Dual Nature of Matter and Radiation Important Question With Answers

NEET Physics 2023

1. An electron is moving with an initial velocity $\vec{v} = v_0 \hat{i}$ (v_0 > 0) and is in a magnetic field $\vec{B} = B_0 \hat{j}$. Then it's de Broglie wavelength :

   a) remains constant   b) increases with time   c) decreases with time
   d) increases and decreases periodically

   Solution : -

   Here, $\vec{v} = v_0 \hat{i}$, $\vec{B} = B_0 \hat{j}$
   Force on moving electron due to magnetic field is
   $\vec{F} = -e\left(\vec{v} \times \vec{B}\right) = -e\left(v_0 \hat{i} \times B_0 \hat{j}\right) = -ev_0 B_0 \hat{k}$

   As this force is perpendicular to $\vec{v}$ and $\vec{B}$, so the magnitude of v will not change. i.e., momentum (= mv) will remain constant in magnitude.

   Therefore, de Broglie wavelength, $\lambda \left(= \frac{h}{mv}\right)$ remains constant.

2. When the energy of the incident radiation is increased by 20% the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is :

   a) 1.3 eV   b) 1.5 eV   c) 0.65 eV   **d) 1.0 eV**

   Solution : -
   0.5 = E - Φ
   0.8 = 1.2 E - Φ
   From above expressions, work function Φ = 1 eV

3. Which of the following statements is correct regarding the photoelectric experiment?

   a) The photo current increases with intensity of light

   b) Stopping potential increases with increase in intensity of incident light.

   c) The photocurrent increases with increase in frequency.   d) All of the these

   Solution : -
   The photo current increases linearly with intensity of the incident light, but is independent of its frequency. The stopping potential increases linearly with the frequency of the incident light, but is independent of its intensity.

4. The wavelength of matter wave is independent of

   a) mass   b) velocity   c) momentum   **d) charge**

5. Light of frequency 7.21×10^{14} Hz is incident on a metal surface. Electrons with a maximum speed of 6×10^5 m s^{-1} are ejected from the surface. The threshold frequency for photoemission of electrons is (Given h = 6.63×10^{-34}) Js, me = 9.1 x 10^{-31} kg)

   a) 2.32×10^{14} Hz   b) 2.32×10^{12} Hz   **c) 4.74×10^{14} Hz**   d) 4.74×10^{12} Hz

   Solution : -

Here, υ = 7.21 x 10^{14} Hz, m_e= 9.1 x 10^{-31}kg
h = 6.63 x 10^{-34} Js, v_{max}= 6 x 10^5 ms^{-1}
According to einstin's photoelectric equation
$\frac{1}{2}m_e v_{max}^2 = h\upsilon - h\upsilon_0 \; or \; \upsilon_0 = \upsilon - \frac{m_e v_{max}^2}{2h}$
$= 7.21 \times 10^{14} - \frac{(9.1\times10^{-31})\times(6\times10^5)^2}{2\times6.63\times10^{-34}}$
$= 7.21 \times 10^{14} - 2.47 \times 10^{14} = 4.74 \times 10^{14} Hz$

6. A and B are two metals with threshold frequencies 1.8 x 10^{14} Hz and 2.2 x 10^{14} Hz. Two identical photons of energy 0.825 eV each are incident on them. Then photoelectrons are emitted in (Take h = 6.6 X 10^{-34} J s)
   a) B alone **b) A alone** c) neither A nor B d) both A and B

   Solution : -
   $\phi_{0A} = \frac{h\upsilon_0}{e} eV = \frac{(66.\times10^{-34})\times(1.8\times10^{14})}{1.6\times10^{-19}} = eV$
   $= 0.74 eV$
   $\phi_{0B} = \frac{(66.\times10^{-34})\times(2.2\times10^{14})}{1.6\times10^{-19}} eV = 0.91 eV$
   Since the incident energy 0.825 eV is greater than 0.74 eV and less than 0.91 eV, so photoelectrons are emitted from metal A only.

