HINTS & SOLUTIONS

TOPIC : MODERN PHYSICS
EXERCISE # 1

SECTION (A)

1. As the maximum kinetic energy depend on the wave length/frequency but not on intensity.

3. Work function

$\phi = \frac{\lambda c}{\lambda_{th}} = \frac{12400 \quad eVA^o}{6800 \quad A^o} = 1.8$ eV

4. Photo electric current (I) α intensity and, intensity α $\frac{1}{r}$

⇒ (I) α $\frac{1}{r}$ ⇒ (I) $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$

5. As maximum energy does not depend on the intensity of light.

7. Emission of photo electron is independent of external factor. It depends only on the nature of the material and wavelength of incident light

8. Einstein's formula $hv_1 = eV_1 + \phi$ if frequency is doubled,

$h.2v_1 = ev_2 + \phi$ ⇒ $eV_2 = 2(eV_1 + \phi)$

$V_2 > 2V_1$.

9. $C = \lambda \cdot v = \frac{h}{p} \cdot \frac{E}{h} = \frac{E}{p}$

10. Experimental obervation.

11. The electrons will get accelerated in the electric field. Hence, kinetic energy will increase.

12. Since frequency of light solurce is double, the energy carried by each photon will be doubled. Hence intensity will be doubled even if number of photons remains constant. Hence saturation current is constant. Since frequency is doubled, maximum KE increases but it is not doubled.

13. Stopping potential depends on the K.E. of emitted electron. The K.E. of emitted electron depends on the frequency of the photon, not on the intensity of the photon.

14. With distance intensity will fall as $\frac{1}{r^2}$

15. Have speeds varying from zero up to a certain maximum value

18. Energy of photon is given by

$E = \frac{ch}{\lambda} = \frac{12375}{\lambda(\text{Å})}$ eV ∴ $E = \frac{12375}{5000} = 2.48$ eV

Einstein's photoelectric equation is

E_k E – w = 2.48 eV – 1.9 eV = 0.58 eV

19. Einstein's photoelectric equation is given by

$E_k = E - w$ but $E_k = \frac{1}{2} mv_2$ and $E = \frac{ch}{\lambda}$

∴ $\frac{1}{2} mv_2 = \frac{ch}{(3\lambda/4)} - w$ or $\frac{1}{2} mv_2 = \frac{4}{3}\frac{hc}{\lambda} - w$ … (ii)

Dividing Eq. (ii) by Eq. (i), we get

$\frac{\nu^2}{\nu^2} = \frac{\frac{4}{3}\frac{ch}{\lambda} - w}{\frac{ch}{\lambda} - w} = \frac{\frac{4}{3}\frac{ch}{\lambda} - \frac{4}{3}w + \frac{1}{3}}{\frac{ch}{\lambda} - w} = \frac{4}{3} + \frac{w}{3\left(\frac{ch}{\lambda} - w\right)} > \frac{4}{3}$ $\therefore$ $\frac{\nu^2}{\nu^2} > \sqrt{\frac{4}{3}}$ or $v' > \sqrt{\frac{4}{3}}\, v$

21. Energy $E = \frac{hc}{\lambda \times 1.6 \times 10^{-19}}$ eV $= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{6 \times 10^{-7} \times 1.6 \times 10^{-19}}$ = 2.66 eV

22. Work function $W = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{5.26 \times 10^{-18}}$

23. Number of Photons

$= \frac{P}{E} = \frac{P\lambda}{hc} = \frac{10 \times 10^{3} \times 300}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$ = 1.5 × 10 $\frac{10 \times 10^{3} \times 300}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$ = 1.5 × 10_{31}

29. de-Broglie wavelength associated with electron,

$\lambda = \frac{h}{m\upsilon} = \frac{h}{\sqrt{2mE_k}} = \frac{h}{\sqrt{2meV}}$ (for electron, E_k = eV) $= \frac{12.3}{\sqrt{V}}$ Å $= \frac{12.3}{\sqrt{100}}$ Å = 1,23 Å

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30. Work function of a photometal,

$W = \frac{ch}{\lambda_0}$ where λ_0 is threshold wavelength. $\therefore$ $\lambda_0 = \frac{ch}{w} = \frac{12375}{(w \text{ in } ev)} = \frac{12375}{6.63}$ Å

31. The de-broglie wavelength is given by

$\lambda = \frac{h}{p}$ where h is Planck's constant and p is monentum.

also p = mu where m is mass, u is velocity

$u = \frac{h}{m\lambda}$ putting the numerical values, we have

h = 6.6 × 10_{-34} Js, m = 9.1 × 10_{-31} kg

$\lambda = 10_{-10}$ m $\therefore$ $u = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^{-10}}$

u = 7.25 × 10_6 m/s

32. $\because$ Work function $W = \frac{hc}{\lambda}$ where h = Planck's constant,

c = velocity of light

Therefore, $\frac{w_{Na}}{W_{Cu}} = \frac{\lambda_{Cu}}{\lambda_{Na}}$ $\Rightarrow$ $\frac{\lambda_{Na}}{\lambda_{Cu}} = \frac{W_{Cu}}{W_{Na}} = \frac{4.5}{2.3}$ = 2 (nearly)

33. de-Broglie wavelength is

$\lambda = \frac{h}{|p|}$ or $\lambda = \frac{h}{|I|}$ [$\because$ | I | = | p |] or $\lambda \propto \frac{1}{|I|}$

34. Energy of photon

$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{5000 \times 10^{-10}}$ = 3.96 × 10_{-19} J $= \frac{3.96 \times 10^{-19}}{1.6 \times 10^{-19}}$ eV = 2.475 eV ≈ 2.5 eV

35. Here : Potential diifference V = 100 V

We know that de=Brogile wavelength of an electron is given by

$\lambda = \frac{h}{\sqrt{2qVm}} = \frac{6.6\times10^{-34}}{2\times(1.6\times10^{-19})\times100\times9.1\times10^{-31}}$ = 1.2 × 10^{-10} m = 1.2 Å

36. Relation between thereshold frequency (V_0) and potential V_0 is $eV_0 = h V_0 - \phi$

So, $V_0 = \frac{h}{e}(v_0) - \frac{\phi}{e}$

Hence, slope of the graph is $\frac{h}{e}$

37. f = hv

$v = \frac{3.3\times1.6\times10^{-19}}{6.67\times10^{-34}} = 10^{15}\times 0.8$.

38. $\lambda = \frac{h}{mv} = \frac{6.67\times10^{-34}}{11\times10^{-12}\times6\times10^{-7}} = \frac{1}{10}\times10^{-15}$

43. Intensity of light is inversely proportional to square of distance.

i. e.,m $I \propto \frac{1}{r^2}$ or $\frac{I_2}{I_1} = \frac{(r_1)^2}{(r_2)^2}$

Given, r_1 = 0.5 m, r_2 = 1.0 m. Therefore, $\frac{I_2}{I_1} = \frac{(0.5)^2}{(1)^2} = \frac{1}{4}$

Now, since number of photoelectrons emitted per second is directly proportional to intensify, so umber of electrons emitted would decrease by factor of 4.

44. According to laws of photoelectric effect

$KE_{max} = E - \phi$

where ϕ is work function and KE_{max} is maximum kinetic energy of photoelectron.

∴ $hv = eV_0 + \phi$ or hv = 5 eV + 6.2 eV = 11.2 eV

∴ $\lambda = \left(\frac{12400}{11.2}\right)$ Å ≈ 1000 Å. Hence, the radiation lies in ultraviolet region.

45. Initial momentum of surface

$p_i = \frac{E}{C}$

where c = velocity of light (constant). Since, the surface is perfectly reflecting so, the same momentum will be reflected completely

Final momentum

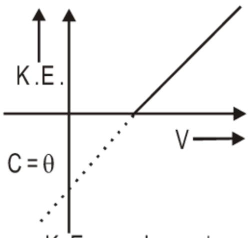
$p_f = \frac{E}{C}$ (negative value) ∴ Change in momentum

$\Delta_p = p_f - p_i = -\frac{E}{C} - \frac{E}{C} = -\frac{2E}{C}$

Thus, momentum transferred to the surface is

$\Delta_{p'} = |\Delta_p| = \frac{2E}{C}$

46. Einstein's photoelectric equation is



The equation of line is
y = mx + C
Comparing above two equations
m = h, c = – ϕ
Hence, slope of graph is equal to Planck's constant (non–variable) and does not depend on intensity of radiation.

