Solution

CET25P11 DUAL NATURE OF RADIATION AND MATTER

Class 12 - Physics

1.

(d) K + $h\nu$

Explanation: When photons of energy $h\nu$ are incident, the maximum kinetic energy of photoelectrons is
$K = h\nu - h\nu_0$
When frequency of incident radiation is doubled,
K' = h $\times$ $2\nu - h\nu_0$
$= h\nu + (h\nu - h\nu_0) = h\nu + K$

2.

(d) 6.0 $\times$ 10^{-20} J

Explanation: 6.0 $\times$ 10^{-20} J

3.

(b) decrease by 2 times

Explanation: $\lambda \propto \frac{1}{\sqrt{V}}$
$\therefore \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{V_1}{V_2}} = \sqrt{\frac{25}{100}} = \frac{1}{2}$ or $\lambda_2 = \frac{\lambda_1}{2}$

4. **(a)** energy spread with an upper limit

Explanation: The photo electrons coming out of the cathode have an energy spread with an upper limit.

5.

(b) zero

Explanation: zero

6.

(c) $\geq$ 2.8 $\times$ 10^{-9} m

Explanation: Energy of photon,
$E = \frac{hc}{\lambda} = \frac{1240}{500}\text{eV}$ = 2.48 eV
K_{max} = E - W = 2.48 - 2.28 = 0.2 eV
$\lambda_{\min}(\text{ electron }) = \frac{12.27}{\sqrt{K_{\max}(\text{eV})}} \overset{\circ}{\text{A}}$
$= \frac{12.27}{\sqrt{0.2}} \overset{\circ}{\text{A}}$ = 27.436 $\overset{\circ}{\text{A}}$ $\simeq$ 2.74 $\times$ 10^{-9} m
Hence, $\lambda \geq$ 2.8 $\times$ 10^{-9} m

7.

(c) increase

Explanation: increase

8.

(c) $\frac{6}{5}$

Explanation: $\lambda \propto \frac{1}{\sqrt{V}}$
$\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\left(\frac{V_2}{V_1}\right)} = \frac{6}{5}$

9.

(c) 2.0 eV

Explanation: 2.0 eV

10.

(d) 1.81 eV

Explanation: $E = h\nu = \frac{hc}{\lambda} = \frac{12400\text{eV}\overset{\circ}{\text{A}}}{8840\overset{\circ}{\text{A}}}$ = 1.81 eV

11.

(d) 0.267×10^{20}

Explanation: The energy of a photon,

$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{590 \times 10^{-9}}$ J $= \frac{663 \times 3}{59} \times 10^{-20}$ J

Light energy emitted per second by 10 W bulb

$= \frac{90}{100} \times 10$ = 9 J

Number of photons emitted per second

$= \frac{9 \times 59 \times 10^{20}}{663 \times 3}$ = 0.267×10^{20}

12.

(c) momentum

Explanation: As both electron and photon have the same de-Broglie wavelength ($\lambda = \frac{h}{p}$), so they have the same momentum p.

13.

(d) 2854 $\overset{0}{A}$

Explanation: $\phi = \frac{hc}{\lambda_o}$, Work function of sodium is = 2.3eV and Work function of tungsten is = 4.4eV

Hence, threshold wavelength is inversely proportional to work function. $\frac{\phi_{(tungsten)}}{\phi_{(sodium)}} = \frac{\lambda_{(sodium)}}{\lambda_{(tungsten)}}$

Therefore, $\lambda_{(tungsten)} = \frac{\phi_{(sodium)}}{\phi_{(tungsten)}} \times \lambda_{(sodium)}$ = 5460 × ($\frac{2.3}{4.4}$) = 2854$\overset{o}{A}$

14.

(d) 1.5×10^{20}

Explanation: A 200 W lamp supplies 200 J of energy per second.

$\therefore n \times \frac{hc}{\lambda} = \frac{25}{100} \times 200$ J

or $n = \frac{50\lambda}{hc} = \frac{50 \times 0.6 \times 10^{-6}}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$

$= \frac{50}{33} \times 10^{20} \simeq 1.5 \times 10^{20}$

15.

(c) 1 : 1

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

Since their wavelengths are equal, their momentum are also equal.

