# PHYSICS

**Q.1** When yellow light is incident on a surface no electrons are emitted while green light can emit. Infrared light is incident on the surface then -

(A) no electrons are emitted
(B) Photons are emitted
(C) electrons of higher energy are emitted
(D) electrons of lower energy are emitted

**[A]**

**Q.2** Light of frequency $\nu$ is incident on a certain photo electric substance with threshold frequency $\nu_0$. The work function for the substance is -

(A) $h\nu$ (B) $h\nu_0$
(C) $h\nu - h\nu_0$ (D) $hc(\nu + \nu_0)$ **[B]**

**Q.3** Three photons of energy 5eV, 6eV, 7eV are incident on metal having work function 3eV. The maximum kinetic energy of emitted photoelectrons is-

(A) 2eV (B) 3 eV
(C) 4 eV (D) 15 eV **[C]**

**Q.4** Electromagnetic radiations having electric field variation is as

$$E = E_0\cos^2\frac{\omega t}{2}\cos\omega_0 t$$

is incident on metal plate having work function $\frac{h(\omega+\omega_0)}{4\pi}$, h is planck's constant. The maximum kinetic energy of emitted photoelectrons is –

(A) $\frac{h\omega_0}{4\pi}$ (B) $\frac{h\omega}{4\pi}$
(C) $\frac{h(\omega+\omega_0)}{4\pi}$ (D) $\frac{h(\omega-\omega_0)}{4\pi}$ **[C]**

**Q.5** We wish to observe an object which is 2.5 Å in size. The minimum energy photon that can be used -

(A) 5 KeV (B) 8 KeV
(C) 10 KeV (D) 12 KeV **[A]**

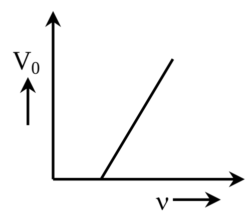
**Q.6** When 24.8 KeV X-rays strike a material, the photoelectrons emitted from K shell are observed to move in a circle of radius 23 mm in a magnetic field of $2 \times 10^{-2}$T. The binding energy of K-shell electrons is –

(A) 6.2 KeV (B) 5.4 KeV
(C) 7.4 KeV (D) 8.6 KeV **[A]**

**Q.7** The number of visible photons of wavelength 5000Å that a 100 W bulb with 3% efficiency emit per second is –

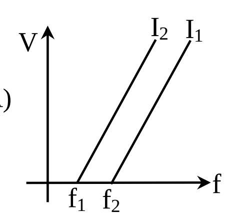
(A) $10^{19}$ (B) $10^{9}$
(C) $10^{33}$ (D) $10^{25}$ **[A]**

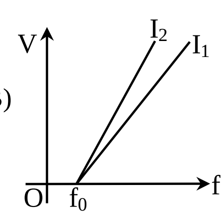
**Q. 8** In photoelectric effect, the slope of straight line graph between stopping potential ($V_0$) and frequency of incident light ($\nu$) gives :

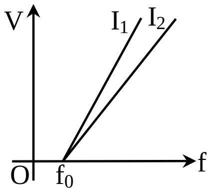



(A) charge on electrons
(B) work function of emitter
(C) Plank's constant
(D) ratio of Planck's constant to charge on electron **[D]**

**Q.9** A photoelectric experiment is performed at two different light intensities $I_1$ and $I_2$ ( > $I_1$). Choose the correct graph showing the variation of stopping potential versus frequency of light.

(A) 

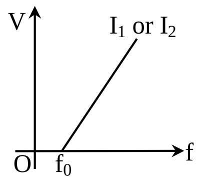

(B) 

(C) 


(D) None of these

**[D]**

**Sol.** The value of stopping potential depends on the maximum kinetic energy of the photo-electron and thus it is independent of the intensity of light. Therefore, none of the graph shown is correct. The correct graph is shown in the figure.




**Q.10** The radiation emitted, when an electron jumps from n = 3 to n = 2 orbit is a hydrogen atom, falls on a metal to produce photoelectron. The electrons from the metal surface with maximum kinetic energy are made to move perpendicular to a magnetic field of $\frac{1}{320}$ T in a radius of $10^{-3}$m. Find the work function of metal-

(A) 1.03 eV (B) 1.89 eV

(C) 0.86 eV (D) 2.03 eV **[A]**

**Sol.** $E_3 - E_2 = 13.6\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$= \frac{13.6 \times 5}{36} = 1.89$ eV

Photoelectrons with $kE_{max}$ are moving on circular path.

