PHYSICS

The following questions consists of two statements each, printed as Assertion/Statement and Reason/Statement. While answering these questions you are to choose any one of the following four responses/Statement.

(A) If both Assertion/Statement and Reason/Statement are true and the Reason/Statement is correct explanation of the Assertion/Statement.

(B) If both Assertion/Statement and Reason/Statement are true but Reason/Statement is not correct explanation of the Assertion/Statement.

(C) If Assertion/Statement is true but the Reason/Statement is false.

(D) If Assertion/Statement is false but Reason/Statement is true.

Q. 1 **Assertion :** In a photoelectric effect, the current increases when positive potential of collector is increased, before saturation of current.
Reason : The number of emitted photoelectrons increases. **[C]**

Q.2 **Assertion :** Work function of copper is greater than that of sodium. But both will have same value of the threshold frequency and threshold wavelength.
Reason : The frequency is inversely proportional to wavelength. **[D]**

Q.3 **Assertion :** The photoelectrons produced by a monochromatic light beam incident on a metal surface, have a spread in their kinetic energies.
Reason : the work function of the metal varies as a function of depth from the surface.

Sol. **[C]**
Statement is correct, but the work function only depends on the photoelectric current.

Q.4 **Assertion** : Photoelectric effect demonstrates the wave nature of light.
Reason : The number of photoelectrons is proportional to the frequency of light. **[D]**

Q.5 **Assertion** : Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.
Reason : The energy of electrons emitted from inside the metal surface is lost in collision with the other atoms in the metal. **[A]**

Q.6 **Assertion** : The threshold frequency of photoelectric effect supports the particle nature of sunlight.
Reason : If frequency of incident light is less than the threshold frequency, electrons are not emitted from metal surface. **[A]**

Q.7 **Assertion** : In the process of photoelectric emission, all the emitted photoelectrons have the same kinetic energy.
Reason : The photon transfers its whole energy to the electron of the atom in photoelectric effect. **[E]**

Q.8 **Assertion** : Photosensitivity of a metal is high if its work function is small
Reason : Work function = hf_0 where f_0 is the threshold frequency. **[B]**

Q.9 **Assertion :** For a point light source, frequency of light emitted is numerically equal to number of photons emitted per second.
Reason : According to wave theory frequency of light wave is equivalent to number of cycles completed per second and wave-particle duality explains the dual nature of electromagnetic waves as a wave or as a corpuscle. **[D]**

Q.10 **Assertion :** Though light of a single frequency (monochromatic light) is incident on a metal, the energies of emitted photoelectrons are different.
Reason : The energy of electrons just after they absorb photons incident on metal surface may be lost in collision with other atoms in the metal before the electron is ejected out of metal. **[A]**

Sol. Energy of photoelectron emitted is different because after absorbing the photon electrons

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within metals collide with other atom before being ejected out of metal. Hence (R) is correct explanation of (A).

Q.11 **Assertion :** In the process of photoelectric emission by monochromatic light, all the emitted photo-electrons possess the same kinetic energy.
Reason : In photoelectric effect a single photon interacts with a single electron and electron is emitted only if energy of each of incident photon is greater than the work function. **[D]**

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

KE of emitted photoelectrons varies from zero to K_{max}.

Q.12 **Statement I :** Photo-electric effect demonstrates particle nature of light.
Statement II : Number of photons is proportional to frequency of photons. **[C]**

Q.13 **Statement I :** K.E. of all photo-electrons are same, when monochromatic light is incident on a metal.
Statement II: $K_{max} = h\nu - \phi$, where all symbols have their usual meaning. **[D]**

Q.14 **Statement I :** Threshold frequency supports wave nature of light.
Statement II : Photo electrons are not emitted when incident light has frequency lesser than threshold frequency. **[D]**

Q.15 **Statement I :** Photosensitivity is high for a metal of low work function.
Statement II : $\phi = h\nu_{th}$ where all symbols has their usual meaning. **[A]**

Q.16 **Statement I :** Slope of K_{max} V/s ν graph is same for all metals having different work function.
Statement II : $K_{max} = h\nu - \phi$, where all symbols have their usual meaning. **[A]**

Q.17 **Statement-1 :** Stopping potential depends upon the frequency of incident light

Statement-2 : Photo electric current depends upon the intensity of incident light. **[B]**

Q.18 **Assertion :** Work function of copper is greater than that of sodium. But both will have same value of the threshold frequency and threshold wavelength.
Reason : The frequency is inversely proportional to wavelength.

Sol.[D]

Q.19 **Statement-1 :** When photon is incident on a photo sensitive surface then electrons are always emitted.
Statement-2 : Minimum energy is required to remove an electron from surface is called as work function.

Sol.[C] Electrons are not emitted if energy of photon is less than work function.