16. **(a)** Option iv

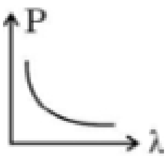
Explanation: The maximum kinetic energy of the photoelectrons is directly proportional to the frequency and it is independent of the intensity of the incident radiation.

17.

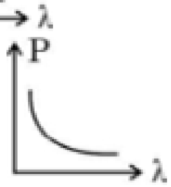
(c) 3 : 4

Explanation: $\frac{E_1}{E_2} = \frac{h\left(\frac{\nu - 3\nu}{4}\right)}{h\left(\frac{\nu - 2\nu}{3}\right)} = \frac{3}{4}$

18. **(a)**



Explanation:



As wavelength is inversely proportional to momentum.

19.

(d) 3.2×10^{-19} J

Explanation: $K_{max} = h\nu - W_0$ = 6.2 eV - 4.2 eV

= 2.0 eV = 2.0 × 1.6 × 10^{-19} J

= 3.2 × 10^{-19} J

20.

(c) 4.98×10^{19} joules

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

$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1}$

$\frac{3.32\times10^{19}}{E_2} = \frac{4000}{6000}$

$E_2 = \frac{6\times3.32\times10^{19}}{4} = 4.98 \times 10^{19} J$

21.

(d) $\frac{nhc}{\lambda}$

Explanation: $E = nhv = \frac{nhc}{\lambda}$

22. **(a)** 8 × 10^6 m/s

Explanation: When photons of energy $2h\nu_0$ are incident, the maximum velocity v of photoelectrons is given by

$\frac{1}{2}mv^2 = 2h\nu_0 - W_0 = 2h\nu_0 - h\nu_0$

or $\frac{1}{2}mv^2 = h\nu_0$

When photons of energy $5h\nu_0$ are incident,

$\frac{1}{2}mv'^2 = 5h\nu_0 - h\nu_0 = 4h\nu_0$

or $\frac{1}{2}mv'^2 = 4 \times \frac{1}{2}mv^2$

or $v' = 2v$ = 2 × 4 × 10^6 = 8 × 10^6 ms^{-1}

23.

(b) Momentum

Explanation: $\lambda = \frac{h}{p}$, when wavelength λ is same momentum p is also the same.

24.

(b) Both 10 W, ultraviolet lamp and 100 W, ultraviolet lamp

Explanation: The incident wavelength should be less than threshold wavelength for photoelectric emission. IR has a wavelength of more than 600 nm. UV has a wavelength of less than 600 nm. So, photoelectrons emitted when illuminated by UV lamp either 100 W or 10 W.

25.

(d) $\frac{h}{mv}$

Explanation: de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{mv}$

26.

(c) 8 ×10^{14} Hz

Explanation: $\phi_0 = h\nu_0$

$3.32 \times 1.6 \times 10^{-19} = 6.6 \times 10^{-34} \times \nu_0$

$\nu_0 = \frac{3.32\times1.6\times10^{-19}}{6.6\times10^{-34}} = 8 \times 10^{14} Hz$

27.

(c) 5.06 ×10^{14} Hz

Explanation: Work function = $h\nu_o = 2.1 \times 1.6 \times 10^{-19} J$

$\nu_o = \frac{2.1\times1.6\times10^{-19}}{6.63\times10^{-34}} = 5.06 \times 10^{14} Hz$

28.

(d) 1.1eV

Explanation: $\phi_0 = 2eV$

$\lambda = 4000\overset{o}{A}$

$E_k = \left[\frac{6.6\times10^{-34}\times3\times10^8}{4000\times10^{-10}\times1.6\times10^{-19}}\right] eV = 3.1eV$

$K_{\max} = E - \phi_0 = 3.1 - 2 = 1.1eV$

29.

(c) 3.3 ×10^{-19} J

Explanation: $\phi_0 = \frac{hc}{\lambda_0} = \frac{6.6\times10^{-34}\times3\times10^8}{6\times10^{-7}} = 3.3\times10^{-19}J$

30. **(a)** 6.7 V

Explanation: Energy of an incident photon,

$h\nu$ = K_{max} + W_0 = 1.7 + 2.5 = 4.2 eV

Now, $c = \nu\lambda = \nu'\frac{\lambda}{2} \Rightarrow \nu' = 2\nu$

$\therefore eV_0 = h\nu' - W_0 = 2h\nu - W_0$

= 2 $\times$ 4.2 - 2.5 = 6.7 eV

$\Rightarrow \nu_0$ = 6.7 V

31.