$r = \frac{mv}{qB}$

$mv = qBr$

$P = qBr = 1.6 \times 10^{-19} \times \frac{1}{3200} \times 10^{-3}$

$\frac{1}{2} \times 10^{-24} = 5 \times 10^{-25}$ kg m/s

Energy of photoelectron = $KE_{max} = \frac{P^2}{2m}$

$= \frac{25 \times 10^{-50}}{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19}}$ eV

= 0.86 eV

Now use Einstein equation

$h\nu = \phi + kE_{max}$

$1.89 = 0.56 + \phi$ ; $\phi = 1.03$ ev

**Q.11** Choose the correct statement (s) related to the photocurrent and the potential difference between the plate and the collector-

(A) Photocurrent always increase with the increase in potential difference

(B) when the potential difference is zero, the photocurrent is also zero

(C) Photocurrent attain a saturation value of some positive value of the potential difference

(D) None of these **[C]**

**Q.12** Two photons having -

(A) equal wavelengths have equal linear monenta

(B) equal energies have equal linear momenta

(C) equal frequencies have equal linear momenta

(D) equal linear momenta have equal wavelengths

**[D]**

**Q.13** If $K_1$ and $K_2$ are the maximum kinetic energies of photo electrons emitted when lights of wavelength $\lambda_1$ and $\lambda_2$ respectively incident on a metallic surface and $\lambda_1 = 3\lambda_2$ . Then -

(A) $K_1 > \frac{K_2}{3}$ (B) $K_1 < \frac{K_2}{3}$

(C) $K_1 = 3K_2$ (D) $K_2 = 3K_1$ **[B]**

**Sol.** $K_1 = \frac{hc}{\lambda_1} - \phi$

$K_2 = \frac{hc}{\lambda_2} - \phi$

$$\frac{K_2}{K_1} = \frac{\left(\frac{3hc}{\lambda_1} - \phi\right)}{\left(\frac{hc}{\lambda_1} - \phi\right)} = \frac{3\left(\frac{hc}{\lambda_1} - \frac{\phi}{3}\right)}{\left(\frac{hc}{\lambda_1} - \phi\right)}$$

$\Rightarrow \frac{K_2}{K_1} > 3$

**Q.14** 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 $n_b$ **[C]**

**Q.15** The equation E = pc is valid -

(A) for an electron as well as for a 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 **[C]**

**Q.16** The work function of a metal is $h\nu_0$. Light of frequency $\nu$ falls on this metal. The photoelectric effect will take place only if -

(A) $\nu \geq \nu_0$ (B) $\nu > 2\nu_0$

(C) $\nu < \nu_0$ (D) $\nu < \nu_0/2$ **[A]**

**Q.17** Light of wavelength $\lambda$ falls on a metal having work function $hc/\lambda_0$. Photoelectric effect will take place only if -

(A) $\lambda \geq \lambda_0$ (B) $\lambda \geq 2\lambda_0$

(C) $\lambda \leq \lambda_0$ (D) $\lambda < \lambda_0/2$ **[C]**

**Q.18** When stopping potential is applied in an experiment on photoelectric effect, no photocurrent is observed. This means that -

(A) the emission of photoelectrons is stopped

(B) the photoelectrons are emitted but are reabsorbed by the emitter metal

(C) the photoelectrons are accumulated near the collector plate

(D) the photoelectrons are dispersed from the sides of the apparatus **[B]**

**Q.19** The kinetic energy of most energetic electrons emitted from a metallic surface is doubled when the wavelength $\lambda$ of the incident radiation is changed from 400 nm to 310 nm. The work function of the metal is -

(A) 0.9 eV (B) 1.7 eV

(C) 2.2 eV (D) 3.1 eV **[C]**

**Sol.** $K = \frac{12400}{4000} - \phi = 3.1 - \phi$

$2K = \frac{12400}{3100} - \phi = 4 - \phi$

$\Rightarrow 6.2 - 2\phi = 4 - \phi$

or $2.2 \text{ eV} = \phi$

$\therefore \phi = 2.2 \text{ eV}$

**Q.20** The mass of an electron in motion depends upon

(A) direction of motion

(B) its velocity

(C) initial mass of $e^-$

(D) its shell number **[B]**

**Q.21** A photon of energy $h\nu$ is absorbed by a free electron of a metal having work function $\varphi < h\nu$,

(A) The electron is sure to come out

(B) The electron is sure to come out with a kinetic energy $h\nu - \varphi$

(C) Either the electron does not come out or it comes out with a kinetic energy $h\nu - \varphi$ **[B]**

(D) It may come out with a kinetic energy less than $h\nu - \varphi$ **[D]**

**Q.22** A modern 200 watt sodium street lamp emits yellow light of wavelength 0.6 µm. Assuming it to be 25% efficient in converting electrical energy to light, number of photons of yellow light it emits per second is -

(A) $6.2 \times 10^{20}$ (B) $3 \times 10^{19}$

(C) $1.5 \times 10^{20}$ (D) $6 \times 10^{18}$ **[C]**

**Sol.** $\frac{n}{t} = \frac{IA}{h\nu} = \frac{IA\lambda}{hc} = \frac{W\lambda}{hc}$

$= \frac{50 \times 6 \times 10^{-7}}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$

$= \frac{300}{20} \times 10^{19}$

$= 1.5 \times 10^{20}$

**Q.23** The collector plate in an experiment on photoelectric effect is kept vertically above the emitter plate. Light source is put on and a saturation photocurrent is recorded. An electric field is switched on which has a vertically downward direction.

