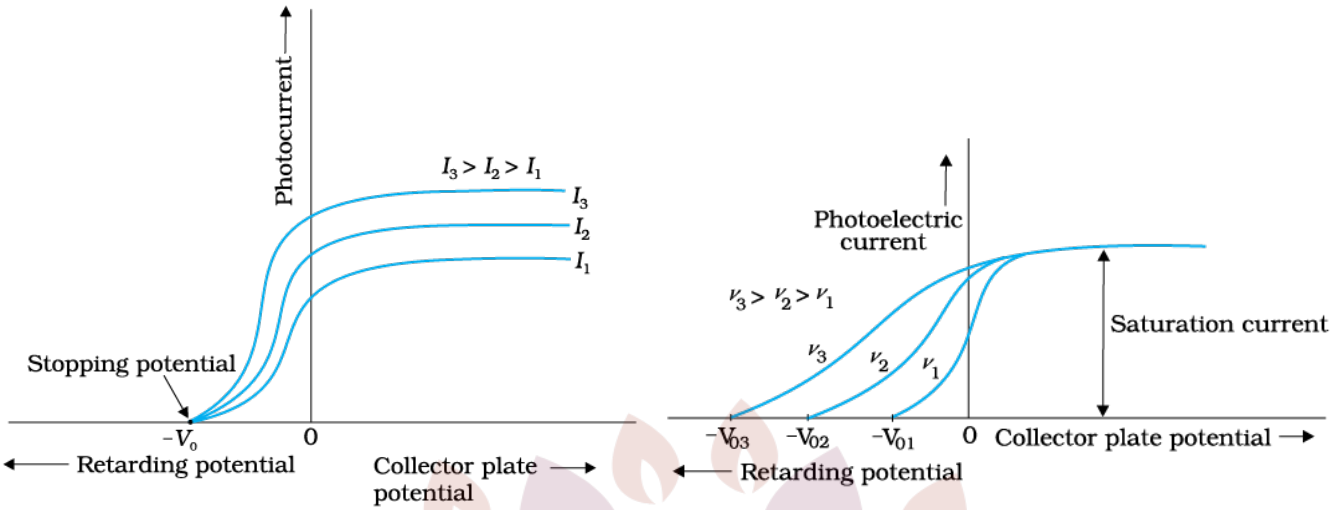
22. If _____ of two particles are equal, then their de Broglie wavelength will be equal.

⇒ momentum

$$\lambda = \frac{h}{P}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{P_2}{P_1} \quad \text{if } P_1 = P_2 \text{ then } \lambda_1 = \lambda_2$$

23. Graph b/w photoelectric current v/s collector plate potential -



24. Einstein's Photoelectric Current. Explain PEE with the help of this eq^n.

BOARD:- 2023

25. Define work function & stopping potential.

26. If the work function of Cs metal is 2.14 eV then find its threshold frequency in Hz.

$\Rightarrow$

$$\phi = h\nu_0$$
$$\nu_0 = \phi/h$$
$$\nu_0 = \frac{2.14 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}}$$
$$\nu_0 = 0.517 \times 10^{15}\ Hz$$

BOARD:- 2024

27. The max. K.E of a photo electron emitted from a metal is 1.8 eV. The value of stopping potential will be -

$\Rightarrow$

$$KE_{max} = eV_0$$
$$1.8\,eV = eV_0$$
$$V_0 = 1.8\ Volt$$

28. The formula for the de Broglie wavelength associated with an e^- accelerated by a potential 'V' is λ = _____ nm.

$\Rightarrow$

$$\lambda = \frac{1.227}{\sqrt{V}}\ A^\circ$$

29. A 20 watt bulb emits 5×10^9 photons per second. Find the energy of each photon.

$\Rightarrow$

$$P = nE/t$$
$$E = \frac{Pt}{n}$$

$$E = \frac{20 \times 1}{5 \times 10^9}$$

$$E = 4 \times 10^{-9} J$$