Q.20 **Statement-1 :** Maximum kinetic energy of emitted e^- is dependent on intensity
Statement-2 : Intensity is proportional to no. of photons
(A) A (B) B (C) C (D) D

Sol.[C] Remember it

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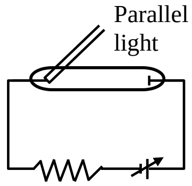
Q.1 In the shown experimental setup to study photoelectric effect, two conducting electrodes are enclosed in an evacuated glass-tube as shown. A parallel beam of monochromatic light, falls on photosensitive electrodes. The emf of battery shown is high enough such that all photo electrons ejected from left electrode will reach the right electrode. Under initial conditions photoelectrons are emitted. As changes are made in each situation of column I,match the statements in column-I with results in calumn-II



Column-I	Column-II
(A) If frequency of incident light is increased keeping its intensity constant	(P) magnitude of stopping potential will increase
(B) If frequency of incident light is increased an it's intensity is decreased	(Q) current through circuit may stop
(C) If work function of photo-sensitive electrode is increased	(R) maximum kinetic energy of ejected photo electrons will increase
(D) If intensity of incident light is increased keeping it's frequency constant.	(S) Saturation current will increase

Sol. **(A → P , R)** **(B → P, R)**
(C → Q) **(D → S)**

Consider two equations

$$eV_s = \frac{1}{2}mv^2_{max} = hv - \phi_o \qquad ....(1)$$

no of photoelectron ejected/sec.

$$\propto \frac{\text{intensity}}{hv} \qquad ....(2)$$

(A) As frequency is increased keeping intensity constant $|V_s|$ will increase, $\frac{1}{2}$ m (v^2_{max}) will increase and saturation current will decrease

(B) As frequency is increased and intensity is decreased $|V_s|$ will increase $\frac{1}{2}$ m (v^2_{max}) will increase and saturation current will decrease.

(C) If work function is increased photo emission may stop.

(D) If intensity is increased and frequency is constant, saturation current will increase.

Q.2

COLUMN I	COLUMN II
(A) Photoelectric effect	(P) Wave nature of light
(B) Millikan's experiment	(Q) Particle nature of light
(C) Young's Double slit experiment	(R) Particle nature of electron
(D) Davisson-Germer experiment	(S) Wave nature of electron

Ans. **$\alpha \to$ Q ; B $\to$ S ; C $\to$ P ; D $\to$ T**

Q.3

Column I	Column II
(A) Pair production	(P) Few MeV
(B) Inverse photoelectric effect	(Q) 20 KeV
(C) De-excitation of Be^{+3} atom from second excited state	(R) 54 eV
(D) K_α – X-ray photons of molybdenum Z = 42	(S) 0.1 eV

Sol. **A → P ; B → Q ; C → R ; D → Q**

$\gamma \to e^- + e^+$

Pair production

$E = 2\,M_ec^2 = 2 \times 0.51$ MeV

$= 1.02$ MeV

Inverse photoelectric effect is X-ray production and energy involved is of order of tens of KeV.

De-excitation of Be^{+3} from first excited state

$$E = \frac{Z^2}{n^2} \times 13.6 = \frac{4^2}{2^2} \times 13.6$$

$E \simeq 54.4$ eV = 55 eV

K_α X-ray photon of molybdenum

$$E(K_\alpha) = h\nu = h\frac{3}{4}cR\,(Z-1)^2$$

$$E(K_\alpha) = \frac{3}{4} \times (hcR)\,[Z-1]^2$$

$$= \frac{3}{4}E_0\,[Z-1]^2$$

$$= \frac{3}{4} \times 13.6 \times (42-1)^2$$

$= 17.146 \times 10^3$ eV

$E(K_\alpha) = 17$ KeV

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Q.4 In a photoelectric effect experiment, if the following changes are made, then match the column -I with column-II

Column-I	Column-II
(A) If frequency of incident light is increased keeping its intensity constant	(P) Stopping potential will increase
(B) If frequency of incident light is increased and its intensity is decreased	(Q) Current through circuit may stop
(C) If work function of photo sensitive electrode is increased	(R) Maximum kinetic energy of ejected photoelectrons will increase
(D) If intensity of incident light is increased keeping its frequency constant	(S) Saturation current will increase

Ans. **A → P, R ; B → P,R ; C → Q ; D → S**

Q. 5 For photoelectric effect match the following table:

Column - I	Column - II
(a) If frequency of incident light is increased	(p) Photo electric current may increase
(b) If intensity of incident light is increased	(q) Stopping potential must increase
(c) If work function of metal is increased	(r) Photoelectric effect may stop

Ans. **$\alpha \rightarrow$ q, b → p, c → r**

Q.6

Column I	Column II
(i) Photo electric effect	(a) Ionization
(ii) Saturation current	(b) Very less usually
(iii) Photon efficiency	(c) Intensity of radiation
(iv) Work function	(d) Photon nature of radiation
(v) Electron microscope	(e) Wave nature of radiation
	(f) Wave nature of e^-

(A) (i) → d, (ii) → c, (iii) → b, (iv) → a, (v) → f
(B) (i) → c, (ii) → d, (iii) → b, (iv) → a, (v) → e
(C) (i) → c, (ii) → b, (iii) → d, (iv) → f, (v) → a
(D) None

Ans **[A]**

Q.7 Some quantities related to photoelectric effect are mentioned under Column-(I) and Column-(II). Match each quantity on Column-I with the corresponding quantity in Column-(II) on which it depends.