7. A 100 W sodium lamp radiates energy uniformly in all directions. The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it. The wavelength of the sodium light is 589 nm. The number of photons delivered per second to the sphere is :
   a) 3 x 10^{15} b) 3 x 10^{10} **c) 3 x 10^{20}** d) 3 x 10^{19}

   Solution : -
   Here, λ = 589 x 10^{-9} m, h = 6.63 x 10^{-34} J s
   p = 100 W
   Energy of a photon,
   E = $\frac{hc}{\lambda}$ = $\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{589 \times 10^{-9}}$ = 3.38 x 10^{-19} J s
   Number of photons delivered per second
   n = $\frac{P}{E}$ = $\frac{100}{3.38 \times 10^{-19}}$ = 3 x 10^{20}

8. Assertion: If the frequency of the incident light on a metal surface is doubled, the kinetic energy of emitted electrons is more than doubled.
   Reason : The metal will provide additional energy to the emitted photoelectron for light of higher frequency than that for lower frequency.
   a) If both assertion and reason are true and reason is the correct explanation of assertion
   b) If both assertion and reason are true but reason is not the correct explanation of assertion.
   c) If assertion is true but reason is false. d) If both assertion and reason are false.

9. The phenomenon of photoelectric emission was discovered in 1887 by
   a) Wilhelm Hallwachs b) Philipp Lenard c) Albert Einstein **d) Heinrich Hertz**

   Solution : -
   The phenomenon of photoelectric emission was discovered by Heinrich Hertz in 1887.

10. An ionization chamber with parallel conducting plates as anode and cathode has 5 $\times$ 10^7 electrons and the same number of single charge positive ions per cm^3. The electrons are moving towards the anode with velocity 0.4 m/s. The current density from anode to cathode is 4 mA/ m^2. The velocity of positive ions moving towards cathode is ____________

a) 0.4m/s b) 1.6m/s c) 0 **d) 0.1m/s**

Solution : -

Total current is due to electrons and positively charged ions.

So, current $I_{net} = I_e + I_p$

Also, current $I_{net} = neAv_d$

where, v_d is drift velocity, A is area ofcross-section, n the number density of ions.

Given,

$n = 5 \times 10^7/\text{cm}^3 = 5 \times 10^{13}/\text{m}^3$

$v_e = 0.4\ \text{m/s}$

Electron current

$I_e = 5 \times 10^{13} \times 1.6 \times 10^{-19} \times A \times 0.4$

$I = I_e + I_p$

$= 5 \times 10^{13} \times 1.6 \times 10^{-19} \times A(v + 0.4)$

$1,4 \times 10^{-6} \times A = 5 \times 10^{-6} \times 1.6 \times A(v + 0.4)$

$0.5 = v + 0.4$

$v = 0.1\ \text{ms}$

11. When the photons of energy $h\upsilon$ fall on a photosensitive metallic surface of work function huo, electrons are emitted from the surface. The most energetic electron coming out of the surface have kinetic energy equal to

a) $h\upsilon$ b) $h\upsilon_0$ c) $h\upsilon + h\upsilon_0$ **d) $h\upsilon - h\upsilon_0$**

Solution : -

Maximum kinetic energy of emitted photoelectrons $= h\upsilon - h\upsilon_0$

12. In a discharge tube ionization of enclosed gas is produced due to collisions between __________

a) negative electrons and neutral atoms/molecules b) photons and neutral atorns /molecules

c) neutral gas atoms/molecules d) positive ions and neutral atoms/molecules

Solution : -

As the eleotrons emitted from cathode collide with gas molecules or atoms, they knock out outer electrons and produce positively charged ions. They becomes part of positive rays.