(A) The photocurrent will increase
(B) The kinetic energy of the electrons will increase
(C) The stopping potential will decrease
(D) The threshold wavelength will increase **[B]**

**Q.24** Two identical metal plates show photoelectric effect. Light of wavelength $\lambda_A$ falls on plate A and $\lambda_B$ falls on plate B. $\lambda_A = 2\lambda_B$. The maximum K.E. of the photoelectrons are $K_A$ and $K_B$ respectively. Which one of the following is true ?

(A) $2K_A = K_B$ (B) $K_A = 2K_B$
(C) $K_A < K_B/2$ (D) $K_A > 2K_B$ **[C]**

**Sol.** $K_A = \frac{hc}{\lambda_A} - \phi = \frac{hc}{2\lambda_B} - \phi$ .... (i)

$K_B = \frac{hc}{\lambda_B} - \phi \Rightarrow \frac{hc}{\lambda_B} = K_B + \phi$ .... (ii)

From eq$^n$ (i) & (ii)

$K_A = \frac{1}{2}(K_B + \phi) = \frac{1}{2} K_B - \frac{\phi}{2}$

$K_A < \frac{1}{2} K_B$

**Q.25** The threshold frequency for photo electric effect on sodium corresponds to a wavelength 5000 Å. Its work function is -

(A) 15 Joule (B) $10 \times 10^{-19}$ Joule
(C) $4 \times 10^{-19}$ Joule (D) None of these
**[C]**

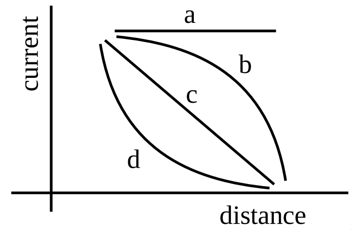
**Sol.** $\phi = \frac{hc}{\lambda_0}$

$\phi = \frac{20 \times 10^{-26}}{5000 \times 10^{-10}} = 4 \times 10^{-19}$ Joule

**Q.26** A point source of light is used in a photoelectric effect. If the source is removed farther from the emitting metal, the stopping potential -

(A) will increase
(B) will decrease
(C) will remain constant
(D) will either increase or decrease **[C]**

**Q.27** A point source causes photoelectric effect from a small metal plate. Which of the following curves may represent the saturation photocurrent as a function of the distance between the source and the metal ?




(A) a (B) b
(C) c (D) d **[D]**

**Q.28** Light of frequency $4\nu_0$ is incident on the metal of threshold frequency $\nu_0$. The maximum kinetic energy of the emitted photo electrons is

(A) $3\,h\nu_0$ (B) $2\,h\nu_0$
(C) $\frac{3}{2}\,h\nu_0$ (D) $\frac{h\nu_0}{4}$ **[A]**

**Sol.** $K.E._{max} = 4h\nu_0 - h\nu_0$

$K.E._{max} = 3\,h\nu_0$

**Q.29** A proton and an electron are accelerated by the same potential difference. Let $\lambda_e$ and $\lambda_p$ denote the de Broglie wavelengths of the electron and the proton respectively -

(A) $\lambda_e = \lambda_p$
(B) $\lambda_e < \lambda_p$
(C) $\lambda_e > \lambda_p$
(D) The relation between $\lambda_e$ and $\lambda_p$ depends on the accelerating potential difference
**[C]**

**Q.30** A surface does not ejects electron when illuminated with blue light. Then photoelectrons will be ejected when the surface is illuminated by -

(A) masers (B) infra-red
(C) laser (D) X-rays **[D]**

**Q.31** The phenomenon of photoelectric emission depends on -

(A) only wavelength of incident light
(B) only work function of surface
(C) only nature of surface
(D) all of the above **[D]**

**Q.32** The work function of a substance is 4 eV. What is the approximate longest wavelength of light that can cause photo-emission ?

