SOLVED EXAMPLES

Ex.1 Two different photons of energies, 1 eV and 2.5 eV, fall on two identical metal plates having work function 0.5 eV, Then the ratio of maximum KE of the electrons emitted from the two surface is-

(A) 1 : 2 (B) 1 : 4
(C) 2 : 1 (D) 4 : 1

Sol $K_{1_{max}} = h\nu_1 - \phi = 1 - 0.5 = 0.5$ eV

$K_{2_{max}} = 2.5 - 0.5 = 2.0$ eV

Thus $K_{1_{max}} : K_{2_{max}} = 0.5 : 2 = 1 : 4$

Ex.2 Ultraviolet light of wavelength 280 nm is used in an experiment on photo electric effect with lithium (ϕ = 2.5 eV) cathode. Stopping potential will be-

(A) 1 .9 eV (B) 1.9 V
(C) 4.4 eV (D) 4.4 V

Sol The maximum kinetic energy is

$$K_{max} = \frac{hc}{\lambda} - \phi = \frac{1242}{280}\frac{eV-nm}{nm} - 2.5 \text{ eV}$$

$= 4.4$ eV $- 2.5$ eV $= 1.9$ eV

Stopping potential V is given by $eV = K_{max}$

$$V = \frac{K_{max}}{e} = \frac{1.9}{e} \text{ eV} = 1.9 \text{ V}$$

Ex.3 A monochromatic source of light operating at 200 W emits 4×10^{20} photons per second. Find the wavelength of light.

(A) 400 mm (B) 200 n
(C) 4×10^{-10} Å (D) None

Sol The energy of each photon $= \frac{200}{4\times10^{20}}$

$= 5 \times 10^{-19}$ J

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

$$= \frac{(6.63\times10^{-34})\times(3\times10^{8})}{5\times10^{-19}}$$

$\Rightarrow \lambda = 4.0 \times 10^{-7} = 400$ nm

Ex.4 Which metal will be suitable for a photo electric cell using light of wavelength 4000Å. The work functions of sodium and copper are respectively 2.0 eV and 4.0 eV.

(A) sodium (B) copper
(C) Both (D) None of both

Sol $\because \lambda_0 = \frac{hc}{\phi}$

$$\therefore (\lambda_0)_{sodium} = \frac{6.6\times10^{-34}\times3\times10^{8}}{2\times1.6\times10^{-19}} = 6188 \text{ Å}$$

$$\because \lambda_0 \propto \frac{1}{\phi} \Rightarrow \frac{(\lambda_0)_{sodium}}{(\lambda_0)_{copper}} = \frac{(\phi)_{copper}}{(\phi)_{sodium}}$$

$$\Rightarrow (\lambda_0)_{copper} = \frac{2}{4} \times 6188 = 3094 \text{ Å}$$

To eject photo-electrons from sodium the longest wavelength is 6188 Å and that for copper is 3094 Å. Hence for light of wavelength 4000 Å, sodium is suitable.

Ex.5 The work function for the surface of aluminum is 4.2 eV. What will be the wavelength of that incident light for which the stopping potential will be zero.

(A) 2496 Å (B) 2946×10^{-7} m
(C) 2649 Å (D) 2946 Å

Sol If the incident light be of threshold wavelength (λ_0), then the stopping potential shall be zero. Thus

$$\lambda_0 = \frac{hc}{\phi}, \lambda_0 = \frac{6.6\times10^{-34}\times3\times10^{8}}{4.2\times1.6\times10^{-19}},$$

$\lambda_0 = 2.946 \times 10^{-7}$ m $= 2946$ Å

Ex.6 Slope of $V_0 - \nu$ curve is -

(A) e (B) $\frac{h}{e}$ (C) ϕ_0 (D) h

Sol. Relation between $V_0 - \nu$., $V_0 = \frac{h\nu}{e} - \frac{h\nu_0}{e}$

Put it in the form of $y = mx - c$,

here $V_0 = y$, $\nu = x$, $\frac{h\nu_0}{e} = c$

$$\therefore y = \left(\frac{h}{e}\right)x - c$$

$$\therefore m = \frac{h}{e}$$

Ex.7 A radio station is transmitting waves of wavelength 300 m, If diffracting power of transmitter is 10 kw, then numbers of photons diffracted per second is-

(A) 1.5×10^{35} (B) 1.5×10^{31}

(C) 1.5×10^{29} (D) 1.5×10^{33}

Sol $P = 10 \times 10^3$ watt

n = ?

