MODERN PHYSICS

SOLUTIONS

Q.1. 400 μS

Q.2. Activity $= \lambda N = \frac{0.693}{(T_{1/2})} N_0$

Where $N_0 = \frac{6 \times 10^{-3}}{215} \times 6.023 \times 10^{23} = 16.8 \times 10^{19}$

$A = \frac{0.693}{100 \times 10^{-6}} \times 16.8 \times 10^{19} = 1.165 \times 10^{24}$ Becqurel

Q.3. Moseley's law

$\frac{1}{\lambda} = R(z-1)^2\left(1 - \frac{1}{n^2}\right)$ for K- lines where n =2,3,4,....................

(a) For K-absorption edge

$(z-1) = \sqrt{\frac{1}{\lambda R}}$

or z = $\sqrt{\frac{1}{(0.171 \times 10^{-10})(1.097 \times 10^{7})}} + 1 = 74$

The element is Tungsten.

(b) K_α-line $\frac{1}{\lambda_\alpha} = R(74-1)^2\left[1 - \frac{1}{2^2}\right]$

$\lambda_\alpha = 0.228 A^\circ$

K_β -line $\frac{1}{\lambda_\beta} = R(74-1)^2\left[1 - \frac{1}{3^2}\right]$

$\lambda_\beta = 0.192 A^\circ$

$K\gamma$ - line $\frac{1}{\lambda\gamma} = R(74-1)^2\left[1 - \frac{1}{4^2}\right]$

$\lambda\gamma = 0.182 A^\circ$

(c) Cut off wavelength

$\lambda_{min} = \frac{hc}{E} = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{100 \times 1.6 \times 10^{-19}} = 124 A^\circ$

Q.4. The speed of light in a
ny medium is given as

$v = \frac{C}{n}$ where C = 3×10^8 m/sec.

The ratio of speeds of light in water and glass is given as

$$\frac{v_w}{v_g} = \frac{C/n_w}{C/n_g} = \frac{n_g}{n_w}$$

Since frequency f of light does not change, $v_w = \lambda_w f$ and $v_g = \lambda_g f$ we obtain,

$$\frac{v_w}{v_g} = \frac{\lambda_w}{\lambda_g} = \frac{n_g}{n_w}$$

$$\Rightarrow \quad \frac{\lambda_w}{\lambda_g} = \frac{3/2}{4/3} = \frac{9}{8}$$

$$\Rightarrow \quad \frac{\lambda_w - \lambda_g}{\lambda_g} = \frac{9-8}{8} = \frac{1}{8}$$

$$\Rightarrow \quad \frac{\Delta\lambda}{\lambda_g} = \frac{1}{8}.$$

Q.5. Momentum of a photon = h/λ

momentum of electron = mv

so $\lambda = h / mv$

$$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2 \times 10^5}$$

λ = 3.6 nm

Q.6. $$\frac{N}{N_0} = \frac{1}{e^{(\lambda T_{1/2})}} = \frac{1}{2^{t/T_{1/2}}}$$

also $\frac{N_1}{N_0} = \frac{1}{4}$ or $t_1 = 2T_{1/2}$

& $\frac{N_2}{N_0} = \frac{1}{8}$ or $t_2 = 3T_{1/2}$

$\Delta t = 10 = t_2 - t_1 = T_{1/2}$

$T_{1/2}$ = 10 sec.

$T_{mean} = \frac{T_{1/2}}{0.693}$ = 14.43 sec.

Q.7. $\sqrt{\nu}$ = a(z - b)

$$\therefore \quad \sqrt{\frac{c}{\lambda_1}} = a(z_1 - b) \qquad \text{. . . . (i)}$$

$$\& \quad \sqrt{\frac{c}{\lambda_2}} = a(z_2 - b) \qquad \text{. . . (ii)}$$

From (i) - (ii), $\sqrt{c}\left[\frac{1}{\sqrt{\lambda_1}}-\frac{1}{\sqrt{\lambda_2}}\right]$ = a(z_1 - z_2)

$\Rightarrow$ a = 5×10^7 $(Hz)^{1/2}$

From (i) /(ii), $\sqrt{\frac{\lambda_2}{\lambda_1}} = \frac{z_1 - b}{z_2 - b} \Rightarrow$ b = 1.37

Q.8. Removal of an electron results into He^+, and energy required to remove an electron from He^+ = $z^2 \times$ 13.6 eV
= 4 × 13.6 = 54.4 eV
so total energy required
= 54.4 + 24.6
= 79 eV.

Q.9. According to Bohr theory

$$\frac{1}{\lambda} = RZ^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

Thus $\lambda \, \alpha \, \frac{1}{Z^2}$

More the atomic number, smaller is the wavelength obtained in the transition of electron (for identical transition).

Q.10. $\sqrt{v} = R(Z-b)$

or $\frac{1}{\lambda} \, \alpha \, (Z-1)^2$ (If b is small)

$\Rightarrow$ $\frac{\lambda_u}{\lambda_{si}} = \left(\frac{46}{91}\right)^2$

λ_u = 0.146 A°

Q.11. $E_2 - E_1 = hc\left[\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right]$

$= \frac{hc}{\lambda_1 \lambda_2}(\lambda_1 - \lambda_2)$

taking approximation that
if $\lambda_y \approx \lambda_2$ then

$\frac{\lambda_1 + \lambda_2}{2} = (\lambda_1 \lambda_2)^{1/2}$

$E_2 - E_1 = 2 \times 10^{-3}$ eV.

Q.12. $\frac{hc}{\lambda_1}+\frac{hc}{\lambda_2}=\frac{hc}{\lambda_3}$

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

Q.13. $\frac{dN}{dt}=n-\lambda N$

$\int_{N_0}^{N}\left(\frac{dN}{n-\lambda N}\right)=\int_0^t dt$

$\frac{1}{\lambda}\ln\left(\frac{n-\lambda N_0}{n-\lambda N}\right)= t$

$\Rightarrow\ N = \frac{n}{\lambda}+\left(N_0-\frac{n}{\lambda}\right)e^{-\lambda t}$

Q.14. Current is independent of work function of metal. It depends on photon density only hence $I_1= I_2$

Q.15. Let at time 't' number of radioactive nuclear be N.