Column-I	Column-II
(A) Saturation current	(P) Frequency of light
(B) Stopping potential	(Q) Work function
(C) de-Broglie wavelength of photoelectron	(R) Area of photo sensitive plate
(D) Force due to radiation falling on metal plate	(S) Intensity of light (at constant ν)

Sol. (A) → S; (B) → P,Q; (C) → P,Q; (D) → P,R,S

Q.8 Match the following -

Column-I	Column-II
(A) Photo electric effect	(P) Ionisation
(B) Saturation photo current	(Q) Very less usually
(C) Photon efficiency	(R) Intensity of radiation
(D) Work function	(S) Photon nature of radiation

Sol. **A → S B → R C → Q D → P**

Q.9 In the experimental setup for a photocell, the wavelength of the light incident on the cathode is initially 0.6 times the threshold wavelength for the material of the cathode. Certain changes in the experiment setup are given in column-I and their possible effects are given in column-II.

Column -I	Column-II
(A) The intensity of the incident light is doubled but the frequency remains unaltered	(P) Saturation photocurrent remains the same
(B) Both the intensity and wavelength of the incident light are doubled	(Q) Photocurrent falls to zero
(C) The intensity of the incident light is doubled and its wavelength is made half	(R) Stopping potential increases
(D) The intensity of the incident light remains the same and the wavelength is made half	(S) Saturation photocurrent increases

Sol. A → S ; B → Q ; C → R,S; D → P,R

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Q.10 In a photoelectric effect experiment, if f is the frequency of radiations incident on the metal surface and I is the intensity of incident radiations, then match the following.

Column -I	**Column-II**
(A) If f is increased keeping I and work function constant	(P) Stopping potential increases
(B) If distance between cathode and anode is increased	(Q) Saturation current increases
(C) If I is increased keeping f & work function constant	(R) Maximum kinetic energy of photoelectron increases
(D) Work function is decreased keeping f & I constant	(S) Stopping potential remain same

Sol. **A $\rightarrow$ P, R;** **B $\rightarrow$ S**
C $\rightarrow$ Q, S; **D $\rightarrow$ P,R**

Q.11 In a photoelectric effect experiment, if f is the frequency of radiations incident on the metal surface and I is the incident radiations, then match the following -

Column-I	**Column-II**
(A) If f is increased keeping I and work function constant	(P) Stopping potential increases
(B) If distance between cathode and anode is increased	(Q) Saturation current increases
(C) If I is increased keeping f and work function constant	(R) Maximum kinetic energy of photo electron increases
(D) Work function is decreased keeping f and I constant	(S) Stopping potential remain same

Sol. A $\rightarrow$ P,R ; **B $\rightarrow$ S ;** **C $\rightarrow$ Q,S ;** **D $\rightarrow$ P,R**

Q. 12 With respect to photoelectric effect experiment, match the entries of Column-I with the entries of Column-II.

Column -I	**Column -II**
(A) If f (frequency) is increased keeping I (intensity) and ϕ (work function) constant	(P) stopping potential increases
(B) If I is increased keeping f and ϕ constant	(Q) Saturation photocurrent increases
(C) If the distance between anode and cathode increases	(R) maximum K.E. of the photoelectrons increases
(D) If ϕ is decreased keeping f and I constant	(S) Stopping potential remains the same

Sol. (A) $\rightarrow$ P,R; (B) $\rightarrow$ Q,S; (C) $\rightarrow$ S; (D) $\rightarrow$ P,R

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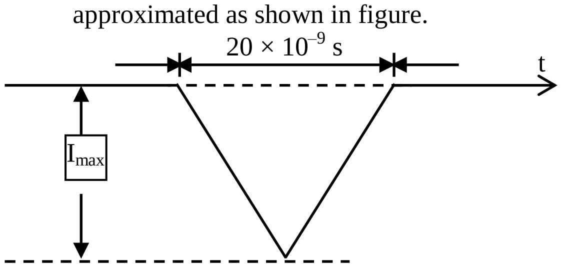
Q.1 A photomultiplier tube is to be used to detect light pulses each of which consists of a small but fixed number of photons. The average photoelectric efficiency is 10%. That is photon has 10% probability of causing the emission of a detectable photoelectron. Assume the photomultiplier gain is 10^6 and that the output current as a function of time can be approximated as shown in figure.