(b) four times

Explanation: A number of electrons emitted per the second $\propto$ intensity of incident light $\propto \frac{1}{d^2}$.

When the distance is decreased to $\frac{d}{2}$, the number of electrons emitted per second becomes four times the original number.

32. **(a)** 4λ

Explanation: In terms of stopping potential V_0 and threshold wavelength λ_0, Einstein's photoelectric equation can be written as

$eV_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

In first case: $e\times 3V_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ...(i)

In second case: $eV_0 = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0}$ ...(ii)

Multiplying equation (ii) by (3), then subtracting from (i), we get

$0 = \frac{hc}{\lambda} - \frac{3hc}{2\lambda} - \frac{hc}{\lambda_0} + \frac{3hc}{\lambda_0}$

$\frac{1}{2}\frac{hc}{\lambda} = \frac{2hc}{\lambda_0}$

$\Rightarrow \lambda_0 = 4\lambda$

33.

(c) 12.42 kV

Explanation: $V = \frac{hc}{e\lambda} = \frac{6.6\times10^{-34}\times3\times10^8}{1.6\times10^{-19}\times1\times10^{-10}}$ V

$= \frac{66\times3}{16}\times10^{-3}$ V

= 12.375 kV $\simeq$ 12.42 kV

34.

(c) Aluminium

Explanation: Of the given metals, Al has the lowest work function.

35.

(c) more than 2 volt

Explanation: $eV_o = K_{max} = \frac{hc}{\lambda} - \phi_o$

Hence V_o increases, if wavelength λ decreases.

36.

(d) increase by a factor of 4

Explanation: The intensity of light at a point obeys inverse square law. Since number of electrons emitted per second is directly proportional to intensity of light, the number of electrons emitted will become 4 times on decreasing distance from 1 m to 0.5 m.

37. **(a)** 1.76 $\times 10^{11}$ Ckg^{-1}

Explanation: $eV_0 = \frac{1}{2}mv^2$

$\frac{e}{m} = \frac{v^2}{2V_0} = \frac{(1.33\times10^7)^2}{2\times500} = 1.76\times10^{11}C\ kg^{-1}$

38.

(b) 1.602 $\times$ 10^{-17} J

Explanation: K = eV = 1.602 x 10^{-19} $\times$ 100 J

= 1.602 $\times$ 10^{-17} J

39. **(a)** $2.25 \times 10^5 \mathrm{ms}^{-1}$
Explanation: $h\nu = 6.63 \times 10^{-34} \times 10^{15} J = 6.63 \times 10^{-19} J$
$\phi_o = 4eV = 4 \times 1.6 \times 10^{-19} = 6.4 \times 10^{-19} J$
$K_{max} = \frac{1}{2} mv_{max}^2 = h\nu - \phi_o = 0.23 \times 10^{-19} J$
mass of electron, $m = 9.11 \times 10^{-31} kg$
On putting values and solving,
$v_{max} = 2.25 \times 10^5 m/s$

40.
(c) $\sqrt{\frac{2eV}{m}}$
Explanation: K.E. gained by an electron when accelerated through a potential difference V,
$\frac{1}{2} mv^2 = eV$
or $v = \sqrt{\frac{2eV}{m}}$

41. **(a)** A and B only
Explanation: Energy of incident photon,
$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{41 \times 10^{-8}}$ J
$= \frac{19.89 \times 10^{-18}}{41 \times 1.6 \times 10^{-19}} \mathrm{eV} \approx 3.0 \mathrm{eV}$.
For metals A and B, the work function is less than 3.0 eV, so photoelectrons from metals A and B will be emitted with radiation of 4000 $\overset{o}{\mathrm{A}}$.

42.
(c) frequency of the incident light exceeds a certain minimum value
Explanation: Photoelectrons are emitted by a metal surface only when frequency of the incident light exceeds a certain threshold value.

43.
(b) 0.5 V
Explanation: Stopping potential,
$V_0 = \frac{K_{\max}}{e} = \frac{0.5 \mathrm{eV}}{e}$ = 0.5 V

44.
(c) intensity of light
Explanation: Photocurrent is proportional to incident light intensity.