47. $\frac{hc}{\lambda} = \phi$ ⇒ $\lambda_{max} = \frac{hc}{\phi} = \frac{6.6\times10^{-34}\times3\times10^{8}}{4\times1.6\times10^{-19}}$ = 310nm

48. We know

$\lambda = \frac{h}{m\upsilon}$

and $K = \frac{1}{2}m\upsilon^2 = \frac{(m\upsilon)^2}{2m}$ ⇒ $m\upsilon = \sqrt{2mK}$

Thus $\lambda = \frac{h}{\sqrt{2mK}}$ ⇒ $\lambda \propto \frac{1}{\sqrt{K}}$

∴ $\frac{\lambda_2}{\lambda_1} = \frac{\sqrt{K_1}}{\sqrt{K_2}} = \frac{\sqrt{K_1}}{\sqrt{2K_1}}$ (∴ $K_2 = 2K_1$)

⇒ $\frac{\lambda_2}{\lambda} = \frac{1}{\sqrt{2}}$ ∴ $\lambda_2 = \frac{1}{\sqrt{2}}$

49. 10^{-10} sec

50. E = pc, hv = pc, $p = \frac{hv}{c}$.

51. Thereshold freq. = γ_0

$K.E_{max} = h\gamma - w = h(2\gamma_0) - h\gamma_0 = h\gamma_0 = \frac{1}{2}v_1^2 \Rightarrow v_1 \alpha \sqrt{\gamma_0}$

Now $K.E_{max} = h5\gamma_0 - h\gamma_0 = 4h\gamma_o = \frac{1}{2}mv_2^2$

$v_2 \alpha \sqrt{v'}$ ⇒ $v_2 \alpha \sqrt{4\gamma_0}$ $v_o = 2 \times v_1 = 8 \times 10^3$ m/s

52. Energy of photon

$K.E = \frac{hc}{\lambda} - W$

$W = \frac{12400(A^o, eV)}{6000(A^o)} - (K.E_{max})_1$ = 2.066eV - 3.32 × 10^{-19} = 2.07 × 1.6 × 10^{-19} - 3.32 × 10^{-19}

$(K.E_{max}) = \frac{hc}{\lambda_2} - W = \frac{12400}{4000} - W$ = 3.1 eV – W = 3.1 × 1.6 × 10^{-19} W
= (4.96 - 0.52) × 10^{-19} = 4.44 × 10^{-19} Joule

53. Because below threshold frequency there is no photoelectron emitted. Hence no photo current.

54. de-Broglie ware length $\lambda = \frac{h}{p}$ $\Rightarrow P = \frac{h}{\lambda}$ or $P \ \alpha \frac{1}{\lambda}$

55. As $\lambda = \frac{h}{p}$
If P-momentum of proton & electron is same then de-Broglie λ is same for both.

56. $K.E_{max} = \frac{hc}{\lambda} - \phi$ $\Rightarrow$ $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$ $\Rightarrow$ $V = \left(\frac{2hc - \lambda\phi}{m\lambda}\right)^{1/2}$

57. $E = h\gamma - \phi$
Slope is h Plank's constant.

58. Work function $\phi = h\nu_0$
Where ν_0 threshold frequency.

59. $E = \frac{hc}{\lambda}$ energy of photon

60. $\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mk}}$

$K.E = \frac{h^2}{2m\lambda^2} = \frac{(6.6 \times 1^{-34})^2}{2 \ \ m_e \times (10^{-10})^2}$ Jule $\Rightarrow$ $K.E = \frac{(6.6 \times 10^{-34})^2}{2m_e \ \ 10^{-20} \times e}$ eV = 150.6 (eV)

61. de-Broglie wave length $(\lambda) = \frac{h}{p}$

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

If $v_1 = v_2$ thus

$\lambda \propto \frac{1}{m}$ Hence [4]

63. $\frac{\lambda_1}{\lambda_2} = \frac{\frac{h}{\sqrt{2mE}}}{\frac{hc}{E}}$ or $\frac{\lambda_1}{\lambda_2} \ \alpha \ E^{1/2}$

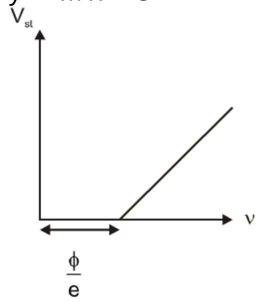
Therefore, the correct option is (2).

64. $KE_{max} = h\nu - \phi$

$eV_{st} = h\nu - \phi$

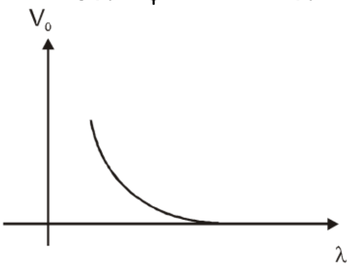
$V_{st} = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$

y = m x + C



So slope will be $\left(\frac{h}{e}\right)$, and it will be same for both the metals.
So ratio of the slopes = 1

65. $\frac{hc}{\lambda} = eV_0 + \phi \Rightarrow V_0 = \frac{hc}{e}\left(\frac{1}{\lambda}\right) - \phi$



67. When the source is 3 times farther, number of photons falling on the surface becomes $\frac{1}{9}$th but the frequency remains same. Hence stopping potential will be same i.e. 0.6V and saturation current become $\frac{1}{9} \times 18$ mA = 2mA,

68. As the distance of the source doubles, the photons falling on the photon cell becomes $\frac{1}{4}$th. Hence, number of photoelectrons will also become $\frac{1}{4}$th.

69. The threshold frequency for Al must be greater as it has higher work function.

71. If the maximum kinetic energy of photo electrons emitted from metal surface is E_k and W is the work function of metal then

$$E_k = h\nu - W$$

where hν is the energy of photon absorbed by the electron in metal.

∴ $E_k = \frac{hc}{\lambda} - W$, where $\nu = \frac{c}{\lambda}$ putting the numerical values, we have

$$E_k = \left[\frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4000 \times 10^{-10} \times 1.6 \times 10^{-19}}\right] \text{eV}$$

$E_k = 3.1 - 2 = 1.1$ eV

Note : Energy of incident photons should be greater than work function of metal for emission of photo electrons to take place.

73. As no. of electron α Intensity
$n_e \propto I$
and $I \propto \frac{1}{\gamma^2} \Rightarrow n_e \propto \frac{1}{\gamma^2}$ Hence % *[4]

74. Frequency of light does not change with medium.

75. The number of photo electron depends on the number of photons

Number of photon = $\frac{I}{hc/\lambda} = \frac{\lambda \cdot I}{hc} \propto \lambda$

Ratio of no. of photo electrons = $\frac{\lambda_A}{\lambda_B}$

76. Change in momentum = $\frac{\text{power} \times \text{total time}}{\text{speed of light}} = \frac{P \times t}{c}$
1.0×10^{-17} kg × m/s

77. Self explanetry.

78. $\frac{I_2}{I_1} = \frac{(r_1)^2}{(r_2)^2}$ $\Rightarrow$ $I_2 = 4\ I_1$

Now, since number of electrons emitted per second is directly proportional to intensity so, number of electrons emitted by photocathode would increase by a factor of 4.

SECTION (B)

1. de-Broglie wave length

$\lambda = \frac{\lambda}{P} = \frac{\lambda}{\sqrt{2km}}$ $\Rightarrow$ $\frac{\lambda_P}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_p}} = 2$

2. $\frac{\lambda_P}{\lambda_\alpha} = \frac{\left(\frac{h}{m_p V_p}\right)}{\left(\frac{h}{m_\alpha V_p}\right)} = \frac{m_\alpha}{m_p}$ $(\therefore V_\alpha = V_p) = 4$

3. $\frac{\lambda_P}{\lambda_N} = \frac{\left(\frac{h}{m_P V_P}\right)}{\left(\frac{h}{m_N V_N}\right)} = \frac{m_N}{m_P}$ $(\because \ V_P = V_N) = 1$

4. $\lambda = \frac{\lambda}{mV} = \frac{h}{\sqrt{2km}}$

$\lambda = \frac{h}{\sqrt{2qVm}}$ $\Rightarrow$ $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}}$ as q and Volume (V) are same.

5. $V_1 = V$ Now $\lambda_1 = \frac{\lambda}{mV}$

$V_2 = \frac{V}{2}$ $\lambda_2 = \frac{\lambda}{mV/2} = 2\lambda_1$

% change = $\frac{\lambda_2 - \lambda_1}{\lambda_1} \times 100 = \frac{2\lambda_1 - \lambda_1}{\lambda_1} \times 100 = 100\%$

6. Energy of X- ray = 3×10^3 eV

$\lambda = \frac{\lambda c}{\varepsilon} = \frac{12400 \ \text{eV} \ \text{A}^o}{3 \times 10^3 \ \text{eV}} = \frac{12.4}{3}$ A^o momentum (P) = $\frac{\lambda}{\lambda} = \frac{\lambda \times 3}{12.4 \times 10^{-10}} = 1.6 \times 10^{-24}$ kg m/s

7. $\lambda = \frac{h}{p}$

Hence, higher the momentum, smaller the wavelength.

8. de Broglie wave length $(\lambda) = \frac{h}{P}$

or $\lambda = \frac{h}{\sqrt{3m_e k}}$ $\because$ $\frac{1}{2}$ $mv^2 = K$ & $P = mv = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times m_e \times e \times 10 \times 10^3}} = 0.12 \times 10^{-10} = 0.12$ Å

9. de-Broglie waves defined for all either it has zero rest mass or zero rest mass or photon.

10. $\lambda = 1.0$ Å $= \frac{h}{p}$

$1 \times 10^{-10} = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times m_e \times e \times v}}$

$v = \frac{(6.6\times10^{-34})^2\lambda}{2\lambda m_e \times e}$ = 150 volt.

11. As $\frac{mv^2}{r} = qVB$

$r = \frac{mv}{qB}$ or mv = P = rqB and $\lambda = \frac{h}{p} = \frac{h}{rqB} = \frac{6.6\times10^{-34}}{0.83\times10^{-2}\times2e\times0.25} = 0.01$ Å

12. $\lambda = \frac{h}{mv} = 1.105 \times 10^{-33}$ m

13. $\lambda_d = \frac{h}{mv}$

E_λ = energy of photon = $\frac{hc}{\lambda}$ = mvc

Energy of electron = $\frac{1}{2}mv^2$

The required ratio = $\frac{\frac{1}{2}mv^2}{mvc} = \frac{1}{2}\frac{v}{c} = \frac{1}{4}$.