(A) 309 nm (B) 209 nm

(C) 109 nm (D) 9 nm **[A]**

**Sol.** $\lambda_{th} = \frac{hc}{\phi} = \frac{12400}{4}$ Å = 3100 Å = 310 nm

$\lambda \le \lambda_{th} \quad \Rightarrow \lambda \le 310$ nm

**Q.33** A photon behaves as if it had a mass equal to -

(A) $\frac{h\nu}{c}$ (B) $\frac{h\nu}{c^2}$

(C) $\frac{c^2}{h\nu}$ (D) $h\nu c$ **[B]**

**Sol.** $E = mc^2$

$m = \frac{E}{c^2} = \frac{h\nu}{c^2}$

**Q.34** A photosensitive plate is illuminated by green light and photoelectrons are emitted with maximum kinetic energy 4 eV. If the intensity of the incident radiation is reduced to one-fourth of the original value, then the maximum K.E. of the photoelectrons will be -

(A) 0.1 eV (B) 1 eV

(C) 4 eV (D) 16 eV **[C]**

**Q.35** Photoelectron are emitted with maximum kinetic energy E from a metal surface when light of frequency υ falls on it when light of frequency υ' falls on the same metal, the max. KE. Of emitted Photoelectrons is found to be 2E then υ' is -

(A) $\upsilon^1 = \upsilon$ (B) $\upsilon^1 = 2\upsilon$

(C) $\upsilon^1 > 2\upsilon$ (D) $\upsilon^1 < 2\upsilon$ **[C]**

**Sol.** $KE = h\upsilon + \phi$ …..(i)

$2KE = h\upsilon' + \phi$ ……(ii)

or $2(h\upsilon + \phi) = h\upsilon' + \phi$

or $\upsilon' = 2\upsilon + \frac{\phi}{h} \Rightarrow \upsilon' > 2\upsilon$

**Q.36** The stopping potentials are $V_1$ and $V_2$ with incident lights of wavelength $\lambda_1$ and $\lambda_2$ respectively. Then $V_1 - V_2$ -

(A) $\frac{hc}{e}\left(\frac{\lambda_1\lambda_2}{\lambda_1 - \lambda_2}\right)$ (B) $\frac{hc}{e}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$

(C) $\frac{he}{c}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$ (D) $\frac{he}{c\lambda_1\lambda_2}(\lambda_1 - \lambda_2)$

**[B]**

**Sol.** $eV_1 = \frac{hc}{\lambda_1} - \phi$

$eV_2 = \frac{hc}{\lambda_2} - \phi$

$V_1 - V_2 = \frac{hc}{e}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$

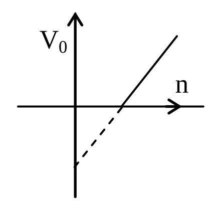
**Q.37** The graph between the stopping potential $V_0$ and frequency (n) of incident photons for photocell is a straight line with a slope -

(A) h (B) eh

(C) e/h (D) h/e **[D]**

**Sol.** $eV_0 = hn - \phi$

$V_0 = \left(\frac{h}{e}\right) n - \frac{\phi}{e}$




**Q.38** All electrons ejected from a surface by incident light of wavelength 200 nm can be stopped before travelling 1 m in the direction of uniform electric field of 4N/C. The work function of the surface is –

(A) 4eV (B) 6.2 eV

(C) 2 eV (D) 2.2 eV **[D]**

**Sol.** $V_s = E.d$

$V_s = 4$Volt

$eV_s = \frac{12400}{\lambda} - W$

$4\text{ eV} = \frac{12400\text{eV}}{2000} - W$

$4\text{eV} = 6.2\text{eV} - W$

[W = 2.2 eV]

**Q.39** The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 5 eV fall on it is 3 eV. The stopping potential in volts is –

(A) 3 eV (B) 2 eV

(C) 8 eV (B) 5 eV **[A]**

**Sol.** $eV_S = h\nu - \phi = K_{max}$

$V_S = 3$ eV

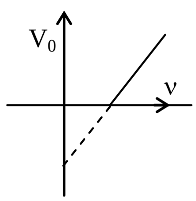
**Q.40** The graph between the frequency of incident light and the stopping potential is a -

(A) Parabola (B) Straight line

(C) Hyperbola (D) Circle **[B]**

**Sol.** Use $eV_0 = h\nu - \phi$

or $V_0 = \frac{h}{e}\,\nu - \frac{\phi}{e}$




**Q.41** The surface of a metal is illuminated with the light of 400 *nm*. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal is (hc = 1240 eV. nm)– **[AIEEE-2009]**

(A) 3.09 eV (B) 1.41 eV

(C) 1.51 eV (D) 1.68 Ev **[B]**

**Sol.** $\because \frac{hc}{\lambda} = \frac{1}{2}mv^2 + \phi$

$\Rightarrow \phi = \frac{hc}{\lambda} - \frac{1}{2}mv^2$

$= \frac{1240}{400} - 1.68 = 1.41$ eV

**Q.42** Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material, photoelectric current is emitted. If the frequency of light is halved and intensity is doubled, the photoelectric current becomes -

(A) 4 times the orginal current

(B) 2 times the original current

(C) half the original current

(D) zero times the original current **[D]**

**Sol.** $\nu_1 = 1.5\ \nu_0$

$\nu_2 = \frac{\nu_1}{2} = 0.75\ \nu_0 < \nu_0$

$\Rightarrow$ photoelectric effect (P.E.E.) not possible.