$\lambda = 300$ m

$$P = \frac{nhc}{\lambda t}$$

$$10^4 = \frac{6.62\times10^{-34}\times3\times10^8\times n}{300\times1}$$

$$n = \frac{300\times10^4}{6.62\times10^{-34}\times10^8} = 1.5 \times 10^{31}$$

Ex.8 Light of wavelength 332 Å incidents on metal surface (work function = 1.07 eV). To stop emission of photo electron, retarding potential required to be-

(A) 3.74 V (B) 2.67 V

(C) 1.07 V (D) 4.81 V

Sol $\phi_0 = 1.07$ eV $= 1.07 \times 1.6 \times 10^{-19}$ J

$\lambda = 332 \times 10^{-10}$ m

$$eV_0 = \frac{hc}{\lambda} - \phi_0 = V_0 = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$$

$$V_0 = \frac{6.62\times10^{-34}\times3\times10^8}{332\times10^{-10}\ e} - \frac{1.07\times1.6\times10^{-19}}{e}$$

$V_0 = 3.74 - 1.07 = 2.67$ volt.

Ex.9 Light of wavelength 5000 Å falls on a sensitive surface. If the surface has received 10^{-7} Joule of energy, then what is the number of photons falling on the surface ?

(A) 25×10^{11} (B) 25×10^{12}

(C) 0.25×10^{11} (D) 2.5×10^{11}

Sol Let the energy of one photon = hc/λ,

∴ Energy of n photons E = nhc/λ

$$\because\ 10^{-7} = \frac{n\times6.6\times10^{-34}\times3\times10^8}{5000\times10^{-10}}$$

$$n = \frac{5000\times10^{-10}\times10^{-7}}{19.8\times10^{-26}} = 0.25 \times 10^{12}$$

$n = 2.5 \times 10^{11}$

Ex.10 An electromagnetic radiation of frequency 3×10^{15} cycles per second falls on a photo electric surface whose work function is 4.0 eV. Find out the maximum velocity of the photo electrons emitted by the surface-

(A) 13.4×10^{-19} m/s (B) 19.8×10^{-19}m/s

(C) 1.73×10^6 m/s (D) None

Sol $h\nu = h\nu_0 + E_k$

$6.6 \times 10^{-34} \times 3 \times 10^{15}$

$= 4 \times 1.6 \times 10^{-19} + E_k$

$19.8 \times 10^{-19} - 6.4 \times 10^{-19} = E_k$

$E_k = 13.4 \times 10^{-19}$ J

$$\Rightarrow \frac{1}{2}mv^2_{max} = 13.4 \times 10^{-19}$$

$$v_{max} = \sqrt{\frac{2\times13.4\times10^{-19}}{m}}$$

$$= \sqrt{\frac{2\times13.4\times10^{-19}}{9\times10^{-31}}} = 1.73 \times 10^6 \text{ m/s}$$

Ex.11 The wavelength of a photon is 4000 Å. Calculate its energy.

(A) 49.5×10^{-19} J (B) 495×10^{-19} J

(C) 4.95×10^{-19} K (D) 4.95×10^{-19} J

Sol $$E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^8}{4000\times10^{-10}}$$

$= 4.95 \times 10^{-19}$ J

Ex.12 When ultraviolet light of energy 6.2 eV incidents on a aluminimum surface, it emits photo electrons. If work function for aluminium surface is 4.2 eV, then kinetic energy of emitted electrons is-

(A) 3.2×10^{-19} J (B) 3.2×10^{-17} J

(C) 3.2×10^{-16} J (D) 3.2×10^{-11} J

Sol $E_k = E - \phi_0 = 6.2 - 4.2 = 2.0$ eV,

$E_k = 2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ J

Ex.13 Using light of wavelength 6000 Å stopping potential is obtained 2.4 volt for photo electric cell. If light of wavelength 4000 Å is used then stopping potential would be-

(A) 2.9 V (B) 1.9 V

(C) 3.43 V (D) 9.4 V

Sol $V_0 = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$,

$$2.4 = \frac{hc}{6000\times10^{-10}e} - \frac{\phi_0}{e} \quad ....(1)$$

$$V_0 = \frac{hc}{4000\times10^{-10}e} - \frac{\phi_0}{e} \quad ....(2)$$

Eq. (1) – Eq.(2)