45.
(d) $\sqrt{\frac{2h\nu}{m}}$
Explanation: $\frac{1}{2} mv_{\max}^2 = h \times 2\nu - W_0 = 2h\nu - h\nu = h\nu$
$\therefore v_{\max} = \sqrt{\frac{2h\nu}{m}}$.

46. **(a)** increase
Explanation: increase

47.
(b) greater than $v(\frac{4}{3})^{1/2}$
Explanation: According to Einstein's phtoelectric equation, when the exciting wavelength is λ,
$h\nu = \frac{hc}{\lambda} = h\nu_0 + \frac{1}{2} mv^2$
When the exciting wavelength is $\frac{3\lambda}{4}$,
$\frac{hc}{3\lambda/4} = h\nu_0 + \frac{1}{2} mv'^2$
or $\frac{1}{2} mv'^2 = \frac{4}{3} \frac{hc}{\lambda} - h\nu_0 = \frac{4}{3} \left(h\nu_0 + \frac{1}{2} mv^2\right) - h\nu$
or $\frac{1}{2} mv'^2 = \frac{1}{3} h\nu_0 + \frac{4}{3} mv^2$
$\Rightarrow \frac{1}{2} mv'^2 > \frac{4}{3} mv^2$
or $v'^2 > \frac{4}{3} v^2$
or $v' > v(4/3)^{1/2}$

48.

(d) 310 nm

Explanation: Here, ω = 4 eV = 4 $\times$ 1.6 $\times$ 10^{-19} J

If λ_0 is the longest wavelength that can cause photoelectron emission, then

$\omega = \frac{hc}{\lambda_0}$

$\lambda_0 = \frac{hc}{\omega} = \frac{6\cdot 62\times 10^{-34}\times 3\times 10^{8}}{4\times 1\cdot 6\times 10^{-19}}$

= 310 $\times$ 10^{-9} m = 310 nm

49. **(a)** 2875 $\overset{o}{A}$

Explanation: 2875 $\overset{o}{A}$

50.

(c) 3 : 4

Explanation: $\frac{KE_A}{KE_B} = \frac{h\nu - h\frac{\nu}{2}}{h\nu - h\frac{\nu}{3}} = \frac{3}{4}$

51. **(a)** different speeds starting from 0 to certain maximum.

Explanation: When a photon strikes a metal surface, the surface electrons come out with maximum speed and maximum kinetic energy. But if the electron emission takes place from inner side of metal, then some energy of the electron is lost due to collision with other electrons and so their speed becomes less. So, ultimately the electrons come out with different speeds.

52. **(a)** -3 V

Explanation: K_{max} = hν - W_0

2eV = 5eV - W_0 $\Rightarrow$ W_0 = 3eV

$\therefore$ Vs = $V_{cathode}$ - V_{anode} = 3V

$\Rightarrow$ V_{anode} - $V_{cathode}$ = -3V

53.

(b) 0.51 eV

Explanation: 0.51 eV

54.

(b) $\frac{hc}{2\lambda}$

Explanation: KE_2 = 3KE_1

$\Rightarrow \frac{hc}{\lambda/2} - W_0 = 3\left(\frac{hc}{\lambda} - W_0\right)$

$\Rightarrow 2W_0 = \frac{3hc}{\lambda} - \frac{2hc}{\lambda}$

$\Rightarrow W_0 = \frac{hc}{2\lambda}$

55. **(a)** X-rays

Explanation: When ultraviolet rays incident on metal plate then photoelectric effect does not occur, it occurs by incidence of X-rays since frequency of X-rays is greater than that of U-V rays.

56.

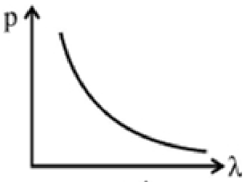
(b) momentum

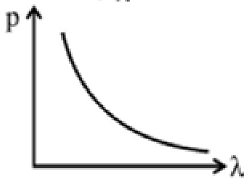
Explanation: As $p = \frac{h}{\lambda}$, so electrons and photons having the same wavelength λ will have the same momentum p.

57.

(d) V is independent of distance (r).

Explanation: V is independent of distance (r).

58. **(a)** 

Explanation: 

59.

(d) 2.7×10^{-21} ms^{-1}

Explanation: 2.7×10^{-21} ms^{-1}

60.

(d) Cadmium

Explanation: Cadmium

61.