**Q.43** We wish to observe an object which is 2.5 Å in size. The minimum energy photon that can be used-

(A) 5 KeV (B) 8 KeV

(C) 10 KeV (D) 12 KeV **[A]**

**Sol.** In order for scattering to occur, the wavelength of the waves must be of the same order of magnitude or smaller than the size of the object being observed. Hence the largest possible wavelength we can use in the present problem is $\lambda$max = 2.5 Å. Hence minimum energy is

$E_{min} = h\nu_{min} = \frac{hc}{\lambda_{max}}$

$= \frac{12.40 \times 10^3 eV.A^\circ}{2.5A^\circ} = 5$ KeV

**Q.44** In an experiment tungsten cathode which has a threshold wavelength 2300 Å is irradiated by ultraviolet light of wavelength 1800 Å. The maximum energy of emitted photo-electron will be –

(A) 1.2 eV (B) 1.5 eV

(C) 1.6 eV (D) 1.8 eV **[B]**

**Sol.** $K_{max} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$

$= \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19}}\left(\frac{10^{10}}{1800} - \frac{10^{10}}{2300}\right)$

= 1.5 eV

**Q.45** The frequency of incident light falling on a photo sensitive plate is doubled, then maximum kinetic energy of the emitted photoelectrons will become –

(A) 2 times of the earlier value

(B) More than 2 times of the earlier value

(C) Less than 2 times of the earlier value

(D) Unchanged **[B]**

**Sol.** $KE_{max} = h(\nu - \nu_0)$

$$\frac{KE'_{max}}{KE_{max}} = \frac{h(2\nu-\nu_0)}{h(\nu-\nu_0)} > 2$$

**Q.46** 1.5 mW of 400 nm light is directed at a photo electric cell. If 0.1% of the incident photons produce photo electrons, the current in the cell is-

(A) 0.48μA (B) 0.42mA

(C) 0.48 mA (D) 0.42μA **[A]**

**Sol.** $n = \frac{P\lambda}{hc}$

$n_e = n \times \beta\,\% = \frac{P\lambda}{hc} \times \frac{\beta}{100}$

$n_e = \frac{1.5\times10^{-3}\times400\times10^{-9}}{6.6\times10^{-34}\times3\times10^{8}} \times \frac{0.1}{100}$

$I = n_e e$

$= 0.48\ \mu A$

**Q.47** Stopping potentials of 24, 100, 110, 115 kV are measured for photoelectrons emitted from a certain element when it is irradiated with monochromatic X-rays. The element is used as a target in an X-ray tube. The energy of $K_\alpha$ line is –

(A) 54 KeV (B) 76 KeV

(C) 88 KeV (D) 32 KeV **[B]**

**Sol.** Let $E_K$, $E_L$, $E_M$, $E_N$ be the binding energies of K, L, M and N shell. Let $E_P$ be energy of incident photon. Then

$E_P - E_K = 24$ KeV ... (1)

$E_P - E_L = 100$ KeV ... (2)

$E_P - E_M = 110$ KeV .... (3)

$E(K_\alpha) = E_K - E_L = 100 - 24 = 76$ KeV

**Q.48** When photons of energy hν are incident on the surface of photosensitive material of work function $h\nu_0$, then -

(A) the kinetic energy of all emitted electrons is $h\nu_0$

(B) the kinetic energy of all emitted electrons is $h(\nu - \nu_0)$

(C) the kinetic energy of all fastest electrons is $h(\nu - \nu_0)$

(D) the kinetic energy of all emitted electrons is hν **[C]**

**Sol.** $\frac{1}{2} mv_{max}^2 = h\nu - h\nu_o$

$= h(\nu - \nu_o)$

This is Einstein's equation of photoelectric effect.

**Q.49** We wish to observe an object which is 2.5 Å in size. The minimum energy photon that can be used -

(A) 5 KeV (B) 8 KeV

(C) 10 KeV (D) 12 KeV **[A]**

**Sol.** In order for scattering to occur, the wavelength of the waves must be of the same order of magnitude or smaller than the size of the object being observed. Hence the largest possible wavelength we can use in the present problem is $\lambda_{max} = 2.5$ Å. Hence minimum energy is

$E_{min} = h\nu_{min} = \frac{hc}{\lambda_{max}}$

$= \frac{12.40\times10^3}{2.5Å}$ eV.Å

$= 4.96 \times 10^3$ eV

$= 5$ KeV

**Q.50** If the rate of emission of energy from a star is $2.7 \times 10^{36}$ J/sec, the rate of loss of mass in the star will be -