13. Frequency of photon having energy 66 eV is :

a) 8×10^{-15} Hz b) 12×10^{-15} Hz **c) 16×10^{15} Hz** d) None of these

Solution : -

Now E = hv or v = E/h

$= 66 \times 1.6 \times 10^{-19}/6.6 \times 10^{-34} = 16 \times 10^{15}$ Hz

14. A metallic surface is irradiated by a monochromatic light of frequency υ_1 and stopping potential is found to be v_1 If the light of frequency υ_2 irradiates the surface, the stopping potential will be

a) $V_1 + \frac{h}{e}(\upsilon_1 + \upsilon_2)$ **b)** $V_1 + \frac{h}{e}(\upsilon_2 - \upsilon_1)$ c) $V_1 + \frac{e}{h}(\upsilon_2 + \upsilon_1)$ d) $V_1 - \frac{h}{e}(\upsilon_1 + \upsilon_2)$

Solution : -

Maximum Kinetic energy

$K_{max} = \frac{1}{2}mv^2 = eV_0$

where V_0 is the stopping potential.

According to Einstein's photoelectric equation

$h\upsilon_1 = \phi_0 + eV_1 \qquad ....(i)$

$h\upsilon_2 = \phi_0 + eV_2 \qquad (ii)$

$h(\upsilon_1 - \upsilon_2) = e(V_1 - V_2)$

$\frac{h}{e}(\upsilon_1 - \upsilon_2) = V_1 - V_2 \quad or \quad V_2 = V_1 + \frac{h}{e}(\upsilon_2 - \upsilon_1)$

15. A particle is moving three times as fast as an electron. The ratio of the de Broglie wavelength of the particle to that of the electron is 1.813 x 10^{-4}. The mass of the particle is (m_e = 9.1 x 10^{-31} kg)

a) 1.67 x 10^{-14} kg **b) 1.67 x 10^{-27} kg** c) 1.67 x 10^{-31} kg d) 1.67 x 10^{-19} kg

Solution : -

de Broglie wavelength of a moving having mass m and velocity v is given by

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

For an electron $\lambda_e = \frac{h}{m_e v_e}$ or $m_e = \frac{h}{\lambda_e v_e}$

Given: $\frac{v}{v_e} = 3$ and $\frac{\lambda}{\lambda_e} = 1.813 \times 10^{-4}$

Mass of the particle, m = $m_e \left(\frac{\lambda_e}{\lambda}\right)\left(\frac{v_e}{v}\right)$

Substituting the values, we get

$$m = 9.1 \times 10^{-31} \times \frac{1}{1.813 \times 10^{-4}} \times \frac{1}{3}$$

or m = 1.67 x 10^{-27} kg

16. 'n' photons of wavelength 'λ' are absorbed by a black body of mass 'm'. The momentum gained by the body is :

a) $\frac{h}{m\lambda}$ b) $\frac{mnh}{\lambda}$ c) $\frac{nh}{m\lambda}$ **d) $\frac{nh}{\lambda}$**

Solution : -

Energy of n photons, E = $\frac{nhc}{\lambda}$

Momentum gained by the body, p = $\frac{E}{c} = \frac{nhc}{\lambda c} = \frac{nh}{\lambda}$

17. In the question number 48, the energy of photon in eV at the red end of the visible spectrum is

a) 6.63 b) 3.62 c) 7.61 **d) 1.64**

Solution : -

For red light, λ=760 nm

E=$\frac{6.63\times10^{-34}\times3\times10^{8}}{760\times10^{-9}} J$

$= 2.62 \times 10^{-19} J = \frac{2.62\times10^{-19}}{1.6\times10^{-19}} eV = 1.64 eV$

18. When a beam of 10.6 eV photons of intensity 2.0 W/m^2 falls on a platinum surface of area 1.0 x 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 :

a) 6.25 x 10^8 b) 1.25 x 10^9 c) 1.25 x 10^6 **d) 6.25 x 10^{11}**

Solution : -

Incident energy E = 10.6 eV = 10.6 x (l.6 x 10^{-19}) J = 16.96 x 10^{-19}J

Given: $\frac{Energy \quad incident}{area \times time}$ = 2W/m^2

$$\therefore \frac{Number \quad of incident photons}{area \times time} = \frac{2}{16.96 \times 10^{-19}}$$ = 1.18 x 10^{18}