$2.4 - V_0$

$$= \frac{hc}{e}\left[\frac{1}{6000\times10^{-10}} - \frac{1}{4000\times10^{-10}}\right]$$

$$2.4 - V_0 = \frac{6.62\times10^{-34}\times3\times10^{8}}{10^{-7}\times1.6\times10^{-19}}\left[\frac{4-6}{24}\right]$$

$$V_0 = 2.4 + \frac{6.62\times10^{-34}\times3\times10^{8}}{12\times10^{-7}\times1.6\times10^{-19}}$$

$V_0 = 2.4 + 1.03 = 3.43$ V

Ex.14 When light source is placed at 1 m distant from photo electric cell, then value of stopping potential is obtained 4 volt. If it is placed at 4 m distant, then value of stopping potential becomes -

(A) 2 volt (B) 1 volt

(C) 4 volt (D) 16 volt

Sol Stopping potential does not depend upon distance from light source.

Ex.15 When monochromatic light of wavelength λ illuminates a metal surface then stopping potential for photo electric current is $3V_0$. If wavelength changes to 2λ then stopping potential becomes V_0 . Threshold wavelength for photo electric emission is-

(A) 4λ (B) 8λ (C) $4/3\lambda$ (D) 6λ

Sol $$\frac{hc}{\lambda} - \phi_0 = 3V_0e \quad .....(1)$$

$$\frac{hc}{2\lambda} - \phi_0 = V_0e \quad .....(2)$$

eq. (1) – eq.(2) : $\frac{hc}{\lambda}\left[1-\frac{1}{2}\right] = 2V_0e$

$\frac{hc}{2\lambda} = 2\,V_0e \Rightarrow \lambda = \frac{hc}{4V_0e}$

$\Rightarrow \frac{hc}{2\lambda} = \phi + \frac{hc}{4\lambda}$

$\Rightarrow \phi = \frac{hc}{4\lambda} = \frac{hc}{\lambda_0} \Rightarrow \lambda_0 = 4\lambda$

LEVEL # 1

Questions based on **Laws of PEE**

Q.1 Photoelectric effect was discovered by -
(A) Hallwachs (B) Einstein
(C) Planck (D) Bohr

Q.2 Photoelectric effect was explained by -
(A) Newton (B) Einstein
(C) Planck (D) Bohr

Q.3 A surface ejects electrons when illuminated by blue light but none with green light. Then photo emission is possible by light of which of the following colours -
(A) violet (B) red
(C) yellow (D) infra-red

Q.4 Dual nature of radiation is shown by -
(A) diffraction and reflection
(B) refraction and diffraction
(C) photo-electric effect alone
(D) photo electric effect and diffraction

Q.5 If the work-function of the metal is ϕ and the frequency of incident light is ν, there is no emission of photoelectrons when -
(A) $\nu < (\phi/h)$ (B) $\nu = (\phi/h)$
(C) $\nu > (\phi/h)$ (D) $\nu \geq (\phi/h)$

Q.6 In photoelectric equation $h\nu = h\nu_0 + \frac{1}{2}mv^2$ of Einstein which classical law is followed -
(A) conservation of momentum
(B) conservation of energy
(C) conservation of charge
(D) conservation of mass

Q.7 In photoelectric effect, emitted electrons are -
(A) those which are moving in a shell near to the nucleus
(B) those which are present in the nucleus
(C) those which are moving freely in the inter atomic distance
(D) those which are produced from neutron disintegration

Q.8 The work-function of a photo-electric material is 3.3 eV. The threshold frequency will be equal to -
(A) 8×10^{14} Hz (B) 5×10^{36} Hz
(C) 8×10^{10} Hz (D) 4×10^{11} Hz

Q.9 Photo electrons emitted from the surface of sodium metal are -
(A) of equal frequency
(B) of equal kinetic energy
(C) of equal De-Broglie's wavelength
(D) having velocities which changes from zero to a fixed maximum value

Q.10 The photoelectric effect can not be explained by the wave theory of light because -
(A) the energy carried by the light waves is not given to a particular electron of the metal, rather it is distributed among all the electrons present on the surface of metal
(B) waves do not have energy
(C) energy of the waves becomes zero as it strikes the metal surface
(D) waves do not have sufficient energy which is required for electron emission

Q.11 Which of the following statement is wrong ?
(A) photoelectric current depends on intensity
(B) the maximum kinetic energy of emitted electrons can be equal to eV_s where V_s is stopping potential
(C) at stopping potential on increasing the intensity of light photoelectric current increases
(D) the maximum energy of photoelectron does not depend on the intensity of light

Q.12 Energy of a photon is 20eV then its momentum is -
(A) 5.33×10^{-27} kg-m/sec
(B) 10.66×10^{-25} kg-m/sec
(C) 10.66×10^{-27} kg-m/sec
(D) 5.33×10^{-30} kg-m/sec