14. $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{3m.\frac{3}{2}kT}} \propto \frac{1}{\sqrt{T}}$

$\frac{\lambda_{27^\circ}}{\lambda_{927^\circ}} = \sqrt{\frac{927+273}{27+273}} = 2$ $\Rightarrow \lambda_{27} = 2 \cdot \lambda$

SECTION (C)

7. $r = a_0\frac{n^2}{Z} = a_0 . \frac{2^2}{4} = a_0$

8. $E_n(Li^{2+}) = E_1(H)$ $\Rightarrow$ $-13.6\frac{3^2}{n^2} = -13.6 \times \frac{1}{1}$ $\Rightarrow$ n = 3

9. Since speed reduces to half, KE reduced to $\frac{1}{4}$th $\Rightarrow$ n = 2

$mvr = \frac{nh}{2\pi}$

$mv_0 r = 1.\frac{h}{2\pi}$ I

$m\frac{v_0}{2}r` = 2.\frac{h}{2\pi}$ II

from I & II

r´ = 4.r

10. $\frac{K}{\lambda_1} = E_\infty - E_1$ $\Rightarrow$ $\frac{K}{\lambda_2} = E_\infty - E_2$

$\frac{K}{\lambda_3} = E_2 - E_7$ $\Rightarrow$ $\frac{1}{\lambda_1} - \frac{1}{\lambda_2} = \frac{1}{\lambda_3}$

11. ΔE(1 to ∞) = ΔE(1 to 2) + ΔE(2 to ∞) = $\upsilon_1 = \upsilon_2 + \upsilon_3$.

12. $r \propto n^2$

∴ $r_{10} = 10^2 \times 1.06$ Å = 106 Å.

13. $E_n = 13.6 \frac{Z^2}{n^2}$

$\Delta E_H = \frac{13.6(1)^2}{(1)^2} - \frac{13.6(1)^2}{(2)^2} = 10.2\text{eV}$ ⇒ $\Delta E_{He} = \frac{13.6(2)^2}{(1)^2} - \frac{13.6(2)^2}{(2)^2} = 40.8$ eV

14. Energy required to remove the second e^-

∴ TE = (54.4 + 24.6) = 79.0 eV.

15. **Key idea:** According to teh Newto's second law, a radially inwaed centripetal force is needed to the electron which is being provided by the Coulomb's attraction getween the proton and electron.

Coulomb's attraction between the positive proton and negative electron = $\frac{1}{4\pi\varepsilon_0}$ Centripetal force has magnitude

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

As per key idea,

$mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$ ⇒ $v^2 = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{mr}$ ⇒ $v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$

For ground state of H-atim, $r = a_0$ ∴ $v = \frac{e}{\sqrt{4\pi\varepsilon_0 ma_0}}$

16. $\left(n^2 = \frac{13.6}{1.5} \Rightarrow n^2 = 9\right)$

∴ n = 3 for 1.5 eV, n = 3

Angular momentum = $n\frac{h}{2\pi} = \frac{3 \times 6.6 \times 10^{-34}}{2 \times 3.14} = 3.15 \times 10^{-34}$ J -sec

21. According to Bohr's theory, angular momentum of electron in H-atom,

$L = \frac{nh}{2\pi}$

For minimum value of L, n = 1

∴ Minimum angular momentum,

$L_{min} = \frac{h}{2\pi}$

22. Energy of H-like atoms,

$E_n = -\frac{Z^2 Rhc}{n^2} = -\frac{Z^2 \times 13.6\ \text{eV}}{n^2}$

For ground state

n = 1

E_1 = – 54.4 eV (given)

∴ $-54.4\text{ eV} = \frac{Z^2 \times 13.6}{(1)^2}$ eV ⇒ $Z^2 = 4$ or Z = 2

Z = 2 is for helium.

23. From Bohr's theory wavelength of radiations emitted in H-atom

$\frac{1}{\lambda} = R\left(\frac{1}{n_2^{\,2}} - \frac{1}{n_1^{\,2}}\right)$

Here $n_1 = 2$, $n_2 = 1$, $R = 1.097 \times 10^7\ m^{-1}$

$\therefore \quad \frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right) = \frac{3}{4}R \quad \Rightarrow \quad \lambda = \frac{4}{3R} = \frac{4}{3 \times 1.097 \times 10^7}$ = 1.215 × 10^{-7} m = 1215 Å

24. Rate of specific charge = $\frac{(q/m)\alpha}{(q/m)_p} = \frac{(2e/4\ m_p)}{e/m_p} = \frac{1}{2}$

25. Energy required to remove an electron from nth orbit is

$E_n = -\frac{13.6}{n^2}$

Here n = 2

Therefore $E_2 = -\frac{13.6}{2^2} = -3.4$ V

26. The third line from the red end corresponds to yellow region i.e. $n_2 = 5$. Thus transition will be from n_2 (= 5) to n_1 (< 5).

27. The energy of electron in n_{th} Bohr orbit

$E = -\frac{13.6}{n^2}$

Energy absorbed by electron in transition from n = 1 → n = 2

$\therefore \quad E = -\frac{13.6}{2^2} - \left(-\frac{13.6}{1^2}\right) = -\frac{13.6}{4} + \frac{13.6}{1} = -3.4 + 13.6 = 10.2$ eV

28. The radius of Bohr orbit, $r \propto n^2$

$\therefore \quad \frac{r_1}{r_2} = \left(\frac{n_1}{n_2}\right)^2 \quad \Rightarrow \quad r_2 = r_1\left(\frac{n_{21}}{n_1}\right)^2$ … (1)

Given : $r_1 = 0.5$ Å, $n_1 = 1$, $n_2 = 4$ putting given values in eq. (1)

$\therefore \quad r_2 = 0.5\left(\frac{4}{1}\right)^2 \quad \Rightarrow \quad r_2 = 0.5 \times 16 \quad \therefore \quad r_2 = 8$ Å

29. The Bohr model of hydrogen atom can be extended to hydrogen like atoms.
Energy of such an atom is given by

$E_n = -13.6\frac{Z^2}{n^2}$

Here, Z = 11 for Na atom; 10 electrons are removed already, so it is 10 times ionised,. For the last electron to be removed, n = 1

$\therefore \quad E_n = -\frac{13.6(11)^2}{(1)^2}$ eV or $E_n = -13.6 \times (11)^2$ eV

32. Photon of lesser energy will be produce and it will be of IR radiation so (4) will be the answer.

36. The discharge of electricity through rarefied gases is an interesting phenomenon which can be systematically studied with the help of a discharge tube. In discharge tube collisions between the charged particles emitted from the cathode and the atoms of the gas results to the coloured glow in the tube.

37. $E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$E_{(4 \to 3)} = Rhc\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = Rhc\left[\frac{7}{9 \times 16}\right] = 0.05\ Rhc$

$E_{(4 \to 2)} = \left[\frac{1}{2^2} - \frac{1}{4^2}\right] = Rhc\left[\frac{3}{16}\right] = 0.2\ Rhc$

$E_{(2\rightarrow 1)}$ = Rhc $\left[\frac{1}{(1)^2}-\frac{1}{(2)^2}\right]$ = Rhc $\left[\frac{3}{4}\right]$ = 0.75 Rhc

$E_{(1\rightarrow 3)}$ = Rhc $\left[\frac{1}{(3)^2}-\frac{1}{(1)^2}\right]$ = $\frac{8}{9}$ Rhc = – 0.9 Rhc

∴ Thus, III transition gives most energy.

39. $\lambda = \frac{1242 eVnm}{11.2} \approx 1100Å$

Ultraviolet region

40. For highest frequency in emission spectra the difference of energy between two states involved should be maximum

ΔeV_{2-4} = 10. 2 eV, $\Delta E_{\infty-1}$ = 13.6 eV

$\Delta E_{\infty-1}$ = 3.4 eV, $\Delta E_{6-2} < \Delta E_{\infty-2}$, $\Delta E_{6-2} < \Delta E_{2-1}$

So photons of highest frequency will be emitted for n = 2 to n = 1.

41. $\frac{mv^2}{r} = \frac{K}{r}$ ...(1)

mvr = $\frac{nh}{2\pi}$ ....(2)

Solve these equation

42. K.E. = – T.E. $\frac{K_H}{K_{He}} = \frac{TE_H}{TE_{He}}$

For same 'n' $\frac{TE_H}{TE_{H_e}} = \frac{(Z_H)^2}{(Z_{He})^2} = \frac{1}{4}$

44. $E = -Z^2 \frac{13.6}{n^2}$ eV

For first excited state

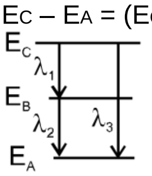
$E_2 = -3^2 \times \frac{13.6}{4}$ = 30.6 eV

Ionization energy for first excited state of Li^{2+} is 30.6 eV.

45. $\Delta E = E_0\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ frist exited state (n = 2)

= 13.6 $\left(\frac{1}{2^2}-\frac{1}{4^2}\right)$ & third exicited state (n = 4) = 13.6 $\left(\frac{4-1}{16}\right)$ = 2.55 eV

46. $E_C - E_A = (E_C - E_A) + (E_B - E_A)$ ⇒ $\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$



⇒ $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2}$.