$\therefore \frac{Incident photons}{time}$ =(1.18 x 10^8)x area

= $1.18 \times 10^{18} \times (1.0 \times 10^{-4}) = 1.18 \times 10^{14}$

$\therefore \frac{Number \quad of \quad photoelectrons}{time} = \left(\frac{0.53}{100}\right)$ x (1.18×10^{14})

or n = 6.25×10^{11}

19. An electron of mass m when accelerated through a potential difference V has de-Broglie wavelength λ The de Broglie wavelength associated with a proton of mass M accelerated through the same potential difference will be :

a) λm/M **b) $\lambda\sqrt{m/M}$** c) λM/m d) $\lambda\sqrt{M/m}$

Solution : -

Now wavelength, λ = h/$\sqrt{2mE}$

As λ α 1$\sqrt{m}$ as potential E is same. So, λ' = $\lambda\sqrt{\frac{m}{M}}$

20. Cathode rays were discovered by

a) Maxwell Clerk James b) Heinrich Hertz **c) William Crookes** d) J.Thomson

21. Light of wavelengths λ falls on a metal having work function Photoelectric effect will take place only

a) $\lambda \geq \lambda_0$ **b) $\lambda \leq \lambda_0$** c) $\lambda \geq 2\lambda_0$ d) $\lambda = 4\lambda_0$

Solution : -

As kinetic energy K=$\frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

K is positive, therefore photoelectric emission will take place if $\frac{hc}{\lambda} \geq \frac{hc}{\lambda_0} \quad or \quad \lambda \leq \lambda_0$

22. Assertion: Free electrons inside a metal are free to move out of the metal.

Reason : Free electrons inside conductor do not need additional energy to get out of the metal.

a) If both assertion and reason are true and reason is the correct explanation of assertion

b) If both assertion and reason are true but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false. **d) If both assertion and reason are false.**

Solution : -

Free electrons in a metal are free to move inside the metal in a constant potential. They are not free to move out of the metal. They need additional energy to get out of the metal.

23. Which phenomenon best supports the theory that matter has a wave nature?

a) Electron momentum **b) Electron diffraction** c) Photon momentum d) Photon diffraction

Solution : -

Matter has a wave nature is best supported by the phenomenon of electron diffraction.

24. A particle of mass 4 m at rest decays into two particles of masses m and 3m having non-zero velocities. The ratio of the de Broglie wavelengths of the particles 1 and 2 is :

a) $\frac{1}{2}$ b) $\frac{1}{4}$ c) 2 **d) 1**

Solution : -

According to law of conservation of linear momentum, two particles will have equal and opposite momentum.

The de Broglie wavelength is given by $\lambda = \frac{h}{p} \therefore \frac{\lambda_1}{\lambda_2}$ = 1

25. Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is :

a) 1 : 2 b) 1 : 1 c) 1 : 5 d) 1 : 4

Solution : -

Since, $\frac{1}{2}mv^2_{max} = hv - \phi_0$

So, $\frac{1}{2}mv^2_{max_1}$ = 1 eV - 0.5 eV = 0.5 eV ...(i)

and $\frac{1}{2}mv^2_{max_2}$ = 2.5 eV - 0.5 eV = 2 eV ...(ii)

From equation (i) and (ii), we have

$\frac{v_{max_1}}{v_{max_2}} = \sqrt{\frac{0.5}{2.0}} = \frac{1}{2}$

26. Which of these particles having the same kinetic energy has the largest de Broglie wavelength?

a) Electron b) Alpha particle c) Proton d) Neutron

Solution : -

As, $\lambda = \frac{h}{\sqrt{2mK}}$ so $\lambda \alpha \frac{1}{\sqrt{m}}$

Out of the given particles m is least for electron, therefore electron has the largest value of de Broglie wavelength.