I_{max} when averaged over many pulses is 80 μA. Then which of the following are true -

(A) The charge carried by one pulse is 8×10^{-13}C

(B) Number of photoelectrons emitted per light pulse is 5

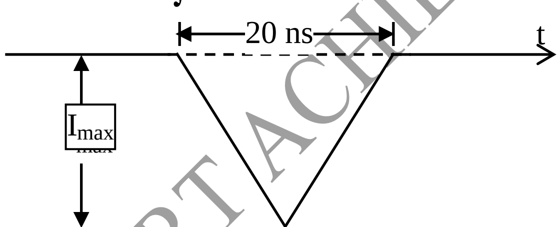
(C) Number of photons in one light pulse is 50

(D) Number of electrons carried by one pulse is 5×10^5

Sol. **[A,B,C]**

The total quantity of charge carried by one pulse of current is

$$Q = \int I \, dt,$$



which is the area of the triangle in Fig. Thus

$$Q = \frac{1}{2} \times 20 \times 10^{-9} \times 80 \times 10^{-6} = 8 \times 10^{-13}\text{C}$$

and the number of electrons carried by one pulse is

$$n = \frac{Q}{e} = \frac{8\times10^{-13}}{1.6\times10^{-19}} = 5 \times 10^6.$$

Then the number of photoelectrons emitted per light pulse is

$$n' = n/10^6 = 5,$$

and hence the number of photons in one light pulse is

$$N = n'/0.1 = 50.$$

Q.2 When the intensity of a light source is increased,

(A) the number of photons emitted by the source in unit time increases

(B) the total energy of the photons emitted per unit time increases

(C) more energetic photons are emitted

(D) faster photons are emitted **[A,B]**

Q.3 Photoelectric effect supports quantum nature of light because -

(A) there is a minimum frequency below which no photoelectrons are emitted

(B) the maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity

(C) even when the metal surface is faintly illuminated the photoelectrons leave the surface immediately

(D) electric charge of the photoelectrons is quantized **[A,B,C]**

Q.4 If the wavelength of light in an experiment on photoelectric effect is doubled,

(A) the photoelectric emission will not take place

(B) the photoelectric emission may or may not take place

(C) the stopping potential will increase

(D) the stopping potential will decrease

[B,D]

Q.5 In which of the following situations the heavier of the two particles has smaller de Broglie wavelength ? The two particles

(A) move with the same speed

(B) move with the same linear momentum

(C) move with the same kinetic energy

(D) have fallen through the same height

[A,C,D]

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Q.6 When the intensity of a light source is increased

(A) The number of photons emitted by the source in unit time increases

(B) The total energy of the photons emitted per unit time increases

(C) more energetic photons are emitted

(D) faster photons are emitted **[A,B]**

Q.7 If the wavelength of light in an experiment on photoelectric effect is doubled -

(A) the photoelectric emission will not take place

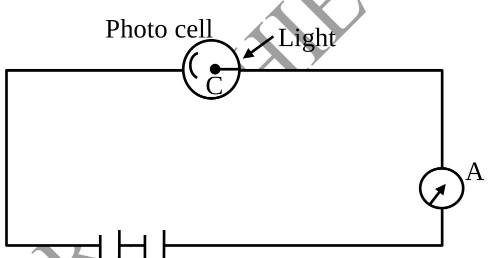
(B) the photoelectric emission may or may not take place

(C) the stopping potential will increase

(D) the stopping potential will decrease

[B,D]

Q.8 Fig. shows a photo cell is illuminated by a monochromatic light. If the intensity is kept constant and the frequency of the incident light is increased, then the –



(A) photo electric current in the circuit increases

(B) photo electric current in the circuit decreases

(C) maximum kinetic energy of the photo electrons increases

(D) photo electric current in the circuit can be reduced to zero, when the polarity of the terminals is reversed. **[C,D]**

Q.9 Which of the following phenomena can be explained only on the basis of quantum theory of light ? -

(A) Energy spectrum of black body radiation

(B) Atomic spectra

(C) Photoelectric effect

(D) Doppler effect **[A,B,C]**

Q.10 Light from a monochromatic source is incident normally on a small photo sensitive surface S having work function ϕ. If power of the source is W and a is the distance between the source and S, then -

(A) the number of photons striking the surface per unit time will be $\left(\frac{W\lambda S}{4\pi hca^2}\right)$

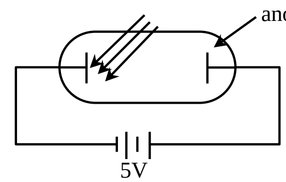
(B) the maximum energy of the emitted electrons will be $(hc - \lambda\phi)$

(C) the stopping potential needed to stop the most energetic photons will be $\frac{e}{\lambda}\ (hc - \lambda\phi)$

(D) photo emission occurs only if $0 \le \lambda \le hc / \phi$

[A,B,D]

Q.11 Photons of energy 4 eV are incident on cathode. Electrons reaching the anode have kinetic energies varying from 5.5 eV to 7eV.