Net rate of formation of nuclear of A is $\frac{dN}{dt}$ = $\alpha - \lambda N$

Or, $\frac{dN}{\alpha-\lambda N}$ = dt

or $\int_{N0}^{N}\frac{dN}{\alpha-\lambda N}$ = $\int_0^t dt$ $\Rightarrow$ this gives N = $\frac{1}{\lambda}\left[\alpha-(\alpha-\lambda N_0)e^{-\lambda t}\right]$

Q.16. $\frac{hc/\lambda_1-\phi}{hc/\lambda_2-\phi}=\frac{2}{1}$

ϕ = 1.05 eV

Q.17. $\sqrt{v}\ = R(Z-b)$

or $\frac{1}{\lambda}\ \alpha\ (Z-1)^2$ (If b is small)

$\Rightarrow$ $\frac{\lambda_u}{\lambda_{si}}=\left(\frac{46}{91}\right)^2$

λ_u = 0.146 A°

Q.18. $\frac{hc/\lambda_1-\phi}{hc/\lambda_2-\phi}=\frac{2}{1}$

ϕ = 1.05 eV

Q.19. Q = total energy released

$= \frac{1}{2} m_\alpha v_\alpha^2 + \frac{1}{2} m_y v_y^2$ . . . . . (i)

by conservation of momentum

$m_\alpha v_\alpha + m_y v_y = 0$ . . . . . (ii)

from equation (i) and (ii)

$Q = \frac{1}{2} m_\alpha v_\alpha^2 \left(1 + \frac{m_\alpha}{m_y}\right)$

$\Rightarrow Q = 5.3410$ MeV

also $Q = (M_x - m_y - m_\alpha) \times 931.5$

$\Rightarrow M_x = 239.048$ amu.

Q.20. Velocity of neutrons = $\sqrt{\frac{2eV}{m_n}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 0.0327}{1.67 \times 10^{-27}}}$

$= \sqrt{6.29 \times 10^6}$ m / s $= 2.5 \times 10^3$ m/s

Time taken by neutron to cover the distance 10 m

$t = \frac{10}{2.5 \times 10^3} = 4 \times 10^{-3}$ seconds

Now $\frac{N}{N_0} = e^{-\lambda t}$

where N is number of neutron after t seconds i.e. fraction of neutron decayed after t seconds will be

$1 - \frac{N}{N_0} = e^{-4 \times 10^{-3} \times 9.9 \times 10^{-4}}$

$\lambda = \frac{0.693}{700} = 9.9 \times 10^{-4}$ / sec $= 4 \times 10^{-6}$

Q.21. According to Moseley's equation for k_α radiation ;

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

$\frac{\lambda_1}{\lambda} = \frac{(z-1)^2}{(z_1-1)^2} = \frac{0.7092}{1.5405}$

z = 29 for cu, hence $z_1 - 1 = 28 \sqrt{\frac{1.5405}{1.6578}} = 27$

or $z_1 = 4z$

$\therefore$ Impurity is molybdenum

similarly ; $\frac{\lambda_2}{\lambda_1} = \frac{(z-1)^2}{(z_2-1)^2} = \frac{1.65768}{1.5405}$

or $z_2 - 1 = 28 \sqrt{\frac{1.5405}{1.6578}} = 27$

$z_2 = 28$

It is atomic number of Nickel.

Hence the other impurity is Nickel.

Q.22. Energy of a photon $= E = \frac{hc}{\lambda} = \frac{12400}{6000} = 206$ eV

$= 2.06 \times 1.6 \times 10^{-19}$ J

$= 3.3 \times 10^{-19}$ J

Photon flux $= \frac{IA}{E} = \frac{1400 \times 1}{3.3 \times 10^{-19}}$

$= 4.22 \times 10^{21}$ photon/sec.

Q.23. Momentum of the photon , p= $\frac{E}{c} = \frac{\left(1.33 \times 10^{6}\right)\left(1.6 \times 10^{-19}\right)}{3 \times 10^{8}}$

$= 7.09 \times 10^{-22}$ kgms^{-1}

Using momentum conservation recoil energy of the

$^{60}\mathrm{Ni}$ is $E = \frac{p^2}{2m} = \frac{\left(7.09 \times 10^{-22}\right)^2}{2\left(60 \times 1.67 \times 10^{-27}\right)} = 2.51 \times 10^{-18}$ J $= 1.57 \times 10^{-5}$ MeV

Recoil speed of the nucleus, v = $\frac{p}{m} = \frac{7.09 \times 10^{-22}}{60 \times 1.67 \times 10^{-27}} = 7.07 \times 10^{3}\ \mathrm{m/s}$

Q.24. (i) Energy of each photon $= E = \frac{hc}{\lambda} = 3.975 \times 10^{-19}$ J

No. of photons falling on surface per second & being absorbed,

$n = \frac{10J}{2.48eV} = 2.52 \times 10^{19}$ eV

(ii) The linear momentum of each photon $= p = \frac{h}{\lambda} = \frac{h\nu}{c}$

$\therefore$ Total momentum of all photons (falling in one sec.)

$= \frac{nh\nu}{c} = \frac{10J}{3 \times 10^{8}} = 3.33 \times 10^{-8}$ N-s

Rate of change of momentum = Force $= \frac{dp}{dt} = 3.33 \times 10^{-8}$ N.

Q.25. By relation,

$eV = \frac{hc}{\lambda} - \phi$, where ϕ is work function

Differentiating w.r.t. λ, we get

$e\frac{dV}{d\lambda} = -\frac{hc}{\lambda^2}$

or $dV = -\frac{hc}{\lambda^2 e} d\lambda$

$$dv = -\frac{6.623\times10^{-34}\times3\times10^{8}\times2\times10^{-10}}{(4000\times10^{-10})^2(1.6\times10^{-19})}$$

= - 1.56 mV.

Q.26. Moseley's law

$$\frac{1}{\lambda} = R(z-1)^2\left(1-\frac{1}{n^2}\right)$$ for K- lines where n =2,3,4,....................