Q.13 Two photons of 2.5eV are incident on the surface of metal. If the work functions of metal is 4.5 eV then from surface -
(A) one electron is emitted
(B) two electron are emitted
(C) no electron is emitted
(D) more than two electrons are emitted

Q.14 Photocell is a device to -
(A) store photons
(B) measure light intensity
(C) convert photon energy into electrical energy
(D) store electrical energy for replacing storage batteries

Q.15 Light of frequency 1.5 times the threshold frequency is incident on photo-sensitive material. If the frequency is halved and intensity is doubled, the photo-current becomes -
(A) quadrupled (B) doubled
(C) halved (D) zero

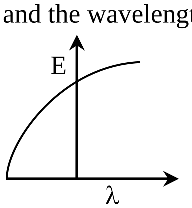
Q.16 Let n_r and n_b be respectively the number of photons emitted by a red bulb and a blue bulb of equal power in a given time -
(A) $n_r = n_b$
(B) $n_r < n_b$
(C) $n_r > n_b$
(D) the information is insufficient to get a relation between n_r and n_b

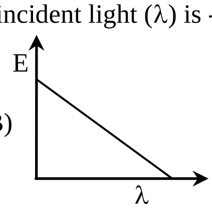
Q.17 Four elements A, B, C, D have work function 2, 2.4, 2.8, 3.2 eV. Light of wavelength 4000 Å is incident on them. The elements which emit photo electrons are -
(A) A, B, C, D (B) A, B, C
(C) A, B (D) A

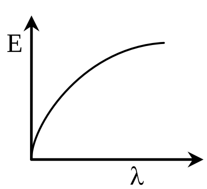
Q.18 The equation E = pc is valid -
(A) for an electron as well as for photon
(B) for an electron but not for a photon
(C) for a photon but not for an electron
(D) neither for an electron nor for a photon

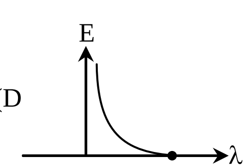
Questions based on Graphs

Q.19 The graph between the energy of photoelectrons (E) and the wavelength of incident light (λ) is -

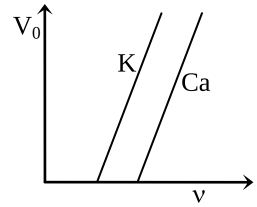
(A)


(B)


(C)


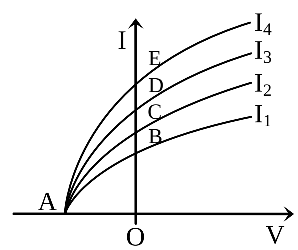
(D


Q.20 In the diagram, graph are drawn between stopping potential V_0 and frequency ν for the elements K and Ca. According this to diagram -



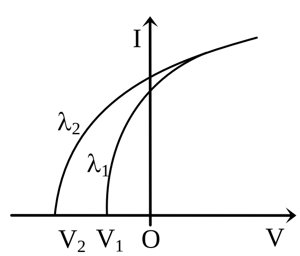
(A) the work functions of K and Ca are equal
(B) the work function of K is greater than that of Ca
(C) the work function of K is less than that of Ca
(D) no information can be obtained about the work function

Q.21 In the following figure the curves have been drawn between the photoelectric current and the potential difference applied at the cathode with respect to anode at four different intensities, the stopping potential is represented by -



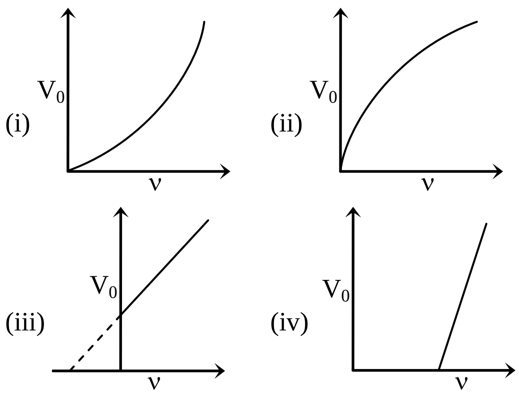
(A) OA (B) OB
(C) OC (D) OD

Q.22 In the given diagram if V represent the stopping potential and wavelength of incident light is λ. If $V_2 > V_1$ then -