27. Assertion: Photosensitivity of a metal is high if its work function is small.

Reason : Work function = $h\upsilon_0$ where υ_0 is the threshold frequency

a) If both assertion and reason are true and reason is the correct explanation of assertion

b) If both assertion and reason are true but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false. d) If both assertion and reason are false.

Solution : -

Work function is the minimum energy required to eject the photoelectron from photosensitive metal. Hence for metal to be photosensitive, the work function should be small.

28. Monochromatic light of frequency 6.0 $\times$ 10^{14} Hz is produced by a traser. The power emitted is 2 $\times$ 10^{14} w. The number of photons emitted, on the average by the sources per second is ___________.

a) 5 $\times$ 10^{16} b) 5 $\times$ 10^{17} c) 5 $\times$ 10^{14} **d) 5 $\times$ 10^{15}**

Solution : -

$\Rightarrow n = \frac{p}{hv} = \frac{2\times10^{-3}}{6.6\times10^{-34}\times6\times10^{14}}$

$= 5 \times 10^{15}$

29. The momentum of a photon of energy 1 MeV in kg m/s, will be _____________ .

a) 7 $\times$ 10^{-24} b) 10^{-22} **c) 5 $\times$ 10^{-22}** d) 0.33 $\times$ 10^{6}

Solution : -

$= \frac{E}{c} = \frac{1.6\times10^{-13}}{3\times10^{8}}$

$= \frac{1.6}{3} \times 10^{-21} = \frac{16}{3} \times 10^{-22}$

$= 5 \times 10^{-22}$ kg m/sec

30. An electron of mass m and charge e is acclerated from rest through a potential difference of V volt in vacuum. Its final speed will be ____________

a) $\frac{eV}{2m}$ b) $\frac{eV}{m}$ **c)** $\sqrt{\frac{2eV}{m}}$ d) $\sqrt{\frac{eV}{2m}}$

Solution : -

In J J Thomson's method, as the electron beam is accelerated liom cathode to anode, its potential energy at the cathode appears as gain in kinetic energy at the anode. If Z is the potential difference between cathode and anode, then potential energy ofelectron at cathode

= charge $\times$ potential difference = eV

Gain in kinetic energy of electron at anode

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

According to conservation of energy, we have

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

$v = \sqrt{\left(\frac{2\mathrm{eV}}{m}\right)}$

31. Which of the following devices is sometimes called an electric eye?
    a) LED **b) Photocell** c) Integrated chip (IC) d) Solar cell

32. Ihe de Broglie wavelength associated with a ball of mass 150 g travelling at 30 m s^{-1} is :
    a) 1.47 x 10^{-34}m b) 1.47 x 10^{-16}m c) 1.47 x 10^{-19}m d) 1.47 x 10^{-31}m

    Solution : -
    Mass of the ball, m = 150 g = 0.15 kg,
    Speed of the ball, v = 30 m s^{-1}
    Momentum, P = mv = 0.15 x 30 = 4.5 kg m s^{-1}
    de Broglie wavelength, $\lambda = \frac{h}{p}\ \frac{6.63 \times 10^{-34}}{4.5}$ = 1.47 x 10^{-34}m

33. A photon of energy E ejects a photoelectron from a metal surface whose work function is Φ_0. If this electron enters into a uniform magnetic field B in a direction perpendicular to the field and describes a circular path of radius r, then the radius r is (in the usual notation)
    a) $\sqrt{\frac{2m(E-\phi_0)}{eB}}$ b) $\sqrt{2m(E-\phi_0)eB}$ c) $\sqrt{\frac{2m(E-\phi_0)}{mB}}$ **d)** $\sqrt{\frac{2m(E-\phi_0)}{eB}}$

    Solution : -
    As the electron describe a circular path of radius r in the magnetic field, therefore