For K-absorption edge

$$(z-1) = \sqrt{\frac{1}{\lambda R}}$$

$$\text{or } z = \sqrt{\frac{1}{(0.171\times10^{-10})(1.097\times10^{7})}} + 1 = 74$$

The element is Tungsten.

Q.27. Current is independent of work function of metal. It depends on photon density only hence

$$\frac{I_1}{I_2} = 1$$

Q.28. Velocity of neutrons = $\sqrt{\frac{2eV}{m_n}} = \sqrt{\frac{2\times1.6\times10^{-19}\times0.0327}{1.67\times10^{-27}}}$

$= \sqrt{6.29\times10^{6}}$ m/s = 2.5 × 10^3 m/s

Time taken by neutron to cover the distance 10 m

$$t = \frac{10}{2.5\times10^{3}} = 4\times10^{-3} \text{ seconds}$$

Now $\frac{N}{N_0} = e^{-\lambda t}$

where N is number of neutron after t seconds i.e. fraction of neutron decayed after t seconds will be

$$1-\frac{N}{N_0} = e^{-4\times10^{-3}\times9.9\times10^{-4}}$$

$\lambda = \frac{0.693}{700} = 9.9\times10^{-4}$ / sec = 4 × 10^{-6}

Q.29. At time t lets say there are N atoms. In time dt, dN_1 decays and dN_2 produces

$dN_2 = \frac{10^{-4}\times dt}{1.6\times10^{-19}\times1000}$ $dN_1 = -\lambda N\, dt$.

Total production in time dt $dN = \left(\frac{1}{1.6\times10^{-12}} - \lambda N\right)dt$

$$\int_0^{N_0}\frac{dN}{6.25\times10^{-11}-\lambda N} = \int_0^{3600} dt$$

$- \frac{1}{\lambda}\log\frac{6.25\times10^{11} - \lambda N_0}{6.25\times10^{11}} = 3600$

$\lambda N_0 = 1.8 \times 10^8$. (given) $\Rightarrow$ $\lambda = 8 \times 10^{-8}$

$t_{1/2} = \frac{0.6931}{8\times10^{-8}} = 8.66 \times 10^6$ sec.

= 100.26 days.

Q.30. $\bar{\nu} = \frac{1}{\lambda} RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\frac{1}{121\times10^{-7}} = 109678\times4\left(\frac{1}{2^2} - \frac{1}{n_2^2}\right)$

$n_2 = 4$

no. of revolution per second = $\frac{\text{velocity in that orbit}}{\text{circumference}}$

$f = \frac{v_0 n / z}{2\pi\times\frac{n^2}{z} r_0} = 4.09 \times 10^{14}$ Hz.

Q.31. $E_n - E_1 = \frac{hc}{\lambda}$

after putting the values we get

n = 4

possible lines in the resulting emission spectrum = 6.

Q.32. $\frac{N_3}{N_0} = \left[1 + \frac{\lambda_1}{\lambda_2 - \lambda_1}e^{-\lambda_2 t} - \frac{\lambda_2}{\lambda_2 - \lambda_1}e^{-\lambda_1 t}\right]$ $\lambda_1 = \frac{0.6931}{30}$ $\lambda_2 = \frac{0.6931}{45}$, t = 60 min.

$= [1 + (-3)\,(2)^{-4/3} - (-2)\,(2)^{-2}]$

$= [1 - 3 \times (2)^{-4/3} + 2(2)^{-2}] = 0.71$

Q.33. $E = \frac{hC}{\lambda} = \phi + (KE)_{max}$

$\Rightarrow 3.1 = 2.5 + (KE)_{max}$

$\therefore$ $(KE)_{max} = 0.6$ ev $= 0.6 \times 1.6 \times 10^{-19}$ J $= 9.6 \times 10^{-20}$ J

$p = \sqrt{2mK} = \sqrt{2\times9.1\times10^{-31}\times9.6\times10^{-20}}$

$= 4.2 \times 10^{-25}$ kg – m/sec

Q.34. (a) $E_n = \frac{-13.6Z^2}{n^2}$

Excitation energy = $\Delta E = E_3 - E_1 = -13.6 \times (3)^2\left[\frac{1}{3^2} - \frac{1}{1^2}\right]$

$= +13.6 \times (9)\,[1 - 1/9] = 13.6 \times (9)\,(8/9) = 108.8$ eV.

Wavelength $\lambda = \frac{hc}{\Delta E} = \frac{(6.63\times10^{-34})(3\times10^{8})}{108.8\,(1.6\times10^{-19})}$ = 114.3 A°

(b) From the excited state (E_3), coming back to ground state, there can be $^3C_2$ = 3 possible radiations.

Q.35. Mass defect

$\Delta m = (2 \times 2.0141 - 4.0026)$ amu

or $\Delta m = (2 \times 2.0141 - 4.0026) \times 931$ MeV

Energy used in reactor per reaction

$= \frac{25}{100}(2 \times 2.0141 - 4.0026) \times 931 = 5.9584$ MeV

$= 9.5334 \times 10^{-13}$ Joule.

Total energy obtained per day

= (200) MW × 24 × 60 × 60 sec.

Mass of deuterium required

$= \frac{(0.6691\times10^{-21})(200\times10^{6}\times24\times60\times60)}{9.5334\times10^{-13}}$ = 120 g.

Q.36. $\frac{dN}{dt} = q - \lambda N$

q = rate of production of nuclei

N = number of nuclei in radionuclide at any instant

λ = decay constant = $\frac{\ln 2}{T}$

T = half life

$\frac{dN}{dt} = q - \lambda N = q - \frac{N\ln 2}{T}$

$\frac{dN}{dt} = \frac{qT - N\ln 2}{T}$

$\frac{dN}{qT - N\ln 2} = \frac{dt}{T}$ . . . (1)

integrating equation (1)

$\int_0^N \frac{dN}{qT - N\ln 2} = \frac{1}{T}\int_0^t dt$

$N = \frac{qT}{\ln 2}\left(1 - e^{-\frac{t\ln 2}{T}}\right) = \frac{1000\times1620}{\ln 2}\left(1 - e^{-\frac{3240\ln 2}{1620}}\right) = 1.753 \times 10^{6}$

Hence, rate of decay $A = \lambda N = q\left(1 - e^{-\frac{t\ln 2}{T}}\right)$

Hence rate of release of energy at this time,

$= AE_0 = qE_0\,(1 - e^{-t\ln 2/T}) = 1000 \times 200\,(1 - e^{(3240 \times \ln 2/1620)})$
$= 150 \times 10^3$ MeV/sec.
Total number of nuclei decayed upto this time $= q \times t - N$
hence total energy released upto this time
$= (qt - N)\,E_0 = 297.43 \times 10^6$ MeV.

