Question 1)If the mass of the particle is m = 1.0 x 10^{-30} kg and a = 6.6 nm, the energy of the particle in its ground state is closest to :

(A) 0.8 meV

(B) 8 meV

(C) 80 meV

(D) 800 meV

Answer: (B) 8 meV

Solution:

According to the model energy in n^{th} state is given by $n^2h^2/8ma^2$

$$= \frac{1^2 \times (6.626 \times 10^{-34})^2}{8 \times 10^{-30} \times (6.6 \times 10^{-9})^2 \times 1.6 \times 10^{-19}} = 8meV$$

Question 2) The speed of the particle, that can take discrete values, is proportional to

(A) $n^{-3/2}$

(B) n^{-1}

(C) $n^{1/2}$

(D) n

Answer: (D) n

Solution:

The de Broglie wavelength,

$\lambda = h/mv$ -----(1)

We also know, $n\lambda = 2\pi a$

$\Rightarrow \lambda = 2\pi a/n$ ------(2)

From equation (1) and (2) we get

$h/mv = 2\pi a/n$

$\Rightarrow v \propto n$

Velocity is proportional to the number of loops

Question 3) An α–particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de Broglie wavelengths are λ_α and λ_p, respectively. The ratio λ_p/λ_α, to the nearest integer is?

Answer: 3

Solution:

$\lambda = h/p$

Momentum in terms of kinetic energy

$p = \sqrt{2mK.E}$

$= \sqrt{2meV}$

$\lambda = h/\sqrt{2qeV}$

$\Rightarrow \lambda_p = h/\sqrt{2m_p e_p V_p}$

$\Rightarrow \lambda_\alpha = h/\sqrt{2m_\alpha e_\alpha V_\alpha}$

Since, $e_\alpha = 2e_p$

$m_\alpha = 4m_p$

$\lambda_\alpha = h/\sqrt{2(4m_p)(2e_p)V_\alpha}$

$= h/\sqrt{16m_p e_p V_\alpha}$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{\frac{h}{\sqrt{2m_p e_p V_p}}}{\frac{h}{\sqrt{16m_p e_p V_\alpha}}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{\sqrt{8 \times V_\alpha}}{V_p}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \frac{\sqrt{8 \times 100}}{100}$$

$$\frac{\lambda_p}{\lambda_\alpha} = 2\sqrt{2}$$

≈ 3

Question 4) A silver sphere of radius 1 cm and work function 4.7 eV is suspended from an insulating thread in free space. It is under continuous illumination of 200 nm wavelength light. As photoelectrons are emitted, the sphere gets charged and acquires a potential. The maximum number of photoelectrons emitted from the sphere is A x 10^2 (where 1 < A < 10). The value of 'Z' is?

Answer: 7

Solution:

R = 1 cm

$f = 4.7$ cm

$hc/\lambda = \Phi + eV_0$

$eV_0 = (hc/\lambda) - \Phi$

$= (1240/200) - 4.7$

$= 6.2 - 4.7 = 1.5$ eV

$V_0 = 1.5$ V

We know, $V_0 = ne/4\pi\varepsilon_0 r$

$n = 4\pi\varepsilon_0 rV/e$

$= 1.5 \times 10^{-2}/(9 \times 10^9 \times 1.6 \times 10^{-19})$

$= 1.2 \times 10^7$

Therefore the value of z is 7

Question 5) The work functions of silver and sodium are 4.6 eV and 2.3 eV, respectively. The ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium is.

Answer: 1

Solution:

$hv = \Phi + eV_0$

$(h/e)v = (\Phi/e) + V_0$

$V_0 = (h/e)v - (\Phi/e)$

Comparing it with equation $y = mx + c$

$\Rightarrow$ Slope , $m = h/e$

Therefore, $(Slope)_{Ag}/(Slope)_N = (h/e)/(h/e)$

$= 1$

Question 6) A metal plate of area 1×10^{-4} m^2 is illuminated by a radiation of intensity 16mW/m^2. The word function of the metal is 5 eV. The energy of the incident photon is 10eV and only 10% of it produces photoelectrons. The number of emitted photoelectrons per second and their maximum energy, respectively will be [1 eV = 1.6×10^{-19} J]

(A) 10^{14} and 10 eV

(B) 10^{12} and 5 eV

(C) 10^{11} and 5 eV

(D) 10^{10} and 5 eV

Answer: (C) 10^{11} and 5 eV

Solution:

K.E = 10eV - 5eV = 5eV

Intensity, I = nE/At

n = number of photoelectrons

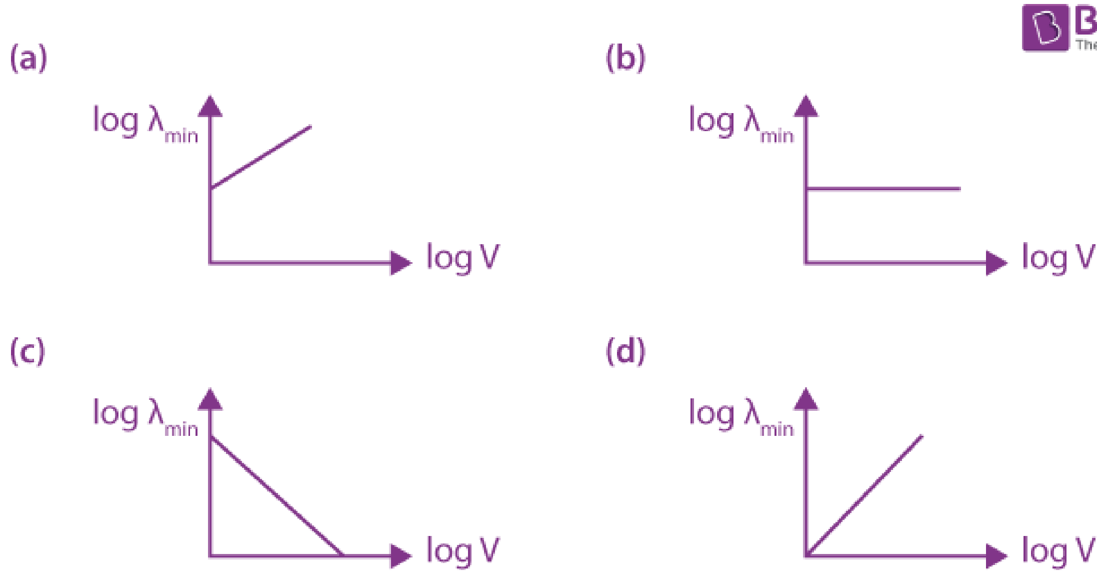
$\Rightarrow 16 \times 10^{-3} = (n/t) \times (10 \times 1.6 \times 10^{-19})/10^{-4}$

$\Rightarrow (n/t) = 10^{12}$

So, effective number of photoelectrons ejected per unit time = $10^{12} \times 10/100$

$= 10^{11}$

Question 7) An electron beam is accelerated by a potential difference V to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays. If λ_{min} is the smallest possible wavelength of X-ray in the spectrum, the variation of log λ_{min} with log V is correctly represented in



Answer: (C)

Solution:

In X-ray tube, λ_{min} = hc/eV

In λ_{min} = In (hc/eV) - InV

Clearly, log λ_{min} versus log V slope is negative, hence option (C) is the correct depiction.

Question 8)Match List -I (Fundamental Experiment) with List - II(its conclusion) and select the correct option from the choices given below the list:

List - 1	List- 2
A. Frank - Hertz Experiment	(i) Particle Nature of Light
B. Photoelectric experiment	(ii) Discrete energy levels of the atom
C. Davison - Germer experiment	(iii) Wave nature of electron
	(iv) Structure of atom

(a) (A) - (ii); (B) - (i); (C) - (iii)

(b) (A) - (iv); (B) - (iii); (C) - (ii)

(c) (A) - (i); (B) - (iv); (C) - (iii)

(d) (A) - (ii); (B) - (iv); (C) - (iii)

Answer: (a) (A) - (ii); (B) - (i); (C) - (iii)

Solution:

Frank - Hertz Experiment - Discrete energy levels of the atom

Photoelectric experiment - Particle Nature of Light

Davison - Germer experiment - Wave nature of electron

Question 9) When the wavelength of radiation falling on a metal is changed from 500 nm to 200 nm, the maximum kinetic energy of the photoelectrons becomes three times larger. The work function of the metal is close to

(A) 0.81 eV

(B) 1.02 eV

(C) 0.52 eV

(D) 0.62 eV

Answer: (D) 0.62 eV

Solution:

$KE_{max} = (hc/\lambda) - \Phi$

$= (hc/500) - \Phi$ -----(1)

Again, $3KE_{max} = (hc/200) - \Phi$------(2)

Dividing equation (2) by (1)

$3KE_{max} / KE_{max} = [(hc/200) - \Phi]/[(hc/500) - \Phi]$

Putting the value of hc = 1237.5 in the above equation we get

$3 = [(1237.5/200) - \Phi]/[(1237.5/500) - \Phi]$

$3[(1237.5/500) - \Phi] = [(1237.5/200) - \Phi]$

$3(2.475 - \Phi] = [6.18 - \Phi]$

$7.425 - 3\Phi = 6.18 - \Phi$

$2\Phi = 1.245$

$\Phi = 0.62$ eV

Question 10) Two sources of light emit X-rays of wavelength 1 nm and visible light of wavelength 500 nm, respectively. Both the sources emit light of the same power 200 W. The ratio of the number density of photons of X-rays to the number density of photons of the visible light of the given wavelength is:

(A) 1/500

(B) 250

(C) 1/250

(D) 500

Answer: (A) 1/500

Solution:

Given,

Wavelength of X-rays, λ_1 = 1nm = 1×10^{-9} m

Wavelength of visible light, $\lambda_2 = 500 \times 10^{-9}$ m

The number of photons emitted per second from a source of monochromatic radiation of wavelength λ and power P is given as

$n = P/E = P/hf = P\lambda/hc$

$\Rightarrow$ Clearly $n \propto \lambda$

$\Rightarrow (n_1/n_2) = (\lambda_1/\lambda_2) = 1/500$