(A) The work function of the metal is 1.5eV

(B) Work function of the metal is 2 eV

(C) Current in the circuit is less than saturation current

(D) Current in the circuit is equal to saturation current **[B,C]**

Sol. $7\,eV = K_{max} + 5eV, K_{max} = 2eV, \phi = 4eV - 2eV = 2\,eV$

Q.12 The threshold wavelength for photoelectric emission from a material is 5200 Å. Photoelectrons will be emitted when this material is illuminated with monochromatic radiation from a -

(A) 50 watt infrared lamp

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(B) 1 watt infra-red lamp

(C) 50 watt ultraviolet lamp

(D) 1 watt ultraviolet lamp **[C,D]**

Q.13 Radiations of monochromatic waves of wavelength 400 nm are made incident on the surface of metals Zn, Fe and Ni of work functions 3.4 eV, 4.8 eV and 5.9 eV respectively (take hc = 12400 eV-Å) :

(A) maximum KE associated with photoelectrons from the surface of any metal is 0.3 eV

(B) no photoelectrons are emitted from the surface of Ni

(C) if the wavelength of source of radiation is doubled then KE of photoelectrons is also doubled

(D) photoelectrons will be emitted from the surface of all the three metals if the wavelength of incident radiations is less than 200 nm

Sol. **[B,D]**

Energy of photon incident

$h\nu = \frac{12400}{4000}$ eV

$h\nu = 3.1$eV

$h\nu <$ work function of all metals

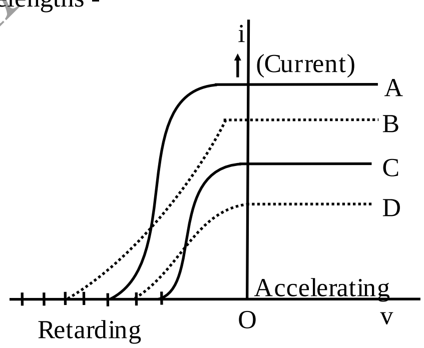
hence no electron will come out

if $\lambda = 200$nm

then $h\nu = \frac{12400}{2000} = 6.2$eV

6.2eV > work function of all metals, hence photoelectron will be emitted

Q.14 Fig. shows the results of an experiment involving photoelectric effect. The graphs A, B, C, D related the light beam having different wavelengths -



(A) Beam B has highest frequency

(B) Beam C has longest wavelength

(C) Beam A has the highest rate of photoelectric emission

(D) Photoelectrons ejected by beam B have the highest momentum **[A,B,C,D]**

Q.15 The maximum kinetic energy of photon electrons ejected from a photometer when it is irradiated with radiation of wavelength 400nm is 1 eV. If the threshold energy of surface is 1.9 eV -

(A) the maximum K.E. of photoelectrons when it is irradiated with 500 nm photon will be 0.42 eV

(B) the maximum K.E. in case (A) will be 1.725eV

(C) the longest wavelength which will eject photoelectrons is nearly 610 nm

(D) All of the above

Sol. **[A,C]**

$\frac{hc}{\lambda} = \phi + (K.E.)_{max}$

Q.16 In an experiment of photoelectric effect, light from a point source of monochromatic light of wavelength 3000 Å is incident on a metal surface. The kinetic energies of photoelectrons range from zero to 4.0×10^{-19} J, then –

(A) Stopping potential for this light is 2.5 V

(B) Threshold wavelength for the material is 7590Å

(C) Stopping potential will be doubled on reducing the distance and the wavelength of light source to half

(D) Saturation current will be doubled on reducing the distance of source to half

[A,B]

Sol. $K_{max} = 4 \times 10^{-19}$ J $= \frac{4\times10^{-19}}{1.6\times10^{-19}} = 2.5$ eV

$\Rightarrow$ Stopping potential = 2.5 eV

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

$2.5 = \frac{1240}{300} - \frac{1240}{\lambda_0}$

$\lambda_0 = 759$ nm

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Q.17 Light of wavelength 496 nm is incident on a metal surface causing ejection of photoelectrons for which stopping potential is 1.5 volt, then –

(A) The work function of the surface is 1 eV

(B) De Broglie wavelength of fastest photoelectron is 100 nm

(C) To move the fastest electron in a circle of radius 1m, perpendicular magnetic field B required is 4.1×10^{-6} Tesla

(D) This fastest electron if strikes zinc target can produce X-rays **[A, C]**

Sol. $K_{max} = 1.5$ eV

$$\lambda_{dB} = \frac{h}{\sqrt{2mK}}$$

$= 1$ nm

E of incident photon $= \frac{1241}{496} \simeq 2.5$ eV

$\phi = 2.5 - 1.5 = 1$ eV

$$qvB = \frac{mv^2}{r}$$

$$B = \frac{mv}{qr} = \sqrt{\frac{2mK_{max}}{qr}}$$

$$= \frac{\sqrt{2\times9.1\times10^{-31}\times e\times1.5}}{e\times1}$$

$$B = \sqrt{\frac{3\times9.1\times10^{-31}}{1.6\times10^{-19}}}$$

$= 4.13 \times 10^{-6}$ Tesla

X-rays are of order of 0.1 nm ≃ 12.4 KeV

Q.18 When a monochromatic point source of light is at a distance of 0.1 m from a photoelectric cell, the cut-off voltage and the saturation current are respectively 0.9 V and 90 mA. If the same source is placed 0.3 m away from the cell, then -

(A) The stopping potential will be 0.9 V

(B) The stopping potential will be 0.3 V

(C) The saturation current will be 30 mA

(D) The saturation current will be 10 mA

[A,D]

Sol. $d \to 3d$

$I \to \frac{I}{9}$

Stopping potential depends on frequency only.