Q.37. Let at time 't' number of radioactive nuclear be N.

Net rate of formation of nuclear of A is $\frac{dN}{dt} = \alpha - \lambda N$

Or, $\frac{dN}{\alpha - \lambda N} = dt$

or $\int_{N0}^{N} \frac{dN}{\alpha - \lambda N} = \int_0^t dt \Rightarrow$ this gives $N = \frac{1}{\lambda}\left[\alpha - (\alpha - \lambda N_0)e^{-\lambda t}\right]$

Q.38. (a) $E = \frac{hC}{\lambda} = \phi + (KE)_{max}$

$\frac{1242}{400} = \phi + (KE)_{max}$

$3.1 = 2.5 + (KE)_{max}$

$(KE)_{max} = 0.6$ ev $= 0.6 \times 1.6 \times 10^{-19}$ J $= 9.6 \times^{-20}$ J

$p = \sqrt{2mK} = \sqrt{2 \times 9.1 \times 10^{-31} \times 9.6 \times 10^{-20}}$

$= 4.2 \times 10^{-25}$ kg – m/sec

(b) Stopping potential $\frac{(KE)_{max}}{e} = 0.6$ volt

Q.39. Let λ be decay constant

$\frac{dN}{dt} = \alpha - \lambda N$ = Rate of formation of nuclei

$\frac{dN}{\alpha - \lambda N} = dt$

Integrating both side we get

$\ln(\alpha - \lambda N)\Big|_0^n = -\lambda t$

i.e. $\ln\left[\frac{\alpha - \lambda N}{\alpha}\right] = -\lambda t$

(at t = 0, N = 0)

$\frac{\alpha - \lambda N}{\alpha} = e^{-\lambda t}$

i.e. $N = \frac{\alpha(1 - e^{-\lambda t})}{\lambda}$

so as $t \to \infty$, $e^{-\lambda t} \to 0$

so after very long time

$N = \frac{\alpha}{\lambda} = \text{constant}$

or N = $\dfrac{\alpha T_{1/2}}{0.693}$

Q.40. The maximum energy of photon during de-excitation will be if transition takes place between (2n) states to ground state.

hence, 204 = 13.6 $\left(\dfrac{1}{1} - \dfrac{1}{4n^2}\right)z^2$ … (i)

also 40.8 = 13.6 $\left(\dfrac{1}{n^2} - \dfrac{1}{4n^2}\right)z^2$ … (ii)

dividing (i) by (ii) we get

5 = $\dfrac{4n^2 - 1}{3}$ $\Rightarrow$ n = 2

substituting n = 2 in equation (i)

15 = $\dfrac{15}{16}z^2$

$\Rightarrow$ z^2 = 16 or z = 4

The minimum energy during de-excitation will be if transition takes place between two outer most adjacent orbit. i.e. n = 4 to 3.

ΔE_{min} = 13.6 $\left(\dfrac{1}{3^2} - \dfrac{1}{4^2}\right)4^2$

= 10.57 eV

Q.41. Mass defect $\Delta m = 2m_D - m_T - m_P$

= 2 $\times$ 2.01458 – 3.01605 – 1.00728

= 0.00583 amu.

hence $\Delta E = 0.00583 \times 930 \times 1.6 \times 10^{-19} \times 10^{6}$

= 8.675×10^{-13} J

The efficiency of the retardation is 60 %

$\Delta E_{available} = 0.6 \times 8.675 \times 10^{-13}$ J

= 5.205×10^{-13} J

Total energy required in one hour

E = $10^8 \times 3600 = 36 \times 10^{10}$ J

Hence number of deuterium nuclides required

= $\dfrac{2E}{\Delta E} = 1.38 \times 10^{24}$

Q.42. (i) A = 228 + 4 = 232

& 92 = z + 2 $\therefore$ z = 90

(ii) $\dfrac{m_\alpha v_\alpha^2}{r} = qv_\alpha B$ $\therefore$ $v_\alpha = 1.59 \times 10^7$ m/s

From COM, $m_\alpha v_\alpha = m_y v_y$

Thus, energy released or the sum of kinetic energies of the products

= $\dfrac{1}{2}\left[m_\alpha v_\alpha^2 + \dfrac{m_\alpha^2 v_\alpha^2}{m_y}\right]$

= 5.342 MeV
= 0.0057 amu.
Applying COE,
Mass of $_{92}X^{232}$ = $m_y + m_\alpha + 0.0057$ amu.
= 232.0387 amu
$\therefore$ Mass defect = 92 (1.008) + 140 (1.009) - 232.0387
= 1.9573 amu = 1823 MeV

Q.43. Reactant / Products

Reactant		Products	
$^{23}_{10}Ne$	22.9945-10m_e	$^{23}_{11}Na$	22.9898-11m_e
		$^{0}_{-1}\beta$	m_e
		$\bar{\nu}$	0
Total	22.9945-10m_e		22.9898-10m_e

mass defect = 22.9945-22.9898=0.0047u
Since, 1u = 931.4 MeV
$\therefore$ Energy release = (0.0047)(931.4)
= 4.4MeV
The major portions of this energy is shared by β particle and anti-neutrino. Hence the energy range of
β - particle varies from 0 to 4.4 Mev.