47. $\Delta E_H = \frac{3}{4} \times 13.6$ eV = Energy released by H atom. Let He^+ go to nth state.
So energy required

$\Rightarrow \quad \Delta E_{He} = 13.6 \times 4 \left(\frac{1}{4} - \frac{1}{n^2}\right)$ eV $\quad \Rightarrow \quad \Delta E_{He} = \Delta E_H$

$\Rightarrow \quad \frac{3}{4} \times 13.6 = 13.6 \times 4 \left(\frac{1}{4} - \frac{1}{n^2}\right) \quad \Rightarrow \quad n = 4$ **Ans. C**

48. $\frac{1}{\lambda_{H_2}} = RZ_H^2\left[\frac{1}{4} - \frac{1}{9}\right] = R(1)^2\left[\frac{5}{36}\right] \quad \Rightarrow \quad \frac{1}{\lambda_{He}} = RZ_{He}^2\left[\frac{1}{4} - \frac{1}{16}\right] = R(4)\left[\frac{3}{16}\right]$

$\frac{\lambda_{He}}{\lambda_{H_2}} = \frac{1}{4}\left[\frac{16}{3} \times \frac{5}{36}\right] = \frac{5}{27} \quad \Rightarrow \quad \lambda_{He} = \frac{5}{27} \times 6561 = 1215$ Å

49. Because Infrared photon has shorter ware length as that of visible light.

SECTION (D)

1. 12.1 = E(n = 3) – E (n = 1)
10.2 = E(n = 2) – E (n = 1)
1.9 = E(n = 3) – E (n = 2)
At least two atoms must be enveloped as there connot be two transition from same level from same atom.

2. All the transition energies in option(1),(2) and (3) are greater than corresponding to n = 4 to n = 3. Hence, option (4).

3. 12.1 eV radiation will excite a hydrogen atom in ground state to n = 3
state number of possible transition = ${}_nC_1 = {}_3C_1 = 3$.

4. $\frac{1}{\lambda_1} = R\left(\frac{1}{4} - \frac{1}{9}\right) \quad \Rightarrow \quad \lambda_1 = \frac{4 \times 9}{5R}$

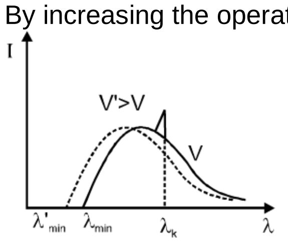
similarly $\frac{1}{\lambda_2} = R\left(\frac{1}{4} - \frac{1}{4^2}\right) \quad \Rightarrow \quad \lambda_2 = \frac{16}{3R} = \frac{16}{3} \times \frac{5\lambda}{4 \times 9} = \frac{20}{27}\lambda$

SECTION (E)

9. The cut off wavelength depends on the accelerating potential difference which is unchanged. Hence, the wavelength will remain unchanged.

10. The characteristic x-rays are obtained due to the transition of electron from inner orbits.

12. By increasing the operating voltage, I_k does not change but I_{min} decreases



Hence, $\lambda_k - \lambda_{min}$

18. For continuous X-rays, minimum wavelength produced,

$$\lambda_{min} = \frac{hc}{eV} = \frac{12375}{(\text{Energy eV})} \text{ Å} = \frac{12375}{40 \times 10^3} \text{ Å} = 0.31 \text{ Å}$$

19. From the relation of momentum and wavelength

$$p = \frac{h}{\lambda} \quad (\text{Here : } \lambda = 0.01\text{Å}, h = 6.6 \times 10^{-34} \text{ Js})$$

$$p = \frac{6.6 \times 10^{-34}}{0.01 \times 10^{-10}} = 6.6 \times 10^{-22} \text{ kg m/s}$$

20. From the formula

$eV = \frac{hc}{\lambda}$ ⇒ $V = \frac{hc}{e\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times0.4125\times10^{-10}}$ = 30 × 10^3 V = 30 kV

22. $I' = Ie^{-\mu x}$

$-\mu x = \log\frac{I'}{I}$

$-\mu .36 = \log\frac{I}{8\ I}$ .... (i)

$-\mu x' = \log\frac{I}{2I}$ .... (ii)

From Eq. (i) and (ii) ⇒ $\frac{36}{x} = \frac{3\log\left(\frac{1}{2}\right)}{\log\frac{1}{2}}$ ∴ x' = 12 mm

23. As $\lambda = \frac{hc}{E}$ or $E = \frac{hc}{\lambda}$ as λ is smallest then E is maximum

25. $\sqrt{\nu_{K_\alpha}}$ = K (Z – α) × $\sqrt{1-\frac{1}{4}}$ ⇒ $\sqrt{\nu_{K_\beta}}$ = K (z – α) × $\sqrt{1-\frac{1}{9}}$

Ratio for $\frac{K_\beta}{K_\alpha} = \frac{\sqrt{\frac{8}{9}}}{\sqrt{\frac{3}{4}}} = \sqrt{\frac{32}{27}}$

26. $hf = 13.6(Z-1)^2 . \left(1-\frac{1}{4}\right) = 13.6 \times \frac{3}{4}(31-1)^2$

$hf' = 13.6 \times \frac{3}{4}(51-1)^2$ ⇒ $\frac{f'}{f} = \frac{50^2}{30^2}$ ⇒ $f' = \frac{25}{9}.f$

27. $\lambda_{min} = \frac{hc}{eV}$.

Cut off wavelength depends on the energy of the accelerated electrons and is independent of nature of target.

$\lambda_{K\alpha} \propto \frac{1}{(z-b)^2}$ characteristic wavelength depend on atomic no and cut off wavelength depend on energy of e^-.

28. With increase of potential difference, x-ray of higher energy will be produced. To stop them, thicker foil is required.

30. Some of the energy of photon will be absorbed by the electron. Hence, energy of the photon will reduce correspondingly wavelength will increase and frequency decreases.

EXERCISE # 2

1. The current I is proportional to light energy falling on the lens per second which is same in the two cases. Hence same I.

2. $hf = hf_0 + \frac{1}{2}mv^2$

Hence, $v_1^2 = \frac{2hf_1}{m} - \frac{2hf_0}{m}$ ⇒ $v_2^2 = \frac{2hf_2}{m} - \frac{2hf_0}{m}$ ∴ $v_1^2 - v_2^2 = \frac{2h}{m}[f_1 - f_2]$

3. **Key Idea :** photons are the packets of energy. Power emitted, p = 2 × 10^{-3} W

Energy of photon, E = hν = 6.6 × 10^{-34} × 6 × 10^{14} J

h being Planck's constant.

Number of photons emitted per second $n = \frac{p}{E} = \frac{2\times10^{-3}}{6.6\times10^{-34}\times6\times10^{14}} = 5 \times 10^{15}$

4. Wavelength of a particle is given by

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

where h is planck's constant.
and wavelength of an electron is given by

$$\lambda_e = \frac{h}{p_c}$$

but $\lambda = \lambda_c$
So, $p = p_e$
or $mv = m_e v_e$
or $v = \frac{m_e v_e}{m}$
putting the under given data
$m_c = 9.1 \times 10^{-31}$ kg, $v_c = 3 \times 10^6$ m/s,
$m = 1mg = 1 \times 10^{-6}$ kg

$$v = \frac{9.1\times10^{-31}\times3\times10^{6}}{1\times10^{-6}} = 2.7 \times 10^{-18}\ ms^{-1}$$

6. Saturation current is proportional to intensity while stopping potential increases with increase in frequency. Hence A & B same intensity. B & C same frequency. Therefore, the correct option is (1)

7. $E_1 = \frac{hc}{\lambda_1}$ and $E_2 = \frac{hc}{\lambda_2}$ Clearly, $\lambda_1 = 2\lambda_2 \Rightarrow \lambda_2 = \frac{\lambda_1}{2}$

$\therefore$ $E_2 - E_1 = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_1}$ $\Rightarrow$ $\Delta E = \frac{2hc}{\lambda_1} - \frac{hc}{\lambda_1} = \frac{hc}{\lambda_1}$ $\Rightarrow$ $\Delta E = E_1$

8. Masses of two nuclei are different.

9. **Key Idea:** Total energy of electron in the orbit is equal to negative of its kinetic energy.
The energy of hydrogen atom when the electron revolves in nth orbit is

$$E = \frac{-13.6}{n^2}\ eV$$

In the ground stage; n = 1 $\therefore$ $E = \frac{-13.6}{1^2} = -13.6$ eV

For $n = 2$, $E = \frac{-13.6}{2^2} = -3.4$ eV
So, kinetic energy of electron in the first excited state (i. e., for n = 2) is
$K = -E - (-3.4) = 3.4$eV

10. Remember

11. $\frac{1}{\lambda} = R(Z-1)^2 \times \left(1-\frac{1}{4}\right)$

$\Rightarrow \frac{1875R}{4} = R\,(Z_1-1)^2\,\frac{3}{4}$ $\Rightarrow$ $Z_1 = 26$ and $675\,R = R\,(Z_2-2)^2 . \frac{3}{4}$ $\Rightarrow$ $Z_2 = 31$
Hence number of elements = 4

12. $(r_m)\left(\frac{m^2}{z}\right)(0.53\ Å) = (n \times 0.53)Å$ $\therefore$ $\frac{m^2}{z} = n$

m = 5 for 100 Fm_{257} (the outermost shell) and z = 100 $\therefore n = \frac{(5)^2}{100} = \frac{1}{4}$

13. $L = \frac{nh}{2\pi} = \frac{3h}{2\pi}$

$n = 3$

$\lambda = \frac{h}{p} = \frac{h}{m\ \ v} = \frac{h\ \ 2\pi r}{3h} = \frac{2\pi r}{3}$