Q.19 For a 75 W point light source assuming all the electric power consumed goes into emitted light of wavelength 600 nm -

(A) Frequency of the emitted light is 5.0×10^{14} Hz

(B) Number of photons emitted per second is 2.3×10^{20}

(C) When this emitted light falls on a metal surface of work function 1.07 eV, kinetic energy photoelectrons emitted range between 0 and 1 eV

(D) On doubling the distance of this metal surface from the point source maximum kinetic energy of photoelectrons emitted becomes 0.25 eV **[A,B,C]**

Sol. (A) $f = \frac{c}{\lambda} = \frac{3\times10^8}{600\times10^{-9}} = 5.0\times10^{-14}$

(B) $N = \frac{p}{hf}$

(C) $KE_{max} = \frac{1240}{600} - 1.07 = 1$

(D) KE_{max} depends upon frequency of incident photons and not distance of source.

Q.20 In an experiment of photoelectric effect, the frequency and intensity of a light source are both doubled, then –

(A) The saturation photocurrent remains almost the same

(B) The saturation photocurrent becomes doubled

(C) The maximum kinetic energy of the photoelectrons is doubled

(D) The stopping potential becomes more than double **[A,D]**

Sol. $f \to 2f \Rightarrow I \to 2I, \quad N \to N$

Number of photons emitted same

$$\frac{1}{2}mv^2 = eV_S = h(\nu - \nu_0)$$

$$h(2\nu - \nu_0) > h(\nu - \nu_0)$$

$\therefore \frac{1}{2}mv^2$ and eV_S becomes more than double.

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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]**

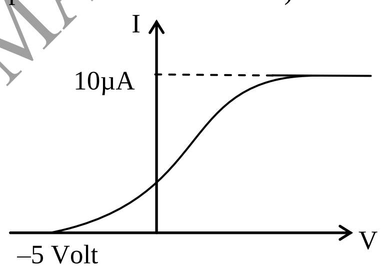
$eV_s = h\nu - W$

$= 12eV - 4eV$

$eV_s = 8eV$

$V_s = 8V$

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 1.7×10^{-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 (ϕ = 1.89eV) electrode is irradiated by radiation of wavelength λ = 2700 Å and a decelerating voltage V = 3V is applied. Then the magnitude of outer contact potential difference is $N \times 10^{-1}$ V, then the value of N is –

Sol.[3] Let ϕ' 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 8×10^{6} m/s, where ν_0 is threshold frequency of

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metal. If $\nu = 2\nu_0$ then the maximum velocity of photoelectron in 10^6 m/s will be -

Sol. **[4]**

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

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

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

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

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

Sol. **[5]**

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

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

solve (1) and (2) and find λ_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

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

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

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

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

$$= 3.8\times10^{-10}\text{m} = 3.8 \text{ Å}$$

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

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

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

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

The rate of emission of photon from source

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

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

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

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

$$KE_{max} = E - \phi$$

$$= 2.58 - 1.17$$

$$= 1.41 \text{ eV}$$

The maximum velocity of photo electrons ejected is gives as $\frac{1}{2} m\ V_{max}^2 = 1.41$ eV

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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.

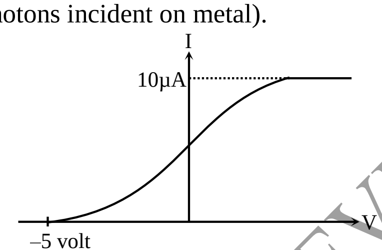
Q.10 If photons of ultraviolet light of energy 12eV are incident on a metal surface of work function of 4eV, then the stopping potential (in eV) will be

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] $eV_s = h\nu - W$

$5eV = h\nu - 2eV$

$h\nu = 7eV$

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

$n_e = n \times \beta\%$

$i = n_e.e$

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

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

$P = 7W$

Q. 12 Photoelectric threshold of silver is λ = 3800Å. Ultraviolet light of λ = 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 = 9.11×10^{-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, ϕ = 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) = 1.6×10^{-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.

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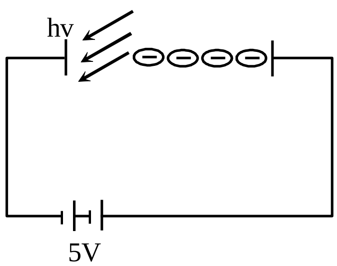
Sol. $h = 6.57 \times 10^{-34}$ Js

Q. 17 When a beam of 10.6 eV photon of intensity 2.0 Wm^{-2} falls on a platinum surface of area 1.0×10^{-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 = 1.6×10^{-19} J.