Q.44. $h\nu_1 = 13.6 \times (2)^2 \times 1.6 \times 10^{-19}\left[\frac{1}{n^2} - \frac{1}{(n+1)^2}\right]$

$h\nu_f = 13.6 \times (2)^2 \times 1.6 \times 10^{-19}\left[\frac{1}{n^2} - \frac{1}{\infty}\right]$

$h(\nu_f - \nu_1) = \frac{13.6 \times (2)^2 \times 1.6 \times 10^{-19}}{(n+1)^2}$ $\qquad \nu_f - \nu_1 = 3.3 \times 10^{15}$ (given)

$\Rightarrow \quad (n+1)^2 = 4 \quad \Rightarrow \quad n = 1$

$\frac{hc}{\lambda_1} = 13.6 \times (2)^2 \times 1.6 \times 10^{-19}\left[\frac{1}{1} - \frac{1}{4}\right]$.

$\Rightarrow \quad \lambda_1 = 303\ A^0$.

Q.45. At time t lets say there are N atoms. In time dt, dN_1 decays and dN_2 produces

$dN_2 = \frac{10^{-4} \times dt}{1.6 \times 10^{-19} \times 1000}$ $\qquad dN_1 = -\lambda N\ dt$.

Total production in time dt $\qquad dN = \left(\frac{1}{1.6 \times 10^{-12}} - \lambda N\right)dt$

$$\int_0^{N_0} \frac{dN}{6.25 \times 10^{11} - \lambda N} = \int_0^{3600} dt$$

$$-\frac{1}{\lambda}\ln\frac{6.25\times10^{11}-\lambda N_0}{6.25\times10^{11}}=3600$$

$\lambda N_0 = 1.8 \times 10^8$. (given)

$\Rightarrow \quad \lambda = 8 \times 10^{-8}$

$t_{1/2} = \dfrac{0.6931}{8\times10^{-8}} = 8.66 \times 10^6$ sec.

$= 100.25$ days.

Q.46. Mass diff. = $2 \times 2.015 - (3.017 + 1.009) = 0.004$ amu.

$\therefore$ energy released = 0.004×331 MeV = 3.724 MeV

energy released per deuteron = $\dfrac{1}{2}\times3.724\,\text{MeV}$

No. of deuteron in 1 kg = $\dfrac{6.02\times10^{26}}{2}$

$\therefore$ energy released / kg = $1.862 \times 0.301 \times 10^{26}$ MeV

$\approx 9 \times 10^{13}$ J.

Q.47. (i). Energy of each photon = E = $\dfrac{hc}{\lambda}$ = 3.975×10^{-19} J

No. of photons falling on surface per second & being absorbed,

$n = \dfrac{10J}{2.48eV} = 2.52 \times 10^{19}$ eV

(ii). A = 228 + 4 = 232

& 92 = z + 2 $\quad\therefore\quad$ z = 90

(1.v) A radioactive nuclide with half life period T is produced at the constant rate of n per second. The number of radioactive nuclide at t = 0 is N_0 , find

(i) the number of radioactive present at time t

(ii) the maximum number of these radioactive nuclei

(1.v) $\dfrac{dN}{dt}=n-\lambda N \Rightarrow \displaystyle\int_{N_0}^{Nt}\frac{dN}{n-\lambda N}=\int_0^t dt \;\Rightarrow\; N_t=\frac{n-(n-\lambda N_0)e^{-\lambda t}}{\lambda}$

Where N is maximum, $\dfrac{dN}{dt}=0 \quad\Rightarrow\quad N = \dfrac{n}{\lambda}$

Q.48. (a) $\dfrac{mv^2}{r}=\dfrac{Ze^2}{4\pi\varepsilon_0 r^2}$ . . . (i)

& $mvr = \dfrac{nh}{2\pi}$ . . . (ii)

From (i) & (ii), $r = \dfrac{n^2h^2\varepsilon_0}{Z\pi me^2}$ Here z = 3 & m = 208 me, $\therefore r_\mu = \dfrac{n^2h^2\varepsilon_0}{624\pi m_e e^2}$,

(b) $\dfrac{n^2h^2\varepsilon_0}{624\pi m_e e^2}=\dfrac{h^2\varepsilon_0}{\pi m_e e^2} \quad\therefore\quad n \approx 25$

(c) E_n = Total Energy $= -\dfrac{ze^2}{8\pi\varepsilon_0 r} = -\dfrac{z^2\pi me^4}{8\pi\varepsilon_0^2 n^2h^2}$

$= \dfrac{1872}{n^2}\left[-\dfrac{m_e e^4}{8\varepsilon_0^2h^2}\right]$

$= -\dfrac{1872}{n^2}\times 13.6\text{ eV}$

$\therefore$ E_1 = -25.4 keV ; E_3 = -2.8 keV & $E_3 - E_1$ = 22.6 keV .

$\therefore$ Required wavelength $= \lambda = \dfrac{hc}{\Delta E}$ = 55 pm.

Q.49. Mass defect

$\Delta m = (2 \times 2.0141 - 4.0026)$ amu

or $\Delta m = (2 \times 2.0141 - 4.0026) \times 931$ MeV

Energy used in reactor per reaction

$= \dfrac{25}{100}(2 \times 2.0141 - 4.0026) \times 931 = 5.9584$ MeV

$= 9.5334 \times 10^{-13}$ Joule.

Total energy obtained per day

= (200) MW $\times 24 \times 60 \times 60$ sec.

Mass of deuterium required

$= \dfrac{(0.6691\times10^{-21})(200\times10^6\times24\times60\times60)}{9.5334\times10^{-13}} = 121$ g.