$r = a_0 \frac{n^2}{Z}$

$\lambda = \frac{2\pi}{3}\ a_0 \frac{n^2}{Z} = \frac{2\pi}{3}\ a_0 \frac{3^2}{3} = 2\pi a_0$

14. $K = \frac{1}{2}mv^2$ and $V_n = \frac{e^2}{2\varepsilon_0 nh}$

or $V_1 = \frac{e^2}{2\varepsilon_0 h} = \frac{ze^2}{z\varepsilon_0 h}$ and $r_n = \frac{\varepsilon_0 n^2 h^2}{\pi me^2}$

$r_1 = \frac{\varepsilon_0 h^2}{\pi me^2} = \frac{\varepsilon_0 h^2}{\pi m\ \ ze^2}$ or $\frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{ze^2}{2\varepsilon_0 h}\right)^2 = \frac{1}{8}\frac{m(z\ \ e^2)^2}{\varepsilon_0{}^2 h^2} = \frac{1}{2\times 4\pi}\frac{ze^2}{\frac{\varepsilon_0 \times \varepsilon_0\ \ h_2}{\pi m(ze)^2}} = \frac{1}{2\times(4\pi\varepsilon_0)}\frac{ze^2}{r}$

In C.G.S unit $4\pi\varepsilon_0 = 1$

$K = \frac{1}{2}\ mv_2 = \frac{1}{2}\frac{ze^2}{r}$

15. $U = eV = eV_0 \ln\left(\frac{r}{r_0}\right)$ $\therefore$ $|F| = \left|-\frac{dU}{dr}\right| = \frac{eV_0}{r}$

This force will provide the necessary centripetal force. Hence

$\frac{mv^2}{r} = \frac{eV_0}{r}$ or $\upsilon = \sqrt{\frac{eV_0}{m}}$ ...(i)

$m\upsilon r = \frac{dh}{2\pi}$ ...(ii)

Dividing equation (ii) by (i) we have

$mr = \left(\frac{nh}{2\pi}\right)\sqrt{\frac{m}{eV_0}}$ or $r_n \propto n$

17. $(\lambda_{k\alpha})_A < (\lambda_{k\alpha})_B$

$\Rightarrow$ $Z_B > Z_A$

$(\lambda_{cut\ off})_A < (\lambda_{cut\ off})_B$

$\Rightarrow$ $V_A > V_B$.

18. $E_n = -13.6\,\frac{z^2}{n^2}$ (for any H-like atom)

But for x-ray

$\sqrt{\frac{c}{\lambda}}$ = a (z-b)

b = 1 for K α lines $\Rightarrow \sqrt{\frac{\lambda_1}{\lambda_2}} = \frac{z_2-1}{z_1-1}$ $\quad \sqrt{\frac{250}{179}} = \frac{z_2-1}{z_1-1}$

$1.18 = \frac{z_2-1}{z_1-1}$

$\frac{118}{100} \Rightarrow \frac{59}{50}$ or $\approx \frac{30}{25} = \frac{z_2-1}{z_1-1}$ thus between z_1 & z_2 three element.

19. $p = \frac{h}{\lambda}$

K.E. = $\frac{p^2}{2\ m} = \frac{h^2}{2\ m\ \lambda^2}$

If entire K.E. of electron is converted into photon then

$\frac{h^2}{2\ m\ \lambda^2} = \frac{hc}{\lambda_0}$, $\quad \lambda_0 = \frac{2mc\lambda^2}{h}$

21. $I = I_0\, e^{-\mu x}$

$\frac{I}{I_0} = e^{-\mu x} = e^{-1.73\times 1.156} = \frac{1}{e^2} = 0.1353$ or 13.5%

22. Energy = volt × current = $50\times10^3 \times 20 \times 10^{-3}$ Joul = 1000 Joul

In calories = $\frac{1000}{4.2}$ cal.× $\frac{99}{100}$ = 238× $\frac{99}{100}$ = 235.62

24. $P = P_- + P_+$

$= 200 \times (6.25 \times 10^{18} + 3.125 \times 10^{18}) \times 1.6 \times 10^{-19}$ W = 300 W.

25. For K_α $\Rightarrow$ $\sqrt{\nu} \propto (z-1)$ $\Rightarrow$ $\frac{1}{\sqrt{\lambda}} \propto (z-1)$

or $\quad \lambda \propto \frac{1}{(z-1)^2}$ ....(i)

$4\lambda \propto \frac{1}{(z'-1)^2}$ ....(ii)

$\Rightarrow \quad \frac{1}{4} = \frac{(z'-1)^2}{(z-1)^2} \quad \Rightarrow \quad \frac{z'-1}{z-1} = \frac{1}{2}$

$\Rightarrow \quad 2z' - 2 = z - 1 \quad \Rightarrow \quad 2z' - 2 = 11 - 1 = 10 \quad \Rightarrow \quad z' = 6$

26. KE = $\left(\frac{hc}{\lambda} - \phi\right)$

$\lambda < \lambda_0$ for photo emission to take place. So, as $\lambda \downarrow \Rightarrow$ KE $\uparrow$

27. $\frac{P^2}{2m} = \left(\frac{hc}{\lambda} - \omega_0\right)$

$$P = \sqrt{2m\left(\frac{hc}{\lambda} - \omega_0\right)}$$

so, $$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2m\left(\frac{hc}{\lambda} - \omega_0\right)}}$$

EXERCISE # 3
PART - I

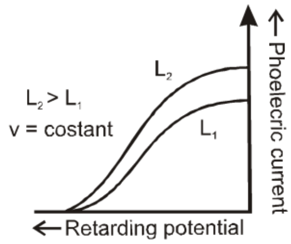
1. Here $\lambda = 667 \times 10^{-9}$ m, $P = 9 \times 10^{-3}$ W

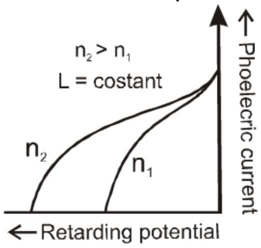
Power = $\frac{\text{energy}}{\text{time}} = \frac{nhc}{\lambda t} = \frac{Nhc}{\lambda}$

where N is number of photons emitted per sec.

$\Rightarrow N = \frac{P \times \lambda}{hc} = \frac{9 \times 10^{-3} \times 667 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^{8}} = 3 \times 10^{16}$ per sec.

2.





From the two graph we can conclude that for the graph in question curves a and b represent incident radiations of same frequency but of different intensities

3. The number of photoelectrons emitted is directrly proportional to the intensity of light.

4. Number of special lines obtained due to transition of electron from n_{th} orbital to lower orbital is

$N = \frac{n\ (n-1)}{2}$ and for maximum wavelength the difference between the orbits of the series should be minimum.

Number of special lines $N = \frac{n\ (n-1)}{2}$

$\Rightarrow \frac{n\ (n-1)}{2} = 6$

or $n^2 - n - 12 = 0$ or $(n-4)(n+3) = 0$ or $n = 4$

Now as the first line of the series has the maximum wavelength, therefore electron jumps from the 4_{th} orbit to the third orbit.

5. Energy of an hydrogen like atom like He^+ in an n_{th} orbit is given by

$E_n = -\frac{-13.6Z^2}{n^2}$ eV

For hydrogen atom, Z = 1

$\therefore \quad E_n = \frac{13.6}{n^2}$ –eV

For ground state, n = 1

$\therefore \quad E_1 = -\frac{13.6}{n^2}$ eV = –13.6 eV

For He^+ ion, Z = 2

For first excited state, n = 2

$E_n = -\frac{4(13.6)}{(2)^2}$ eV = –13.6 eV

Hence, the energy in He^+ ion in first excited state is same that of energy of the hydrogen atom in ground state i.e., – 13.6 eV

6. For a source S_1, Wavelength, $\lambda_1 = 5000$ Å

Number of photons emitted per second, $N_1 = 10^{15}$

Energy of each photon, $E_1 = \dfrac{hc}{\lambda_1}$. Power of source S_1, $P_1 = E_1 N_1 = \dfrac{N_1 hc}{\lambda_1}$

For a source S_1,

Wavelength, $\lambda_2 = 5100$ Å

Number of photons emitted per second, $N_2 = 1.02 \times 10^{15}$

Energy of each photon, $E_2 = \dfrac{hc}{\lambda_2}$

Power of source S_2, $P_2 = N_2 E_2 = \dfrac{N_2 hc}{\lambda_2}$ $\therefore$ $\dfrac{\text{Power of } S_2}{\text{Power of } S_1} = \dfrac{P_2}{P_1} = \dfrac{\dfrac{N_2 hc}{\lambda_2}}{\dfrac{N_2 hc}{\lambda_2}} = \dfrac{N_2 \lambda_1}{N_2 \lambda_2}$

$$\frac{(1.02 \times 10^{15} \text{ photons/s}) \times (5000\text{Å})}{(10^{15} \text{photons/s}) \times (5100\text{Å})} = \frac{51}{51} = 1$$

7. Here, incident wavelength, $\lambda = 200$ nm

Work function, $\phi_0 = 5.01$ eV

According to Einstein's photoelectric equation

$eV_s = h\nu - \phi_0$

$eV_s = \dfrac{hc}{\lambda} - \phi_0$ where V_s is the stopping potential

$eV_s = \dfrac{(1240 \text{ eV nm})}{(200 \text{ nm})} - 5.01 \text{ eV} = 6.2 \text{ eV} - 5.01 \text{ eV} = 1.2 \text{ eV}$

Stopping potential, $V_s = 1.2$ V

The potential difference that must be applied to stop photoelectrons = $-V_s = -1.2$ V

8. The number of photoelectrons ejected is directly proportional to the intensity of incident light. Maximum kinetic energy is independent of intensity of incident light but depends upon the frequency of light. Hence option (2) is correct.