    $\frac{mv^2}{r} evB$

    $r = \frac{mv}{eB} = \frac{p}{eB} = \frac{\sqrt{2mK}}{eB} \qquad \left(As K = \frac{p^2}{2m}\right)$

    From Einstein's photoelectric equation

    $K = E - \phi_0 \quad \therefore \quad r = \frac{\sqrt{2m(E-\phi_0}}{eB}$

34. The wavelength associated with an electron, accelerated through a potential difference of 100V is ofthe order of _________ .
    a) 1000 b) 100 c) 10.5 **d) 1.2**

35. Photons absorbed in matter are converted to heat. A source emitting n photons per second of frequency Uis used to convert 1 kg of ice at 0°C to water at O°c. Then, the time T taken for the conversion
    a) decreases with increasing n, with υ fixed. b) decreases with n fixed, υ increasing
    c) remains constant with nand υ changing such that -nυ = constant **d) All of these**

    Solution : -
    Energy spent to convert ice into water
    = mL = (1000 g) x 80 calg^{-1} = 80000 cal
    Energy of photons used = nT x E = nT x h υ

    $\therefore \quad nThv = mL \quad or \quad T = \frac{mL}{mhv}$

    $\therefore T \propto$ 1/n

36. Which of the following statements about photon is incorrect?
    a) Photons exert no pressure b) Momentum of photon is $\frac{hv}{c}$ c) Rest mass of photon is zero.
    d) Energy of photon is hυ

    Solution : -

In a photon-particle collision, (such as photon electron collision), the total energy and total momentum are conserved. However, the number of photons may not be conserved in photon-particle collision. The photon may be absorbed or a new photon may be created.

37. An electron of mass m with an initial velocity v = v_0i(v_0 > 0) enters in electric field E = - E_0î (E0 = constant > 0). If λ_0 is its de-Broglie wavelength initially, then its de Broglie wavelength at time t is :

a) λ_0 /[1 + (eE_0/mv_0) x t] b) λ_0[1 + (eE_0/mv_0) x t] c) λ_0t d) λ_0

Solution : -

Initial velocity v = v_0 î

Electric field E = - E_0î

Now force due to electric field on electrons,

$\vec{F}$ = - e x - E_0î = eE_0î

Acceleration in electrons, a = $\vec{F}$/m = E_0î/m

Velocity will be | vt | = v_o + eE_0t/m

Hence wavelength, λ = h/mv_t

= h/mv_o[1 + eE_0t/mv_o] = λ_0/[1+ eE_0t/mv_o]

38. A proton, a neutron, an electron and an α-particle have same energy. Then their de Broglie wavelengths compare as

a) $\lambda_p=\lambda_n>\lambda_e>\lambda_\alpha$ **b)** $\lambda_\alpha<\lambda_p=\lambda_n<\lambda_e$ c) $\lambda_e<\lambda_p=\lambda_n>\lambda_\alpha$ d) $\lambda_e=\lambda_p=\lambda_n=\lambda_\alpha$

Solution : -

Kinetic energy of particle, K =$\frac{1}{2}$ mv^2

or mv= $\sqrt{2mK}$

de Broglie wavelength, λ =$=\frac{h}{mv}=\frac{h}{\sqrt{2mK}}$

For the given value of K, $\lambda\alpha\frac{1}{\sqrt{m}}$

$\therefore \lambda_p=\lambda_n>\lambda_e>\lambda_\alpha$ = $\frac{1}{\sqrt{m_p}}:\frac{1}{\sqrt{m_n}}:\frac{1}{\sqrt{m_e}}:\frac{1}{\sqrt{m_\alpha}}$

Since $m_p=m_n$, hence $\lambda_p=\lambda_n$

As m_α > m_p, therefore λ_α <λ_p

As $m_e<m_n$ therefore $\lambda_n=\lambda_e$

Hence $\lambda_\alpha<\lambda_p=\lambda_n<\lambda_e$

39. In question number 5, find the kinetic energy of the most energetic photoelectron emitted at t = 10 s when it reaches plate B.