(A) $3 \times 10^{18}$ kg/sec (B) $3 \times 10^{19}$ kg/sec

(C) $3 \times 10^{20}$ kg/sec (D) $3 \times 10^{21}$ kg/sec

**[B]**

**Sol.** $E = mc^2$

$\therefore m = \frac{E}{c^2} = \frac{2.7\times10^{36}}{9\times10^{16}}$

$= \frac{27\times10^{35}}{9\times10^{16}} = 3 \times 10^{19}$ kg/sec

**Q.1** The wavelength of light incident on a metal surface is reduced from 300 nm to 200 nm (both are less than threshold wavelength). What is the change in the stopping potential for photoelectrons emitted from the surface.
(Take $h = 6.6 \times 10^{-34}$ J-sec) **[0002]**

**Sol.** $eV_1 = \frac{hc}{\lambda_1} - \phi$

$eV_2 = \frac{hc}{\lambda_2} - \phi$

$e(V_2 - V_1) = hc\left(\frac{\lambda_1 - \lambda_2}{\lambda_1\lambda_2}\right)$

$V_2 - V_1 = \frac{hc}{e}\left(\frac{\lambda_1 - \lambda_2}{\lambda_1\lambda_2}\right)$

$= \frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}} \times \frac{100}{6\times10^{-5}}$

$= \frac{66}{32} \times 10^{-34+8+2+19+5}$

$= \frac{33}{16} = 2.0625 \text{ volt} \approx 2 \text{ volt}$

**Q.2** If photons of ultraviolet light of energy 12eV are incident on a metal surface of work function of 4eV, then the stopping potential (in eV) will be -

**Sol.** **[8]**

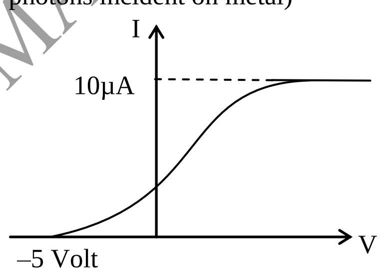
$eV_s = h\nu - W$

$= 12eV - 4eV$

$eV_s = 8eV$

$V_s = 8V$

**Q.3** In the photoelectric experiment, if we use a monochromatic light, the I – V curve is as shown. If work function of the metal is 2eV, estimate the power of light used (in W) (Assume efficiency of photo emission = $10^{-3}$ %, i.e. number of photoelectrons emitted are $10^{-3}$ % of number of photons incident on metal) –




**Sol.[7]** $eV_s = h\nu - W$

$5eV = h\nu - 2eV$

$h\nu = 7eV$

$n = \frac{P}{h\nu}$

$n_e = n \times \beta\ \%$

$i = n_e.e$

$10 \times 10^{-6} = \frac{P}{h\nu} \times \frac{10^{-3}}{100} \times 1.6 \times 10^{-19}$

$10 \times 10^{-6} = \frac{P\times10^{-3}\times1.6\times10^{-19}}{7\times1.6\times10^{-19}\times100}$

$P = 7W$

**Q.4** The human eye can barely detect a yellow light (6000 Å) that delivers $1.7 \times 10^{-8}$ W to the retina. How many photons strike the retina in one second ? (in $10^{10}$)

**Sol.[5]** Try yourself.

**Q.5** The photoelectric current in a vacuum photocell is reduced to zero when its cesium ($\phi$ = 1.89eV) electrode is irradiated by radiation of wavelength $\lambda$ = 2700 Å and a decelerating voltage V = 3V is applied. Then the magnitude of outer contact potential difference is N × $10^{-1}$ V, then the value of N is –

**Sol.[3]** Let $\phi'$ is work function in eV of material of connecting wire.

$(\phi - \phi')\,e = \Delta Ve \Rightarrow \phi - \phi' = \Delta V$

also $\left(\frac{hc}{\lambda} - \phi e\right) = Ve + (\phi - \phi')e$

Where V is the observed potential difference.

$\therefore \frac{hc}{\lambda} - \phi e = Ve + \Delta Ve$

$\Rightarrow \Delta V = \frac{hc}{\lambda} - \phi - V$

**Q.6** On a certain metal light of frequency $\nu = 5\nu_0$ falls then maximum velocity of electrons emitted is $8 \times 10^6$ m/s, where $\nu_0$ is threshold frequency of metal. If $\nu = 2\nu_0$ then the maximum velocity of photoelectron in $10^6$ m/s will be -

**Sol.** **[4]**

$\frac{1}{2}$ m $(8 \times 10^6)^2 = h(5\nu_0 - \nu_0)$ …(1)

also KE = $\frac{1}{2}$ $mv^2 = (2\nu_0 - \nu_0)$ …(2)

$\therefore \frac{(8\times10^6)^2}{v^2} = 4$

$\therefore v = 4 \times 10^6$ m/s

**Q.7** When a surface 1 cm thick is illuminated with light of wavelength $\lambda$, the stopping potential is $V_0$, but when the same surface is illuminated by light of wavelength $3\lambda$, the stopping potential is $\frac{V_0}{6}$. Then the threshold wavelength for metallic surface will be $n\lambda$. Find n.