9. Energy released when electron in the atom jumps from excited state (n = 3) to ground state (n = 1) is

$E = h\nu = E_3 - E_1 = \dfrac{-13.6}{3^2} - \left(\dfrac{-13.6}{1^2}\right) = \dfrac{-13.6}{9} + 13.6 = 12.1$ eV

Therefore, stopping potential

$eV_0 = h\nu - \phi_0 = 12.1 - 5.1$ [$\because$ work function $\phi_0 = 5.1$]

$V_0 = 7$V

10. K.E. = $h\nu - h\nu_{th} = eV_0$ (V_0 = cutoff voltage)

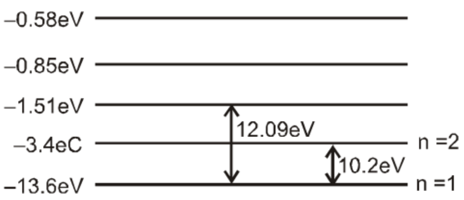
$V_0 = \dfrac{h}{e}(8.2 \times 10^{14} - 3.3 \times 10^{14}) = \dfrac{6.6 \times 10^{-34} \times 4.9 \times 10^{14}}{1.6 \times 10^{-19}} \approx 2$V

11. $KE_{max} = 10$ eV

$\phi = 2.75$ eV

$E = \phi + KE_{max} = 12.75$ eV = Energy difference between n = 4 and n = 1 $\Rightarrow$ value of n = 4

12.



Obviously difference of 11.1eV is not possible.

13. $\dfrac{1}{2}mv^2 = h\upsilon - \upsilon_0$

for Photo electric emission
$\upsilon \geq \upsilon_0$

14. For hydrogen

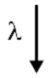
$$\frac{hc}{\lambda} = Rhc\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

for hydrogen like ion

$$\frac{hc}{\lambda} = Z^2 Rhc\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

or $\left(\frac{1}{1} - \frac{1}{2}\right) = Z^2\left(\frac{1}{4} - \frac{1}{16}\right)$ or $Z = 2$

15. 

16. 

microwave, infrared, ultraviolet, gamma rays.

17. $K.E = \phi - \phi_0$
$K.E_1 = 1\text{ ev} - 0.5\text{ ev} = 0.5\text{ ev}$
$K.E_2 = 2.5\text{ ev} - 0.5\text{ ev} = 2\text{ ev}$

$$\frac{K.E_1}{K.E_2} = \frac{0.5\ \text{ev}}{2\ \text{ev}} = \frac{1}{4}$$

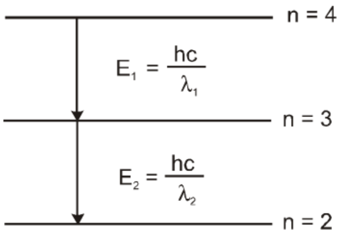
$$\frac{v_1}{v_2} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

18. $\lambda \propto \frac{1}{\sqrt{v}}$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{v_2}{v_1}} = \sqrt{\frac{100\ \text{Kev}}{25\ \text{Kev}}} = 2$$

$$\lambda_2 = \frac{\lambda_1}{2}$$

19. Maximum K.E. = Stopping Potential

20. 

$$E_1 = \frac{hc}{\lambda_1} = 13.6\left[\frac{1}{(3)^2} - \frac{1}{(4)^2}\right] \quad \text{............(1)}$$

$$E_2 = \frac{hc}{\lambda_2} = 13.6\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] \quad \text{.............(2)}$$

dividing $\frac{2}{1}$

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{1}{4} - \frac{1}{9}}{\frac{1}{9} - \frac{1}{16}} = \frac{20}{7}$$

21. Given that

$\left(\frac{hc}{\lambda}\right)\times N = 200\times\frac{25}{100}$ $\Rightarrow$ $N = \frac{200\times 25}{100}\times\frac{\lambda}{hc}$ = $\frac{200\times 25\times 0.6\times 10^{-6}}{100\times 6.2\times 10^{-34}\times 3\times 10^{8}}$ = 1.5 × 10^{20} Ans. (1)

22. For emission

$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ = R $\left(\frac{1}{1^2}-\frac{1}{5^2}\right)$ = R $\left(1-\frac{1}{25}\right)$ $\Rightarrow$ $\frac{1}{\lambda} = R\frac{24}{25}$

linear momentum

P = $\frac{h}{\lambda} = h\times R\times\frac{24}{25}$ = mv = $\frac{24hR}{25}$ = V = $\frac{24hR}{25m}$

23. n → 2 – 1

E = 10.2 eV

kE = E – ϕ

Q = 10.20 – 3.57

h υ_0 = 6.63 eV

$\upsilon_0 = \frac{6.63\times 1.6\times 10^{-19}}{6.67\times 10^{-34}}$ = 1.6×10^{15} Ans. (3)

24. λ = $\frac{h}{p}$ ⇒ λ = $\frac{h}{mv}$

$r = \frac{mv}{qB} \Rightarrow mv$ = qrB ⇒ (2e) (0.83 × 10^{-2}) $\left(\frac{1}{4}\right)$

$\lambda = \frac{6.6\times 10^{-34}\times 4}{2\times 1.6\times 10^{-19}\times 0.83\times 10^{-12}}$ Ans. (4)

25. $\lambda = \frac{h}{P}$

$\frac{d\lambda}{\lambda} = -\frac{dp}{P}$

$\frac{0.5}{100} = \frac{P}{P'}$

P' = 200P

26. K.E_{max} = E–W

$\frac{1}{2}mv_1^2$ = (1 – 0.5) eV = 0.5 eV

$\frac{1}{2}mv_2^2$ = (2.5 – 0.5) eV = 2 eV

$\frac{v_1}{v_2} = \sqrt{\frac{0.5}{2}} = = \frac{1}{\sqrt{4}} = 2$

28. hv_1 = hv + K_{max} ....(i)

h 2v = hv + $\frac{1}{2}$ mV_{max} ⇒ hv = $\frac{1}{2}$ m V_{max} ⇒ V_{max} = $\sqrt{\frac{2hv}{m}}$

29. P = $\frac{E}{C}$ ...(i)

λ_P = $\frac{\hbar C}{E}$ ...(ii)

$\lambda_e^2 = \frac{\hbar h}{\sqrt{2mE}}$

$\lambda_P \propto \lambda_e^2$

30. for lyman series (2 → 1)

$\frac{1}{\lambda_L} = R\left[1-\frac{1}{2^2}\right] = \frac{3R}{4}$

for balmer series (3 → 2)

$\frac{1}{\lambda_B} = R\left[\frac{1}{4}-\frac{1}{a}\right] = \frac{5R}{36} = \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{36}\left(\frac{5}{3}\right) = \frac{5}{27}$

31. $KE_{max} = h\nu - \psi$

$0.5eV = h\nu - \psi$ ....(1)

$0.8eV = 1.2\, h\nu - \psi$ ....(2)

solving $\psi = 1$ eV

32. Energy of the photone $E = \frac{hc}{\lambda} = \frac{1240}{97.5} = 12.75$ eV

This energy is equal to energy gap between n = 1 (– 13.6) and n = 4(–0.85). So by this energy, the electron will excite from n = 1 to n = 4. When the electron will fall back, numbers of spectral lines emmitted $= \frac{n(n-1)}{2} = \frac{(4)(4-1)}{2} = 6$

33. according to De-broglie $P = \frac{h}{\lambda}$

34. $eV_s = \frac{hc}{\lambda} - \Psi$

$3eV_0 = \frac{hc}{\lambda} - \Psi$ .....(1)

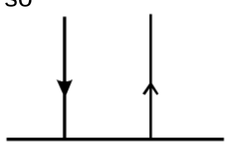
$(eV_0 = \frac{hc}{2\lambda} - \Psi$ .....(2)) × 3

$\frac{3eV_0}{2} = \frac{3hc}{2\lambda} - 3\Psi$

substructing both the equations

$\Psi = \frac{hc}{4\lambda}$

so $\lambda_{th} = \frac{hc}{\Psi} = \frac{hc}{hc/4\lambda} = 4\lambda$

35. 

$\frac{E}{C} = P$

som momentum transfered $\frac{2E}{C}$

36. $KE_{max.} = eV_{st} = \frac{hc}{\lambda} - \psi$

$eV = \frac{hc}{\lambda} - \psi$ ...(i)

$\left(\frac{V}{4}\right) = \frac{hc}{2\lambda} - \psi$ ...(ii)

Solving equation (i) and (ii)

$\psi = \frac{hc}{3\lambda} = \frac{hc}{\lambda_{th}}$ ⇒ $\lambda_{th} = 3\lambda$

37. $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$ ⇒ wave number = $\frac{10^7 m^{-1}}{4}$

38. $\lambda_{electron} = \frac{h}{\sqrt{2ME}}$ …(1)

For λ_{photon}

$E = h\nu = \frac{hc}{\lambda_{photon}}$ …(2)

from these two ratio obtained by dividing these (2)

$\lambda_1 : \lambda_2 = \frac{1}{c}\left[\frac{E}{2M}\right]^{1/2}$

39. K.E. of electrons = $\frac{P^2}{2m} = \frac{\left(\frac{h}{\lambda}\right)^2}{2m} = \frac{h^2}{2m\lambda^2}$

So maximum energy of photon will also be this much.