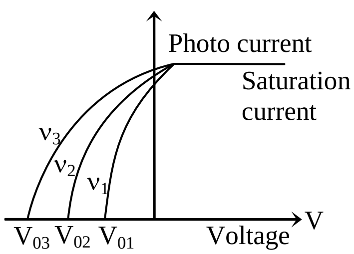
(A) $\lambda_1 = \lambda_2$ (B) $\lambda_1 > \lambda_2$
(C) $\lambda_1 < \lambda_2$ (D) none of these

Q.23 For a photoelectric cell, the graph showing the variation of cut off voltage (V_0) with frequency (ν) of incident light is -



(A) (i) (B) (ii) (C) (iii) (D) (iv)

Q.24 Photoelectric current as a function of voltage V for different light frequencies is shown here. Then the correct relation is -



(A) $\nu_1 = \nu_2 = \nu_2$ (B) $\nu_1 > \nu_2 > \nu_3$

(C) $\nu_1 < \nu_2 < \nu_3$ (D) none of the above

Q.25 The graph between the frequency of incident light and the stopping potential is -

(A) parabolic

(B) elliptical

(C) a straight line passing through origin

(D) a straight line not passing through the origin

Q.26 The graph between the stopping potential V_0 and frequency (n) of incident photons for photocell is a straight line with a slope -

(A) h (B) eh (C) e/h (D) h/e

Questions based on Stopping potential and K.E. of electrons

Q.27 The work function of a metal is 1 eV. On making light of wavelength 3000Å incident on this metal, the velocity of photoelectrons emitted from the metal, in m/s will be -

(A) 10^2 (B) 10^3 (C) 10^6 (D) 10^4

Q.28 The threshold wavelength for photoelectric emission in tungsten is 230 nm. What wavelength of light must be used in order for electrons to be ejected with a maximum kinetic energy 1.5 eV ?

(A) 190 nm (B) 180 nm

(C) 160 nm (D) 170 nm

Q.29 If the wavelength of incident light decreases from λ_1 to λ_2 in photoelectric cell then corresponding charges in stopping potential will be -

(A) an increase of (hc/e) $(1/\lambda_2 - 1/\lambda_1)$

(B) a decrease of (hc/e) $(1/\lambda_2 - 1/\lambda_1)$

(C) an increase of (hc) $(1/\lambda_2 - 1/\lambda_1)$

(D) a decrease of (hc) $(1/\lambda_2 - 1/\lambda_1)$

Q.30 The retarding potential for having zero photoelectron current -

(A) Is proportional to the wavelength of incident light

(B) Increases uniformly with the increase in the wavelength of incident light

(C) Increases uniformly with the increase in the frequency of incident light wave

(D) Is proportional to the frequency of incident light

Q.31 In photoelectric effect work function of any metal is 2.5 eV. Emitted electrons are stopped by the potential of –1.5 volt then -

(A) energy of incident photons is 4 eV

(B) energy of incident photons is 1 eV

(C) photoelectric current increases when we use photons of high frequency

(D) none of the above

Q.32 If the wavelength of incident light changes from 4000 Å to 3600 Å, change in stopping potential will be -

(A) + 0.35V (B) –0.35 V

(C) + 0.40V (D) –0.40V

Q.33 Silver has a work function of 4.7 eV. When ultraviolet light of wavelength 100 nm is incident upon it, a potential of 7.7 volt is required to stop the photoelectrons from reaching the collector plate. The potential required to stop photo electrons when light of wavelength 200 nm is incident upon silver is -

(A) 1.5 V (B) 1.85 V

(C) 1.95 V (D) 2.37 V

Q.34 The K.E. of the photoelectrons is E when the incident wavelength is $\lambda/2$. The K.E. becomes 2E when the incident wavelength is $\lambda/3$. The work function of the metal is -

(A) $\frac{hc}{\lambda}$ (B) $\frac{2hc}{\lambda}$

(C) $\frac{3hc}{\lambda}$ (D) $\frac{hc}{3\lambda}$

Q.35 Electrons of 0.5 eV energy are emitted from a metal surface when photons of wavelength 3000Å are incident. The energy of electrons, when photons of 2000Å are incident will be -

(A) equal to 0.5 eV (B) higher then 0.5 eV

(C) less then 0.5 eV (D) none of the above

Q.36 If the frequency of light in a photoelectric experiment is doubled, the stopping potential will -

(A) be doubled

(B) be halved

(C) become more than double

(D) become less than double

Q.37 The stopping potential for photo electrons does not depend on -

(A) the intensity of incident light

(B) the nature of stopping electrode

(C) distance between photo cathode and the stopping electrode

(D) all of the above