Q.50. For photons of λ_1 = 4000A°, energy $E_1 = \dfrac{12375}{4000}$ eV = 3.094 eV

and for λ_2= 6000A°, energy $E_2 = \dfrac{12375}{6000}$ eV = 2.061 eV

Thus photo-electronic emission is possible with λ_1 only, which experience Lorenz force and move along circular path. The ammeter will indicate zero deflection if the photoelectrons just complete semi-circular path before reaching the plate P. Thus separation d = 2r = 10 cm

$\Rightarrow$ r = 5m

but, $r = \dfrac{mv}{qB}$ $\Rightarrow$ $B_{min} = \dfrac{mv}{qr}$

Now, $\dfrac{1}{2}mv^2 = \dfrac{hc}{\lambda_1} - W = (3.094 - 2.39)$eV

Substituting the value for v, m, q and r,

$B_{min} = 5.66\times10^{-5}$T

Q.51. de-Broglie wavelength $\lambda_1 = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mve}}$

Shortest X-ray wavelength $\lambda_2 = \dfrac{hc}{ve}$

$$\Rightarrow \quad \frac{\lambda_1}{\lambda_2} = \frac{ve}{c\sqrt{2mve}} = \frac{1}{c}\sqrt{\frac{ve}{2m}}$$

Substituting the values, $\dfrac{\lambda_1}{\lambda_2} = \dfrac{1}{3\times10^8}\sqrt{\dfrac{10\times10^3}{2}\times1.8\times10^{11}}$ = 0.1

Q.52. (a) Using Einstein's relation

$E_{max} = hf - W_o$

here $E_{max} = hf - W_o = 13.6$ eV

and $E_{max} = h\left(\frac{5}{6}f\right) - W_o = \dfrac{hc}{\lambda} = \dfrac{(6.63\times10^{-3})(3\times10^8)}{(12.15\times10^{-8})(1.6\times10^{-19})}$ = 10.2 eV

From the above two equations,

$\dfrac{hf}{6} = 3.4$ eV

or $f = \dfrac{6(3.4)(1.6\times10^{-19})}{6.63\times10^{-34}} = 4.92\times10^{15}$ Hz

(b) $W_o = hf - 13.6 = 6(3.4) - 13.6 = 6.8$ eV

Q.53. (i) $E = \phi + \frac{1}{2}mv_{max}^2$

= 1.82 + 0.73 = 2.55 eV

(ii) $E_n = -\dfrac{13.6}{n^2}$ eV (for hydrogen atom)

$\therefore$ $E_1 = -13.6$ eV, $E_2 = -3.4$ eV, $E_3 = -1.51$ eV, $E_4 = -0.85$ eV

clearly $E_4 - E_2 = -0.85 - (-3.4) = 2.55$ eV.

Hence quantum levels involved are 4 and 2.

(iii) $\ell = n\left(\dfrac{h}{2\pi}\right)$

change in angular momentum $= \ell_4 - \ell_2$

$= (4-2)\left(\dfrac{h}{2\pi}\right) = \dfrac{h}{\pi}$

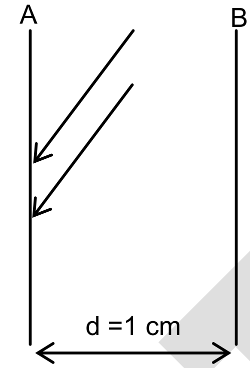
(iv) If P = linear momentum, then

$P = \dfrac{E}{c} = 1.36\times10^{-27}$ kg ms^{-1}

If v = recoil speed of hydrogen atom of mass M, then from COM,

Mv = P

or $v = \dfrac{P}{M}$ = 0.85 ms^{-1}.



Q.54. (a) Number of photoelectrons emitted from plate A upto

t =10 s $\quad n_e = \dfrac{(5\times10^{-4})\times10^{16}}{10^6}\times10 = 5\times10^7$

(b) Charge on plate B at t = 10 sec

$Q_b = 33.7 \times 10^{-12} - 5 \times 10^7 \times 1.6 \times 10^{-19}$

$= 25.7 \times 10^{-12}$ C

also $Q_a = 8 \times 10^{-12}$ C

$$E = \frac{\sigma_B}{2\varepsilon_0} - \frac{\sigma_A}{2\varepsilon_0} = \frac{1}{2A\varepsilon_0}(Q_B - Q_A)$$

$$= \frac{17.7\times10^{-12}}{5\times10^{-4}\times8.85\times10^{-12}} = 2000 \text{ N/C}$$

(c) K.E. of most energetic particles

$= (h\nu - \phi) + e(Ed) = 23$ Ev

Q.55. $\dfrac{1}{\lambda} = \dfrac{1}{1500}\left[1-\dfrac{1}{p^2}\right]\times10^{10}\text{m}^{-1}$ .... (i)

or $E = \dfrac{hc}{\lambda} = \dfrac{hc}{1500}\left[1-\dfrac{1}{P^2}\right]\times10^{10}\text{J} = \dfrac{hc\times10^{10}}{1500\times(0.6\times10^{-19}}\left(1-\dfrac{1}{p^2}\right)\text{eV}$

$= 8.28\left(1-\dfrac{1}{p^2}\right)\text{eV}$

(a) wavelength of the most energetic photon is corresponding to $p = \infty$,

$\therefore \quad \lambda = 1500 \times 10^{-10}$ m = 1500 A^0

wavelength of least energetic photon. corresponding to

p = 2, hence again

$\lambda = 1500 \times 10^{-10} \times \dfrac{4}{4-1} = 2000\ A^0$

(b) According to equation

$E = 8.28\left(\dfrac{P^2-1}{P^2}\right) = -\dfrac{8.28}{\dfrac{P^2}{(1-P^2)}} = -\dfrac{8.28}{n^2}\text{eV}$

or $E_n = -\dfrac{8.28}{n^2}$ eV

for n = 1, E_1 = - 8.28 eV	n = 3_______ - 0.92 eV
for n = 2, E_2 = - 2.07 eV	n = 2_______ -2.07 eV
for n = 3, E_3 = -0.92 eV	n = 1_______ -8.28 eV

(c) Ionization energy = - E_1 = 8.28 eV

Hence ; ionization potential = 0.28 volt.

Q.56. (a) $\frac{mv^2}{r} = \frac{Ze^2}{4\pi\varepsilon_0 r^2}$ . . . (i)

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

From (i) & (ii), $r = \frac{n^2h^2\varepsilon_0}{Z\pi me^2}$ Here z = 3 & m = 208 me,

$\therefore r_\mu = \frac{n^2h^2\varepsilon_0}{624\pi m_e e^2}$,

(b) $\frac{n^2h^2\varepsilon_0}{624\pi m_e e^2} = \frac{h^2\varepsilon_0}{\pi m_e e^2}$ $\therefore$ $n \approx 25$

(c) E_n = Total Energy $= -\frac{ze^2}{8\pi\varepsilon_0 r} = -\frac{z^2\pi me^4}{8\pi\varepsilon_0^2 n^2h^2}$

$= \frac{1872}{n^2}\left[-\frac{m_e e^4}{8\varepsilon_0^2 h^2}\right]$

$= -\frac{1872}{n^2} \times 13.6\,\text{eV}$

$\therefore$ $E_1 = -25.4$ keV ; $E_3 = -2.8$ keV

& $E_3 - E_1 = 22.6$ keV .