$\frac{hc}{\lambda_0} = \frac{h^2}{2m\lambda^2}$ ⇒ $\lambda_0 = \frac{2mc\lambda^2}{h}$

40. $k_{max} = h\nu - \phi$

$2eV = 5eV - \phi$ ⇒ $\phi = 3eV$

So $V_{st} = 3$ volt

$V_{cathode} - V_{anode} = 3$ volt

$V_{anode} - V_{cathode} = -3$ volt

41. $\frac{1}{\lambda} = Re\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$\frac{1}{\lambda'} = Re\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$

dividing $\lambda' = \frac{20}{7}\lambda$

42. $\frac{hc}{\lambda} - \frac{hc}{\lambda_{th}} = \frac{1}{2} \times m_e \times v^2$

$V = \sqrt{\frac{2hc}{m_e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_{th}}\right)} = \sqrt{\frac{2 \times 4.14 \times 10^{-15} \times 1.6 \times 10^{-19} \times 3 \times 10^8}{9.1 \times 10^{-31} \times 10^{-10}}\left[\frac{1}{2536} - \frac{1}{3250}\right]}$

Solving this we get

$V = 6 \times 10^5\ ms^{-1}$

43. Last line of Balmer series :

$\frac{1}{\lambda_1} \propto \left(\frac{1}{\infty^2} - \frac{1}{2^2}\right) = \frac{1}{4}$

Last line of Lymen series

$\frac{1}{\lambda_2} \propto \left(\frac{1}{\infty^2} - \frac{1}{1^2}\right) = \frac{1}{1}$

$\Rightarrow \quad \frac{\lambda_1}{\lambda_2} = 4$

44. KE = $\frac{3}{2}KT = \frac{P^2}{2m}$ $\Rightarrow$ P = $\sqrt{3mkT}$

λ = $\frac{h}{p} = \frac{h}{\sqrt{3mKT}}$

45. $KE = \frac{1}{2}mV^2$, Total energy $= \left(-\frac{1}{2}mV^2\right)$

So KE : Total energy = 1 : –1

46. $KE_{max} = \frac{1}{2}mV_{max}^2 = h(\nu - \nu_{th})$

$\frac{1}{2}mV_1^2 = h(2\nu_0 - \nu_0)$

$\frac{1}{2}mV_2^2 = h(5\nu_0 - \nu_0)$

Dividing $\frac{V_2^2}{V_1^2} = \frac{4}{1}$ $\Rightarrow$ $V_2 = 2V_1$ $\Rightarrow$ $\frac{V_1}{V_2} = \frac{1}{2}$

47. v = u + at $\Rightarrow$ $v = v_0 + \left(\frac{eE_0}{m}\right)t$

$\lambda = \frac{h}{P} = \frac{h}{m\left(v_0 + \frac{eE_0}{m}t\right)} = \frac{h}{mv_0\left(1 + \frac{eE_0}{mv_0}t\right)}$

$\lambda = \frac{\lambda_0}{\left(1 + \frac{eE_0}{mv_0}t\right)}$

48. Total energy = – 3.4 eV

K.E. = – (T.E.) = 3.4 eV

P.E. = 2 (T.E) = 2 × (– 3.4 eV) = – 6.8 eV

49. α particle is nucleus of He, so it contains 2 protons and 2 neutrons

50. de Broglie wave length of electron (λ_e) = $\frac{12.27}{\sqrt{v}}$ A°

v = accelerating voltage

$\lambda_e = \frac{12.27}{\sqrt{10000}} \times 10^{-10} m$

$\lambda_e = 12.2 \times 10^{-12}$ m

51. r = $\frac{n^2h^2}{4\pi^2mkze^2}$ $\Rightarrow$ $r \propto \frac{1}{m}$

$\frac{r_1}{r_2} = \frac{m_2}{m_1}$ $\Rightarrow$ $\frac{0.51 \times 10^{-10}}{r_2} = \frac{207m_e}{m_e}$

$\Rightarrow$ $r_2 = 2.56 \times 10^{-13}$ m

E = – $\frac{kze^2}{r}$ $\Rightarrow$ $E \propto \frac{1}{r} \propto m$

$\frac{E_1}{E_2} = \frac{m_1}{m_2} \Rightarrow \frac{-13.6ev}{E_2} = \frac{m_e}{207m_e} \Rightarrow$ $E_2 = 207 \times (-13.6 \text{ ev}) = -2.8$ kev

52. $E = \frac{hC}{\lambda} = \phi$
hc = 12400 Å
$\lambda = \frac{12400 \text{Å eV}}{4eV} = 3100$ Å
λ = 310 nm

53. $\lambda = \frac{h}{\sqrt{2mE}}$
E = same
$\lambda \propto \frac{1}{\sqrt{m}}$
$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_p}} = \sqrt{\frac{4m}{m}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \frac{2}{1}$

PART - II

1. 5 → 4 Transition energy from 5 to 4 will be lessthan from 4 → 3. All other transition energy are higher than that for 4 → 3.

2. $E_\lambda = \frac{1240}{400}$ eV = 3.1 eV
$E_\lambda - k = (3.10 - 1.68)$eV
= 1.42 eV
Q < 1.42 eV

3. Energy of X-rays-photon is greater then ultraviolet photon.
So, V_0 and K_{max} increases.
Electrons have speed ranging from 0 to maximum, because before emitting a large number of collisions take place and energy is lost in collision.

4. Energy of each photon = $\frac{4000}{10^{20}} = 4 \times 10^{17}$
$\lambda = \frac{12400 \times 1.6 \times 10^{-19}}{4 \times 10^{-17}}$ $A_0 = 49.6$ Å
It is in X-ray spectrum.

5. $E_1 = -\frac{13.6(3)^2}{(1)^2} \Rightarrow E_3 = -\frac{13.6(3)^2}{(3)^2}$
∴ $\Delta E = E_3 - E_1 = 13.6(3)^2 \left[1 - \frac{1}{9}\right] = \frac{13.6 \times 9 \times 8}{9} \Rightarrow \Delta E = 108.8$ eV.

6. $hv = hv_0 + k_{max}$
$k_{max} = hv - hv_0$

7. $P_i = 0$
$P_f = P_1 + P_2$
$P_i = P_f$
$0 = P_1 + P_2$
$(P_1 = -P_2)$
$\lambda_1 = \frac{h}{P_1} \Rightarrow \lambda_2 = \frac{h}{P_2}$

$|\lambda_1| = |\lambda_2|$
$\lambda_1 = \lambda_2 = \lambda$.

8. If n = 4

lines = $\frac{n(n-1)}{2} = 6$

9. As λ is increased, there will be a value of λ above which photoelectrons will be cease to come out so photocurrent will become zero. Hance (4) is correct answer.

10. $r = \frac{mv}{eB} \Rightarrow \frac{r^2e^2B^2}{2} = \frac{m^2v^2}{2}$

$\frac{r^2e^2B^2}{2m} = \frac{mv^2}{2}$

$1.89 - \phi = \frac{r^2e^2B^2}{2\ m}\frac{1}{e}\ eV = \frac{r^2e\ B^2}{2\ m}\ eV = \frac{100\times10^{-6}\times1.6\times10^{-19}\times9\times10^{-8}}{2\times9.1\times10^{-31}}$

$\phi = 1.89 - \frac{1.6\times9}{2\times9.1} = 1.89 - 0.79 \cong 1.1\ eV$

11. $\frac{1}{\lambda} = Rz^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right)$

$\frac{1}{\lambda_1} = R\ \ (1)^2\left(\frac{3}{4}\right)$ $\frac{1}{\lambda_2} = R\ \ (1)^2\left(\frac{3}{4}\right)$ $\Rightarrow$ $\frac{1}{\lambda_3} = R\ \ 2^2\left(\frac{3}{4}\right)$ $\frac{1}{\lambda_4} = R\ \ 3^2\left(\frac{3}{4}\right)$

$\frac{1}{\lambda_1} = \frac{1}{4\lambda_3} = \frac{1}{9\ \lambda_4} = \frac{1}{\lambda_2}$ So option (3) is correct

12. $KE \propto \left(\frac{Z}{n}\right)^2$

as n decreases KE increases and TE, PE decreases

13. (1) Frants – Hertz Experiment is associated with Discrete energy levels of atom
(2) Photo electric experiment is associated with particle nature of light and Davison – Germer experiment is associated with wave nature of electron.