Sol. No. of photoelectrons emitted = 6.25×10^{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. ϕ = 2 eV, less than saturation current

Q.19 A small plate of metal (ϕ = 1.17 eV) is placed at a distance of 2m from a monochromatic light source of wavelength 4.8×10^{-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. 4.8×10^{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

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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 ν is incident on a certain photo electric substance with threshold frequency ν_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]**

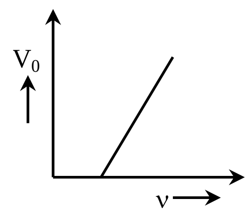
Q.6 When 24.8 KeV X-rays strike a material, the photoelectrons emitted from K shell are observed to move in a circle of radius 23 mm in a magnetic field of 2×10^{-2}T. The binding energy of K-shell electrons is –

(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 –

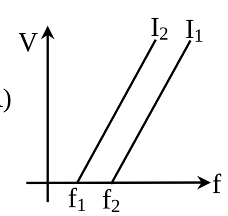
(A) 10^{19} (B) 10^{9}
(C) 10^{33} (D) 10^{25} **[A]**

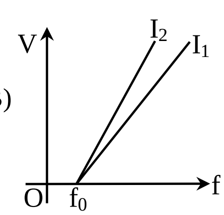
Q. 8 In photoelectric effect, the slope of straight line graph between stopping potential (V_0) and frequency of incident light (ν) gives :



(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)


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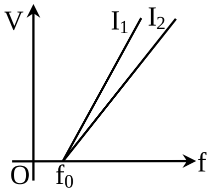
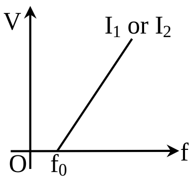
(C) 

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

$= \frac{13.6\times5}{36} = 1.89$ 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 = $KE_{max} = \frac{P^2}{2m}$

$= \frac{25\times10^{-50}}{2\times9.1\times10^{-31}\times1.6\times10^{-19}}$ 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 λ_1 and λ_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. $K_1 = \frac{hc}{\lambda_1} - \phi$

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

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

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

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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 ν falls on this metal. The photoelectric effect will take place only if -

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

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

Q.17 Light of wavelength λ falls on a metal having work function hc/λ_0. Photoelectric effect will take place only if -

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

(C) $\lambda \le \lambda_0$ (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 λ 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) 6.2×10^{20} (B) 3×10^{19}

(C) 1.5×10^{20} (D) 6×10^{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.

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(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 λ_A falls on plate A and λ_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) 10×10^{-19} Joule
(C) 4×10^{-19} Joule (D) None of these **[C]**

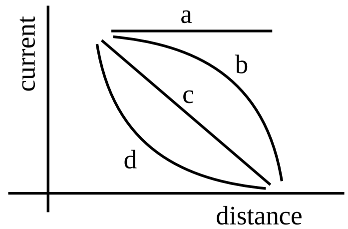
Sol. $\phi = \frac{hc}{\lambda_0}$

$\phi = \frac{20 \times 10^{-26}}{5000 \times 10^{-10}} = 4 \times 10^{-19}$ 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 ν_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 λ_e and λ_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 λ_e and λ_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]**

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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) hνc **[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 λ_1 and λ_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. $eV_1 = \frac{hc}{\lambda_1} - \phi$

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

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

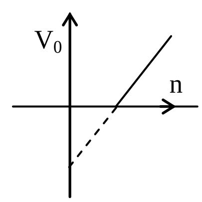
Q.37 The graph between the stopping potential V_0 and frequency (n) of incident photons for photocell is a straight line with a slope -

(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

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

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

4eV = 6.2eV – W

[W = 2.2 eV]

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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

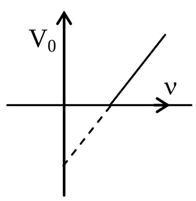
Q.40 The graph between the frequency of incident light and the stopping potential is a -

(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 λmax = 2.5 Å. Hence minimum energy is

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

$= \frac{12.40 \times 10^3 eV.A°}{2.5A°} = 5$ 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]**

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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_α 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. $\frac{1}{2} mv^2_{max} = h\nu - h\nu_o$

$= h(\nu - \nu_o)$

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

$E_{min} = h\boldsymbol{\nu}_{min} = \frac{hc}{\lambda_{max}}$

$= \frac{12.40\times10^3}{2.5\text{Å}}$ eV.Å

$= 4.96 \times 10^3$ eV

$= 5$ KeV

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

(A) 3×10^{18} kg/sec (B) 3×10^{19} kg/sec
(C) 3×10^{20} kg/sec (D) 3×10^{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

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Q.1 Visible light has wavelengths in the range of 400 nm to 780 nm. Calculate the range of energy of the photons of visible light.

Ans. 2.56×10^{-19} J to 5.00×10^{-19} J

Q.2 Calculate the momentum of a photon of light of wavelength 500 nm.