(Neglect the time taken by the photoelectron to reach plate B)

a) 23 eV b) 30 eV c) 15 eV d) 20 eV

Solution : -

Charge on A, Q_A = (5 X 10^7 x 1.6 x 10^{-19}) = 8 x 10^{-12}

Charge on B, Q_B = (33.7 - 8) x 10^{-12} C = 25.7 X 10^{-12} C

$\therefore$ E=$\frac{\sigma_B}{2\epsilon_0}-\frac{\sigma_A}{2\epsilon_0}$ or E$=\frac{1}{2A\epsilon_0}(Q_B-Q_A)$

or E=$=\frac{17.7\times10^{-12}}{2\times\left(5\times10^{-4}\right)\times\left(8.85\times10^{-12}\right)}$

or E = 2000 N/C

Energy of photoelectrons on plate B

Energy = E - W = (5 - 2) eV = 3 eV
Increase in energy = (Ed) eV = $(2 \times 10^3)(10^{-2})$ eV = 20 eV
∴Energy of photoelectrons on plate
B = (20 + 3) eV= 23 eV

40. Kinetic energy of an electron which is accelerated in a potential difference of 100 V is ____________
a) 1.6×10^{-17} J b) 1.6×10^{-19} J c) 1.6×10^{-21} J d) 1.6×10^{-25} J

Solution : -
When electrons are acceleated through V volt, the gain in KE of the electron is given by
$\mathrm{KE} = \frac{1}{2}mv^2 = eV$
$V = 100V$
$\mathrm{KE} = \left(1.6 \times 10^{-19}\right) \times 100 = 1.6 \times 10^{-17}$ J

41. If alpha particle, proton and electron move with the same momentum, then their respective de Broglie wavelengths $\lambda_\alpha, \lambda_p, \lambda_e$ are related as
a) $\lambda_\alpha = \lambda_p = \lambda_e$ b) $\lambda_\alpha < \lambda_p < \lambda_e$ c) $\lambda_\alpha > \lambda_p > \lambda_e$ d) $\lambda_p > \lambda_e > \lambda_\alpha$

Solution : -
de Broglie wavelength, $\lambda = \dfrac{h}{P}$
where symbols have their usual meaning
$\because P_\alpha = P_p = P_e \quad \therefore \lambda_\alpha = \lambda_p = \lambda_e$

42. Assertion: Aphotocell is a technological application of the photoelectric effect.
Reason : Photocell is a device whose electric properties are affected by electricity.
a) If both assertion and reason are true and reason is the correct explanation of assertion
b) If both assertion and reason are true but reason is not the correct explanation of assertion.
c) If assertion is true but reason is false. d) If both assertion and reason are false.

Solution : -
Photocell is a device whose electric properties are affected by light.

43. There are two sources of light, each emitting with a power of 100 W One emits X-rays of wavelength 1 nm and the other visible light of 500 nm. The ratio of number of photons of X-rays to the photons of visible light of the given wavelength is
a) 1: 500 b) 1: 400 c) 1: 300 d) 1: 200

Solution : -
Here, P = 100 W, λ_1 = 1 nm, λ_2= 500 nm
Let n_1 and n_2 be the number of photons of X-rays and visible light emitted from the two sources.∵
$\therefore n_1 \frac{hc}{\lambda_1} = n_2 \frac{hc}{\lambda_2} \quad or \quad \frac{n_1}{\lambda_1} = \frac{n_2}{\lambda_2} \quad or \quad \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{1}{500}$

44. Assertion: Photoelectric effect is the phenomenon of emission of photon by metal when illuminated by light of suitable frequency.
Reason: An electron beam carries sufficient energy to release photons from the metal
a) If both assertion and reason are true and reason is the correct explanation of assertion
b) If both assertion and reason are true but reason is not the correct explanation of assertion.
c) If assertion is true but reason is false. **d) If both assertion and reason are false.**

Solution : -
Photoelectric effect is the phenomenon of emission of electrons by metal when illuminated by light of suitable frequency.