14. $\frac{hc}{\lambda} = w + \frac{1}{2}mv^2$ …(i)

$\frac{hc}{\lambda'} = w + \frac{1}{2}m(v')^2$

$\frac{hc}{\left(\frac{3\lambda}{4}\right)} = w + \frac{1}{2}m(v')^2$ …(ii)

equation $\left[(i) \times \frac{4}{3}\right] - (ii)$

$\frac{4hc}{3\lambda} - \frac{4}{3}\frac{hc}{\lambda} = \frac{4}{3}w + \frac{4}{3}\left(\frac{1}{2}mv^2\right) - w - \frac{1}{2}m(v')^2$

$\Rightarrow \frac{4}{3}w + \frac{4}{3}\left(\frac{1}{2}mv^2\right) = w + \frac{1}{2}m(v')^2$

$\Rightarrow \frac{1}{2}m(v')^2 = \frac{w}{3} + \frac{4}{3}\frac{1}{2}mv^2$

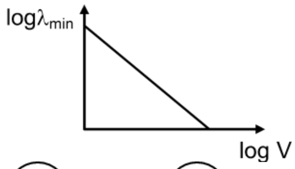
$\Rightarrow \frac{1}{2}m(v')^2 > \frac{4}{3}\left(\frac{1}{2}mv^2\right)$

$\Rightarrow v' > \sqrt{\frac{4}{3}}v$

15. $eV = \frac{hc}{\lambda_{min}} \Rightarrow \lambda_{min} = \frac{12400}{eV}$

$\log(\lambda_{min}) = \log(12400) - \log(e) - \log(V)$

$\log\lambda_{min.} = C - \log V \Rightarrow Y = C - mx$



16.

Momentum Conservation

$mv = mv_A + \frac{m}{2} v_B$ ...(i)

$e = \frac{v_B - v_A}{v} = 1$ ...(ii)

$2(v_B - v_A) = 2v_A + v_B$

$2v_B - v_B = 4v_A$

$v_B = 4v_A$

$\frac{\lambda_A}{\lambda_B} = \frac{m_B v_B}{m_A v_A} = \frac{m/2}{m} \times 4 = 2$

17. $(-E) - (-2E) = \frac{hc}{\lambda_1}$ ...(i)

$(-E) - (-\frac{4}{3}E) = \frac{hc}{\lambda_2}$ ...(ii)

Equation (ii) / (i)

$\frac{\frac{4}{3} - 1}{2 - 1} = \frac{\lambda_1}{\lambda_2} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{1}{3}$

18. $h\nu_L = 13.6$ ev

$h\nu_p = \frac{13.6}{25}$ ev $\Rightarrow \frac{\nu_L}{\nu_P} = 25 \Rightarrow \nu_P = \frac{\nu_L}{25}$

19. $V_n = \left(\frac{2\pi Ke^2}{h}\right)\frac{1}{n} \Rightarrow E_n = -\frac{1}{2}mv_n^2$

$\lambda_n = \frac{h}{mv_n} = \left(\frac{h^2}{m2\pi Ke^2}\right)n \Rightarrow \lambda_n >>> \lambda_g$

$\frac{hc}{\Lambda_n} = E_n - E_1 = \frac{1}{2}m\left(v_1^2 - v_n^2\right) \Rightarrow \frac{hc}{\Lambda_n} = \frac{1}{2}m\left(\left(\frac{h}{m\lambda_g}\right)^2 - \left(\frac{h}{m\lambda_n}\right)^2\right)$

$\Rightarrow \frac{hc}{\Lambda_n} = \frac{h^2}{2m}\left(\frac{1}{\lambda_g^2} - \frac{1}{\lambda_n^2}\right) = \frac{h^2}{2m\lambda_g^2}\left(1 - \frac{\lambda_g^2}{\lambda_n^2}\right) \Rightarrow \frac{\Lambda_n}{hc} = \frac{2m\lambda_g^2}{h^2}\frac{1}{\left(1 - \frac{\lambda_g^2}{\lambda_n^2}\right)}$

since $\frac{\lambda_g}{\lambda_n} <<< 1$ so using binomial expansion

$\Lambda_n = \left(\frac{2mc\lambda_g^2}{h}\right)\left(1 + \frac{\lambda g^2}{\lambda_n^2}\right) \Rightarrow \Lambda_n = A + \frac{B}{\lambda_n^2}$

20. $\frac{hc}{\lambda_1} = \phi + \frac{1}{2}m(2v)^2$

$$\frac{hc}{\lambda_2} = \phi + \frac{1}{2}m(v)^2$$

$$3\frac{1}{2}mv^2 = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$$

$$\frac{1}{2}mv^2 = \frac{1}{3}\left(\frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}\right)$$

$$\frac{hc}{\lambda_2} - \frac{1}{2}mv^2 = \phi$$

$$\frac{hc}{\lambda_2} - \frac{hc}{3\lambda_1} + \frac{hc}{3\lambda_2} = \frac{4}{3}\frac{hc}{\lambda_2} - \frac{hc}{3\lambda_1}$$

$$\frac{4}{3} \times \frac{1240}{540}eV - \frac{1240}{3 \times 350}eV$$ = 1.87 eV

21. B = B_0[sin (3.14 × 10^7ct) + sin (6.28 × 10^7 ct)].
ω = 2π × 10^7 × 3 × 10^8 = 2πf
⇒ f = 3 × 10^{15} Hz

$\lambda = \frac{C}{f}$ = 1000Å

$E = \frac{12400}{1000}eV = 12.4eV$

$K_{max} = E - \phi$ = 12.4 – 4.7 = 7.7 eV

22. $\lambda(\text{Å}) = \sqrt{\frac{150}{V}}$ ⇒ 7.5 × 10^{-2} = $\sqrt{\frac{150}{V}}$

$V = \frac{150}{7.5 \times 7.5 \times 10^{-4}} = \frac{80}{3}kV$. Nearby value is 25 keV

23. Energy of radiation = $\frac{12500}{980}$ = 12.75eV

Energy of electron in n^{th} orbit = $-\frac{13.6}{n^2}$

⇒ $E_n - E_1 = -13.6\left[\frac{1}{n^2} - \frac{1}{1^2}\right]$ ⇒ $12.75 = 13.6\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$ ⇒ n ≈ 4
Electron will transit to n = 4
New radius will be $16a_0$.

24. For photon $\nu = \frac{C}{\lambda}$

$\lambda_p = \frac{C}{\nu} = \frac{3 \times 10^8}{6 \times 10^{14}} = \frac{1}{2} \times 10^{-6}m$

For electron

$\lambda_e = 10^{-3} \times \lambda_p = \frac{10^{-9}}{2}m$

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

$V = \frac{h}{\lambda m} = \frac{6.63 \times 10^{-34}}{\frac{1}{2} \times 10^{-9} \times 9.1 \times 10^{-31}}$ = 1.45 × 10^6 m/s

25. From M orbit to L orbit :

$$\frac{hc}{\lambda_1} = (13.6\text{eV})Z^2\left(\frac{1}{4}-\frac{1}{9}\right) \quad \text{...(i)}$$

From N orbit to L orbit :

$$\frac{hc}{\lambda_2} = (13.6\text{eV})Z^2\left(\frac{1}{4}-\frac{1}{16}\right) \quad \text{...(ii)}$$

dividing (i) by (ii)

$$\frac{\lambda_2}{\lambda_1} = \frac{5}{36}\times\frac{64}{12} = \frac{20}{27} \quad \Rightarrow \quad \lambda_2 = \frac{20}{27}\lambda_1$$

26. $V_{s_1} = \frac{1240}{300} - \phi \quad \Rightarrow \quad V_{s_2} = \frac{1240}{400} - \phi$

$$V_{s_1} - V_{s_2} = \frac{1240}{300} - \frac{1240}{400} = 4.13 - 3.1 = 1.03 \approx 1$$

27. $F_r = \frac{-dU}{dr} = -kr$ for circular motion

$$|F_r| = kr = \frac{mv^2}{r} \Rightarrow kr^2 = mv^2 \quad \text{............. (1)}$$

Bohr's quantization $\Rightarrow mvr = \frac{nh}{2\pi}$ .... (2)

from (1) & (2)

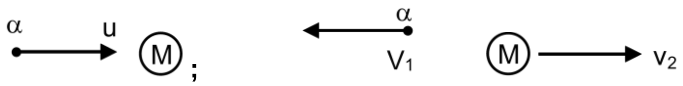
$$\frac{m^2v^2}{m} = kr^2$$

$$\Rightarrow \frac{1}{m}\left(\frac{nh}{2\pi r}\right)^2 = kr^2 \quad \Rightarrow \quad \frac{n^2h^2}{4\pi^2 mk} = r^4 \quad \Rightarrow \quad r = \left(\frac{h^2}{4\pi^2 mk}\right)^{1/4} n^{1/2}$$

$r \propto \sqrt{n}$ from equation (1) $U \propto \sqrt{n}$

KE = $\frac{1}{2}mv^2$ PE = $\frac{1}{2}kr^2 \Rightarrow$ E = K + U = $\frac{1}{2}mv^2 + \frac{1}{2}kr^2 = kr^2 \propto n$

28. $\lambda = \frac{h}{\sqrt{2mqV}} \quad \Rightarrow \quad \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{4\times 1\times 2500}{1\times 1\times 50}} = 10\sqrt{2} = 14.14$

29. 

Conserving momentum : $mu = -mv_1 + MV_2$ ...(1)

Collision of nuclear particle to be elastic

$$e = \frac{v_2 + v_1}{u} = 1$$

$\therefore$ $v_2 = u - v_1$ ...(2)

$v_1 = 0.6\,u$

$1.6\,m = 0.4\,M$

$M = 4\,m$

30. $h\nu = W + \frac{V_0}{2}e$

$$\frac{h\nu}{2} = W + V_0 e$$

on solving we get, $W = \frac{3}{2}h\nu \quad \Rightarrow \quad h\nu_0 = \frac{3}{2}h\nu \quad \Rightarrow \quad \nu_0 = \frac{3}{2}\nu$

31. Energy retained by mercury vapor = 5.6 – 0.7 eV = 4.9 eV

$$\lambda = \frac{12400}{4.9} \approx 2500 \text{Å}$$