$\therefore$ Required wavelength $= \lambda = \frac{hc}{\Delta E} = 55$ pm.

Q.57. $\sqrt{\nu} = a(z - b)$

$\therefore$ $\sqrt{\frac{c}{\lambda_1}} = a(z_1 - b)$ . . . . (i)

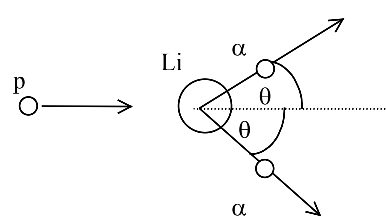
& $\sqrt{\frac{c}{\lambda_2}} = a(z_2 - b)$ . . . . (ii)

From (i) - (ii), $\sqrt{c}\left[\frac{1}{\sqrt{\lambda_1}} - \frac{1}{\sqrt{\lambda_2}}\right] = a(z_1 - z_2)$

$\Rightarrow$ $a = 5 \times 10^7\ (\text{Hz})^{1/2}$

From (i) /(ii), $\sqrt{\frac{\lambda_2}{\lambda_1}} = \frac{z_1 - b}{z_2 - b}$ $\Rightarrow$ $b = 1.37$

Q.58. Q value of the reaction, Q $= (2 \times 4 \times 7.06 - 7 \times 5.6)$ MeV



Q = 17.28 Mev

Applying C.O.E for collision

$k_p + Q = 2\,k_\alpha$ . . . (i)

$\sqrt{2m_pk_p} = 2\sqrt{2m_\alpha k_\alpha}\cos\theta$

$\Rightarrow k_p = 16\, k_\alpha \cos^2\theta$

$k_p = k_\alpha$ ($\because \cos\theta = ¼$)

Putting in (i) we get

$k_p = Q = 17.28$ MeV

Q.59. The quantum number of the initial state is given by n, where $\frac{n(n-1)}{2} = 15$, i.e. n = 6

The work function of the photo cathode (B) is given by

$$E = \frac{6.63\times10^{-34}\times3\times10^{8}}{830\times10^{-9}\times1.6\times10^{-19}}\text{ eV}$$

= 1.5 eV.

The maximum velocity of the emitted photoelectrons is given by

$$v = \frac{E_0}{B_0} = \frac{3.7\times10^2}{10^3} = 3.7\times10^5\text{ m/s}$$

the kinetic energy of the fastest photoelectrons is

$$E_{max} = \frac{1}{2}mv^2 = \frac{1}{2}\times\frac{9.1\times10^{-31}\times(3.7\times10^5)^2}{1.6\times10^{-19}}\text{ eV}$$

= 0.39 eV

The energy of the emitted photons is

1.5 eV + 0.39 eV = 1.89 eV

If the atomic number of the atoms is Z, and the quantum number of the final state is m, then

$$13.6\, Z^2\left(\frac{1}{m^2}-\frac{1}{6^2}\right) = 1.89$$

Rewriting this equation in the form:

$$z = \frac{1.89/13.6}{\frac{1}{m^2}-\frac{1}{6^2}} \approx \frac{1}{7}\frac{6^2m^2}{6^2-m^2}$$

or, $$z = \frac{6m}{\sqrt{7(36-m^2)}}$$

We get by substituting possible values of m : 5, 4, 3 …… etc ; for the only possible integral value of z.

The correct values are: n = 6, m = 4 and z = 2.

Q.60. (a) Radius of circular path $r = \frac{mv}{qB} = \frac{\sqrt{2mk}}{qB}$

$$k = \frac{(rqB)^2}{2m} = 0.86\text{ eV}$$

(b) $E_3 - E_2 = 13.6\,(1/2^2 - 1/3^2) = 1.9$ eV

$\phi = h\nu - (KE)_{max}$

= 1.04 eV

(c) $E = hc/\lambda$

$$\lambda = \frac{3\times10^8\times6.6\times10^{-34}}{1.9\times1.6\times10^{-19}} = 6513\ A^0.$$

Q.61. (a) The wavelength of emitted radiation is given as

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

for the Lithium atom z = 3

$$\frac{1}{\lambda} = 3^2R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = 9R \times \frac{7}{144}$$

$\lambda = 2.08 \times 10^{-7}$ m

(b) Relation orbit of the electron

$$r = \frac{mv}{qB}$$

$$\Rightarrow v = \frac{qBr}{m} = 1.18 \times 10^6 \text{ m/s}$$

KE of the electron = $\frac{1}{2}$ mv^2 = 3.96 eV

(c) $KE_{max} = \frac{hc}{\lambda} - \phi$

$$\Rightarrow \phi = \frac{hc}{\lambda} - KE_{max} = 2eV$$

Q.62. a) n=4 --------------------- $E_4 = -1.125$ eV
n=3 --------------------- $E_3 = -2.0$ eV

n=2 --------------------- $E_2 = -4.5$ eV

n=1 --------------------- $E_1 = -18$eV

b) Excitation potential for state n = 2 is 18-4.5 = 13.5 V

c) Energy of the electron accelerated through a potential difference of 16.2 εV is 16.2eV
At the most, it can excite electron fron n=1 to n=3
The number of possible wavelength are 3

$$\frac{1}{\lambda} = \frac{18 \times 1.6 \times 10^{-19}}{hc}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]x$$

For transiton 3-2, n_1 =2, n_2 = 3.

λ_{32} = 4970 Å

For 3-1; n_1 = 1;n_2 =3

λ_{31} = 777 Å

For 2-1; $n_1 = 1; n_2 = 2$

$\lambda_{21} = 920\ \mathring{A}$

d) No

The energy corresponding to $\lambda = 2000\ \mathring{A}$ is

$$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(2\times10^{-7})(1.6\times10^{-14})}$$

$= 6.21$ eV

The minimum excitation energy is 13.5 eV.