45. A 5 watt source emits monochromatic light of wavelength 5000 A. When placed 0.5 m away, it liberates photoelectrons from a photosensitive metallic surface. When the source is moved to a distance of 1.0 m, the number of photoelectrons liberated will be reduced by a factor of __________

a) 4 b) 16 c) 2 d) 14

Solution : -

Number of emitted electrons NE

$\propto intensity$

$\propto \frac{1}{(\text{ Distance })^2}$

When distance is doubled,N_E decrease by l/4 times.

46. The energy flux of sunlight reaching the surface of the earth is 1.388 x 10^3W m^2. The photons in the sunlight have an average wavelength of 550 nm. How many photons per square metre are incident on the earth per second?

a) 4 x 10^{21} b) 4 x 10^{34} c) 4 x 10^{31} d) 4 x 10^{28}

Solution : -

Here, I = 1.388 x 10^3 Wm^{-2}

λ = 550 x 10^{-9} m, h = 6.63 x 10^{-34} Js

Number of photons incident on earth's surface per second per square metre is

$n = \frac{1}{E} = \frac{I\lambda}{hc} \qquad \left(\because E = \frac{hc}{\lambda}\right)$

$= \frac{1.388 \times 10^3 \times 550 \times 10^{-9}}{6.63 \times 10^{-34} \times 3 \times 10^8} = 4 \times 10^{21}$

47. When the light of frequency $2v_0$ (where v_0 is threshold frequency), is incident on a metal plate, the maximum velocity of electrons emitted is v_1. When the frequency of the incident radiation is increased to $5v_0$, the maximum velocity of electrons emitted from the same plate is v_2. The ratio of v_1 to v_2 is :

a) 1 : 2 b) 1 : 4 c) 4 : 1 d) 2 : 1

Solution : -

From Einstein's equation

$\frac{1}{2}mv_1^2$ = $2hv_0$ - hv_0 = hv_0

Again, $\frac{1}{2}mv_2^2$ = $5hv_0$ - hv_0 = $4hv_0$

So, $\frac{v_1}{v_2}$=$\sqrt{\frac{1}{4}}$ = $\frac{1}{2}$

48. The de Broglie wavelength of an electron in a metal at 27°e is

(Given m_e = 9.1 x 10^{-31} kg, k_B = 1.38 x 10^{-23} J K^{-1})

a) 6.2 x 10^{-9} m b) 6.2 x 10^{-10} m c) 6.2 x 10^{-8} m d) 6.2 x 10^{-7} m

Solution : -

Here, T= 27 + 273 = 300 K

For an electron in a metal, momentum de Broglie wavelength of an electron is p = $\sqrt{3mK_BT}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{3mK_BT}}$

$\frac{h}{\sqrt{3 \times (9.1 \times 10^{-31}) \times (1.38 \times 10^{-23}) \times 300}}$

= 6.2 x 10^{-9} m

49. A metal surface ejects electrons when hit by green light but none when hit by yellow light. The electrons will be ejected when the surface is hit by

a) blue light b) heat rays c) infrared light d) red light

Solution : -

The photoelectric emission is possible if the wavelength of the incident light is less than that of yellow light.

50. Wavelength of a 1 keV photon is 1.24×10^{-9} m. What is the frequency of 1 MeV photon?

a) 1.24×10^{15} Hz **b) 2.4×10^{20} Hz** c) 1.24×10^{18} Hz d) 2.4×10^{23} Hz

Solution : -

Now $E = h\nu$, so $\nu = E/h$

$= 1 \times 10^{6} \times 1.6 \times 10^{-19}/6.6 \times 10^{-34}$

$= 2.4 \times 10^{20}$ Hz