Ans. 1.33×10^{-27} kg-m/s

Q.3 Calculate the number of photons emitted per second by a 10 W sodium vapour lamp. Assume that 60% of the consumed energy is converted into light. Wavelength of sodium light = 590 nm.

Ans. 1.77×10^{19}

Q.4 Find the maximum kinetic energy of the photoelectrons ejected when light of wavelength 350 nm is incident on a cesium surface. Work function of cesium = 1.9 eV.

Ans. 1.6 eV

Q.5 The work function of a metal is 2.5×10^{-19}J. (a) Find the threshold frequency for photoelectric emission. (b) If the metal is exposed to a light beam of frequency 6.0×10^{-14} Hz, what will be the stopping potential ?

Ans. (a) 3.8×10^{14} Hz (b) 0.91 V

Q.6 The electric field at a point associated with a light wave is $E = (100 \text{ V/m}) \sin [(3.0 \times 10^{15} \text{ s}^{-1})t] \sin [(6.0 \times 10^{15} \text{ s}^{-1})t]$. If this light falls on a metal surface having a work function of 2.0 eV, what will be the maximum kinetic energy of the photoelectrons ?

Ans. 3.93 Ev

Q.7 In a photoelectric experiment, it was found that the stopping potential decreases from 1.85 V to 0.82 V as the wavelength of the incident light is varied from 300 nm to 400 nm. Calculate the value of the Planck constant from these data.

Ans. 4.12×10^{-15} eV-s

Q.8 Light described at a place by the equation

$$E = (100 \text{ V/m}) [\sin(5 \times 10^{15} \text{ s}^{-1})t + \sin (8 \times 10^{15} \text{ s}^{-1}) t]$$

falls on a metal surface having work function 2.0 eV. Calculate the maximum kinetic energy of the photoelectrons.

Ans. 3.27 eV

Q.9 The work function of a photoelectric material is 4.0 eV. (a) What is the threshold wavelength ? (b) Find the wavelength of light for which the stopping potential is 2.5 V.

Ans. (a) 310 nm (b) 190 nm

Q.10 Find the maximum magnitude of the linear momentum of a photoelectron emitted when light of wavelength 400 nm falls on a metal having work function 2.5 eV.

Ans. 4.2×10^{-25} kg-m/s

Q.11 When a metal plate is exposed to a monochromatic beam of light of wavelength 400 nm, a negative potential of 1.1 V is needed to stop the photocurrent. Find the threshold wavelength for the metal.

Ans. 620 nm

Q.12 The electric field associated with a light wave is given by

$$E = E_0 \sin [(1.57 \times 10^7 \text{ m}^{-1}) (x - ct)]$$

Find the stopping potential when this light is used in an experiment on photoelectric effect with the emitter having work function 1.9 eV.

Ans. 1.2 V

Q.13 Find the maximum kinetic energy of the photoelectrons ejected when light of wavelength 350 nm is incident on a cesium surface . Work function of cesium = 1.9 eV.

Ans. 1.6 eV

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Q.14 The work function of a photoelectric material is 4.0 eV. (a) what is the threshold wavelength ?
(b) Find the wavelength of light for which the stopping potential is 2.5 V.

Ans. 310 nm (b) 190 nm

Q.15 Find the maximum magnitude of the linear momentum of a photoelectron emitted when light of wavelength 400 nm falls on a metal having work function 2.5 eV.

Ans. 4.2×10^{-25} kg-m/s

Q.16 The work function of metal is 2.5×10^{-19} J.
(a) Find the threshold frequency for photoelectric emission (b) If the metal is exposed to a light beam of frequency 6.0×10^{14} Hz , what will be the stopping potential ?

Ans. (a) 3.8×10^{14}Hz, (b) 0.91 V

Q.17 The photo-electrons emitted from a metal for light of wavelengths 4.36×10^{-7} m and 5.46×10^{-7} m have speeds 6.51×10^{5} ms^{-1} and 4.74×10^{5} ms^{-1} respectively. Compute
(i) value of Planck's constant
(ii) work function of the metal
(iii) threshold wavelength λ_0.

Ans. (i) 6.53×10^{-34} J-s
(ii) Work- function = 2.57×10^{-19} J (iii) 7702 Å

Q.18 What will be the change in the stopping potential for photoelectrons emitted from a surface if the wavelength of the incident radiation is reduced from 4000 Å to 3600 Å ?

Ans. 0.34 V (increase)

Q.19 A photometer is illuminated by monochromatic light of unknown wavelength. It is known that no photo-electrons are emitted above a wavelength 5000 Å from the same metal. Find the unknown wavelength, if the stopping potential is found to be 3.1 volt.

Ans. 2222Å

Q.20 In a photoelectric experiment, the collector plate is at 2.0 V with respect to the emitter plate made of copper (ϕ = 4.5 eV). The emitter is illuminated by a source of monochromatic light of wavelength 200 nm. Find the minimum and maximum kinetic energy of the photoelectrons reaching the collector.

Ans. 2 eV & 3.71 eV

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