(c) 3000 $\overset{o}{A}$

Explanation: $\lambda_0 = \frac{hc}{W_0} = \frac{6.63\times10^{-34}\times3\times10^8}{4.125\times1.6\times10^{-19}}$ m

= 3×10^{-7} m = 3000 $\overset{o}{A}$

62.

(c) 1.2 $\overset{o}{A}$

Explanation: Here K = 100 eV = 1.6×10^{-17} J

$\lambda = \frac{h}{\sqrt{2mK}} = \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-17}}}$ m

= 1.22×10^{-10}m = 1.22 $\overset{o}{A}$

63.

(c) 9

Explanation: $eV_0 = \frac{1}{2}m\nu_{\max}^2$

$\nu_0 = \frac{1}{2}\left(\frac{m}{e}\right)V_{\max}^2 = \frac{1}{2}\frac{\left(1.8\times10^6\right)^2}{1.8\times10^{11}}$ = 9V

64.

(d) more than 2K

Explanation: more than 2K

65.

(d) 2.29 eV

Explanation: $W_0 = \frac{hc}{\lambda_0} = \frac{12424\text{eV}\overset{o}{A}}{5420\overset{o}{A}}$

= 2.29 eV

66.

(c) ultraviolet rays

Explanation: Ultraviolet rays can cause photoelectric emission as their frequency is greater than that of green light.

67.

(c) $3100\overset{o}{A}$

Explanation: We know that $E\;or\;\Phi = h\nu$

where Φ is work function of metal

Now, $h\nu = \frac{hc}{\lambda}$

Thus,

$\lambda = \frac{hc}{\Phi}$ {since hc is nearly equal to 1240 eV-nm}

$\lambda = \frac{1240eV-nm}{4eV}$

$\rightarrow \lambda = 310\ nm$

Wavelength of incident light is 310 nm or 3100$\overset{o}{A}$

68.

(d) diffraction and photoelectric effect

Explanation: Diffraction exhibits wave nature while photoelectric effect exhibits particle nature. Hence these two phenomena exhibit the dual nature of light.

69. **(a)** $\frac{hc}{E}$

Explanation: $\frac{hc}{E}$

70.

(c) 6.63 $\times$ 10^{-34} J-sec

Explanation: Planck's constant h = 6.63 $\times$ 10^{-34} J-sec

71. **(a)** $I_1 = I_2$

Explanation: Photoelectric current $\propto$ Intensity of incident radiation. So long as the frequency of incident radiation is greater than the threshold frequency, the photocurrent remains the same.

Therefore, $I_1 = I_2$.

72.

(d) 4eV

Explanation: de-Broglie wavelength (λ),

Momentum mv = $\frac{h}{\lambda}$ = p = $\sqrt{2m(KE)}$

$\therefore \lambda = \frac{h}{\sqrt{2mKE}}$

$\Rightarrow \lambda \propto \frac{1}{\sqrt{KE}}$

$\therefore \frac{\lambda_A}{\lambda_B} = \sqrt{\frac{K_B}{K_A}} = \sqrt{\frac{T_A - 1.5}{T_A}}$ ...(as given)

Also, $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$

On solving we get, T_A = 2 eV

$\therefore$ $KE_B = T_A - 1.5 = 2 - 1.5 = 0.5$ eV

$\therefore$ Work function of metal B is

$\phi_B = E_B - KE_B = 4.5 - 0.5 = 4$eV

73.

(c) λ is smaller than or equal to 2d

Explanation: For Bragg's diffraction,

$2d \sin\theta = n\lambda$

$\Rightarrow \lambda = \frac{2d \sin\theta}{n}$

$\theta \leq \sin\theta \leq 1 \Rightarrow \lambda \leq 2d$

74.

(c) 4 V

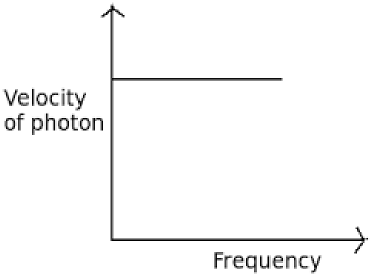
Explanation: $eV_0 = K_{max}$

eV_0 = 4eV

So, V_0 = 4V

75.

(b) straight line parallel to frequency axis

Explanation: 

Velocity of photon in vacuum is independent of frequency.