**Sol.** **[5]**

$eV_0 = hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$ …(1)

$\frac{eV_0}{6} = hc\left[\frac{1}{3\lambda} - \frac{1}{\lambda_0}\right]$ …(2)

solve (1) and (2) and find $\lambda_0$.

**Q.8** Hydrogen gas in the atomic state is emitted to an energy level such that the electrostatic potential energy of H-atom becomes 1.7 eV. Now the photo-electric plate having work function $\phi = 2.3$ eV is exposed to the emission spectra of this gas. Assuming all the transitions to be possible, find the minimum de-Broglie wavelength of ejected photo-electrons (in Å).

**Sol.** **[4]**

Given that electrostatic potential – 1.7 eV we know that

KE = $\left|\frac{PE}{2}\right| = \frac{1.7}{2} = 0.85$ eV.

Thus total energy = – 1.7 + 0.85 = – 0.85 eV

Now $E_n = -\frac{3.6}{n^2} = -0.85$ eV

or $n^2 = \frac{13.6}{0.85} = 16$ or n = 4

Hence the atom is exited to state n = 4. The maximum energy is emitted when electrons will make a transition n = 4 to n = 1 for which energy emitted is

$\Delta E = -0.85 - (-13.6) = 12.75$ eV.

Now this photon energy when incident on a metal plate having work function 2.3 eV, the kinetic energy of fastest electron ejected can be given as

$KE_{max} = \Delta E - \phi = 12.75 - 2.3 = 10.45$ eV

The minimum de-Broglie wavelength is given by

$$\lambda_{min} = \frac{h}{P_{max}} = \frac{h}{\sqrt{2m(K.E)_{max}}}$$

$$= \frac{6.63\times10^{-34}}{\sqrt{2\times(9.1\times10^{-31})(10.45\times1.6\times10^{-19})}}$$

$= 3.8\times10^{-10}$m = 3.8 Å

**Q.9** A small plate of a metal (work function = 1.17 eV) is placed at a distance of 2m from a monochromatic light source of wavelength 4800 Å and power 1.0 watt. The light falls normally on the plate. If a constant magnetic field of strength $10^4$ tesla is applied parallel to metal surface. Find the radius of the largest circular path followed by the emitted photo electrons. The answer in cm.

**Sol.[4]** Energy of incident photon in eV is

$E = \frac{12431}{4800}$ eV = 2.58 eV

$= 2.58 \times 1.6 \times 10^{-19}$ J

$= 4.125 \times 10^{-19}$

The rate of emission of photon from source

$r = \frac{I}{E} = \frac{10 joule/sec}{4.125\times10^{-19}}$ joule $= 2.424 \times 10^{18}$/sec

No. of photon striking per square metal per sec on the plate

$= \frac{2.425\times10^{18}}{4\times.314\times(2)^2} = 4.82 \times 10^{16}\ m^{-2}\ sec^{-1}$

The maximum kinetic energy of the photoelectrons emitted from the plate having work function $\phi = 1.17$eV is given by

$KE_{max} = E - \phi$

$= 2.58 - 1.17$

$= 1.41$ eV

The maximum velocity of photo electrons ejected is gives as $\frac{1}{2}$ m $V_{max}^2 = 1.41$ eV or $V_{max} = \sqrt{\dfrac{2\times1.41\times1.6\times10^{-19}}{9.1\times10^{-31}}}$

$= 7.036 \times 10^{5}$ m/sec

The radius of the circle traversed by photoelectrons in magnetic field B is given by

$$r = \frac{mV}{qB} = \frac{(9.1\times10^{-31})(7.036\times10^{5})}{(1.6\times10^{-19})(10^{-4})}$$

$= 40.0 \times 10^{-3}$ metre (as $qVB = \dfrac{mV^2}{r}$) = 4.0 cm.

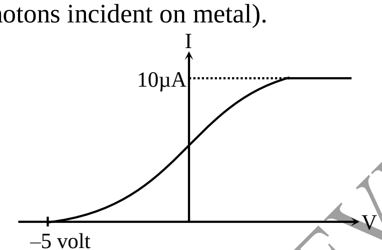
**Q.10** If photons of ultraviolet light of energy 12eV are incident on a metal surface of work function of 4eV, then the stopping potential (in eV) will be

**Sol.[8]** $eV_s = h\nu - W$

$= 12eV - 4eV = 8eV$

$V_s = 8V$

**Q.11** In the photoelectric experiment, if we use a monochromatic light, the I – V curve is as shown. If work function of the metal is 2eV, estimate the power of light used (in W) (Assume efficiency of photo emission = $10^{-3}$ %, i.e. number of photoelectrons emitted are $10^{-3}$ % of number of photons incident on metal).




**Sol.[7]** $eV_s = h\nu - W$

$5eV = h\nu - 2eV$

$h\nu = 7eV$

$n = \dfrac{P}{h\nu}$

$n_e = n \times \beta\%$

$i = n_e.e$

$$10 \times 10^{-6} = \frac{P}{h\nu} \times \frac{10^{-3}}{100} \times 1.6\times10^{-19}$$

$$10 \times 10^{-6} = \frac{P\times10^{-3}\times1.6\times10^{-19}}{7\times1.6\times10^{-19}\times100}$$

$P = 7W$

**Q. 12** Photoelectric threshold of silver is $\lambda$ = 3800Å. Ultraviolet light of $\lambda$ = 2600 Å is incident on a silver surface. Calculate

a. the value of work function in joule and in eV.

b. maximum kinetic energy of the emitted photoelectrons

c. the maximum velocity of the photoelectrons

(Mass of the electrons = $9.11 \times 10^{-31}$ kg)

**Sol.** (a) 3.27 eV (b) 1.5 eV (c) $0.7289 \times 10^{6}ms^{-1}$

**Q. 13** The stopping potential for photoelectrons emitted from a surface illuminated by light wavelength of 5893 Å is 0.36 V. Calculate the maximum kinetic energy of photoelectrons, the work function of the surface and the threshold frequency.

**Sol.** K.E. max. = 0.36 eV, $\phi$ = 1.7 46 eV,

$F_0 = 4.22 \times 10^{14}$Hz

**Q. 14** Light of wavelength of 2000 Å falls on an aluminium surface. In aluminium, 4.2 eV are required to remove an electron from its surface. What is the kinetic energy in electron volt, of

(a) the fastest, and

(b) the slowest emitted photoelectrons.

(c) What is the stopping potential?

(d) What is the cut-off wavelength for aluminium?

(Plank's constant $h = 6.6 \times 10^{-34}$ Js, and speed of light $c = 3 \times 10^{8}$ $ms^{-1}$.

**Sol.** (a) 2eV (b) zero (c) 2V (d) 3000 Å

**Q. 15** **(i)** A stopping potential of 0.82 V is required to stop the emission of photoelectrons from the surface of a metal by light of wavelength 4000 Å. For light of wavelength 3000 Å, the stopping potential is 1.85 V. Find the value of Planck's constant. [1 electron volt (eV) = $1.6 \times 10^{-19}$J]

**(ii)** At stopping potential , if the wavelength of the incident light is kept fixed at 4000 Å, but the intensity of light increased two times, will photoelectric current be obtained? Give reasons for your answer.

**Sol.** (i) h = $6.592 \times 10^{-34}$ J–s (ii) No, because stopping potential does not depend on intensity of incident light

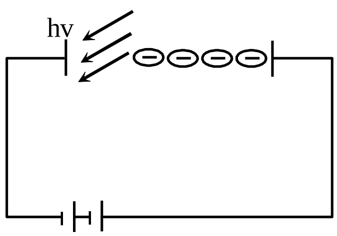
**Q. 16** Ultraviolet light of wavelength 800 Å and 700 Å when allowed to fall on hydrogen atoms in their ground states is found to liberate electrons with kinetic energies 1.8 eV and 4.0 eV, respectively. Find the value of Planck's constant.

**Sol.** $h = 6.57 \times 10^{-34}$ Js

**Q. 17** When a beam of 10.6 eV photon of intensity 2.0 $Wm^{-2}$ falls on a platinum surface of area $1.0 \times 10^{-4}$ $m^2$ and work function 5.6 eV, 0.53% of the incident photons eject photoelectrons. Find the number of photoelectrons, emitted per second and their minimum and maximum energies (in eV). Take 1 eV = $1.6 \times 10^{-19}$ J.

**Sol.** No. of photoelectrons emitted = $6.25 \times 10^{11}$ **,**
max K.E. = 5 eV, min. K.E. = 0

**Q. 18** Photons of energy 5 eV are incident on the cathode. Electrons reaching the anode have kinetic energies varying from 6 eV to 8 eV. Find the work function of the metal and state whether the current in the circuit is less than or equal to saturation current.




**Sol.** $\phi$ = 2 eV, less than saturation current

**Q.19** A small plate of metal ($\phi$ = 1.17 eV) is placed at a distance of 2m from a monochromatic light source of wavelength $4.8 \times 10^{-7}$ m and power 1.0 watt. The light falls normally on a plate. Find the number of photons striking the metal plate per square meter per sec. If a constant uniform magnetic field of strength $10^{-4}$ tesla is applied parallel to the metal surface then find the radius of largest circular path followed by emitted photoelectrons.

**Sol.** $4.8 \times 10^{16}$, 4.0 cm

**Q.20** Light of wavelength 330 nm falling on a piece of metal ejects electrons with sufficient energy which requires voltage $V_0$ to prevent an electron from reaching collector. In the same setup, light of wavelength, ejects electron which requires twice the voltage $V_0$, to stop them in reaching a collector. Find the numerical value of $V_0$.

**Sol.** 15/3 volt