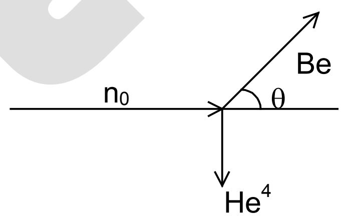
e) Minimum photoelectric wavelength is

$$\lambda_{min} = \frac{hc}{18\times1.6\times10^{-19}} = 690\ \mathring{A}$$

Q.63. The nucleus reaction can be written as

$n^1 + C^{12} \longrightarrow Be^9 + He^4$

Q value of the reaction



$$= -T_{th}\left[\frac{\text{mass of the target}}{\text{mass of the target} + \text{mass of the projectile}}\right]$$

$$= -6.17\left[\frac{12}{1+12}\right]\text{MeV}$$

[k_1, k_3, k_4 [m_n, m_{Be} m_{He} is the kinetic energy and masses of n^1, Be^9, He^4 then corresponding momentum is $\sqrt{2m_nk_1}$, $\sqrt{2m_{Be}k_3}$, $\sqrt{2m_{He}k_4}$

Conservation of momentum

$\sqrt{2m_nk_1} = \sqrt{2m_{Be}k_3}\cos\theta$ . . . (i)

$\sqrt{2m_{He}k_4} = \sqrt{2m_{Be}k_3}\sin\theta$ . . . (ii)

From (i) and (ii) we get

$m_n k_1 + m_{He} k_4 = m_{Be} k_3$ . . . . (iii)

$n_n = 1$ $m_{He} = 4$ $m_{Be} = 9$

$k_1 + 4k_4 = 9k_3$ . . . . . (iv)

conservation of energy

$k_1 + Q = k_3 + k_4$ . . . . (v)

From (iv) and (v) we get,

$$\frac{k_1 + 4k_4}{9} = k_1 + Q - k_4$$

$$k_4 = \frac{8k_1 + 9Q}{13}$$

$= 2.2$ MeV.

Q.64. (i) $E = \phi + \frac{1}{2} m v_{max}^2$

$= 1.82 + 0.73 = 2.55$ eV

(ii) $E_n = -\frac{13.6}{n^2}$ eV (for hydrogen atom)

$\therefore$ $E_1 = -13.6$ eV, $E_2 = -3.4$ eV, $E_3 = -1.51$ eV, $E_4 = -0.85$ eV

clearly $E_4 - E_2 = -0.85 - (-3.4) = 2.55$ eV.

Hence quantum levels involved are 4 and 2.

(iii) $\ell = n\left(\frac{h}{2\pi}\right)$

change in angular momentum $= \ell_4 - \ell_2$

$= (4 - 2)\left(\frac{h}{2\pi}\right) = \frac{h}{\pi}$

(iv) If P = linear momentum, then

$P = \frac{E}{c} = 1.36 \times 10^{-27}$ kg ms^{-1}

If v = recoil speed of hydrogen atom of mass M, then from COM,

Mv = P

or $v = \frac{P}{M} = 0.85$ ms^{-1}.

Q.65. (a) For $\lambda_1 = 5000$ A^0, $E_1 = \frac{hc}{\lambda_1} = \frac{12400}{4500}$ eV = 2.75 eV

$\lambda_2 = 6000$ A^0 $E_2 = \frac{hc}{\lambda_2} = 2.06$ eV

and for $\lambda_3 = 12000$ A^0 $E_3 = 1.03$ eV

The energy of excitation of H atom (n = 2 to n = 4)

$\Delta\varepsilon = 13.6\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$ eV ≈ 2.55 eV

The work function of the material = (2.75 – 2.55) eV = 0.2 eV

The maximum energy P.E.'s have energies of 2.55 eV and 2.06 – 0.2 = 1.86 eV and 1.03 – 0.2 = 0.83 eV

The de-Broglie wavelengths are $\frac{12400}{10^3 \times \sqrt{1.9}}$ A^0, $\frac{12.400}{10^3\sqrt{1.86}}$ A^0, $\frac{12400}{1000\sqrt{0.83}}$

or 8.99A^0, 9.09 A^0, 13.6 A^0

(b) All three wavelengths will cause photo emission.

Number of photoelectrons /sec

$N_{PE} = 1.44 \times 10^2 \times \frac{1}{3} \times 0.2 \times 1 \times 10^{-4}\left(\frac{1}{1.6 \times 10^{-19} \times 2.75} + \frac{1}{1.6 \times 10^{-19} \times 2.06} + \frac{1}{1.6 \times 10^{-19} \times 1.03}\right)$

The photocurrent = 1.74 mA

(c) If the work function was 40 % lower, the third wavelength would also cause photoemission.
The stopping potential = (2.75 - 0.2)V = 2.55 V.

Q.66. (a) According to the problem, α – decay is given by,
${}_{92}X^A \rightarrow {}_zY^{228} + \alpha$
i.e. ${}_{92}X^A \rightarrow {}_zY^{228} + {}_2He^4$
A = 228 + 4 = 232
Z = 92 – 2 = 90 **[1]**

(b) Since α – particle moves in a circular orbit in the magnetic field

$$\frac{m_\alpha v_\alpha^2}{r} = qv_\alpha B$$

$$v_\alpha = \frac{rqB}{m_\alpha} = 1.59 \times 10^7 \text{ m/s}$$ **[1]**

From law of conservation of momentum
$m_\alpha v_\alpha = m_y v_y$

$$E_y = \frac{m_\alpha^2 v_\alpha^2}{2m_y}$$ **[1]**

So the sought energy $E = E_\alpha + E_y$

$$E = \frac{1}{2}\left[m_\alpha v_\alpha^2 + \frac{m_\alpha v_\alpha^2}{m_y}\right] = \frac{m_\alpha v_\alpha^2}{2}\left[1 + \frac{m_\alpha}{m_y}\right]$$ **[1]**

$$= 5.342 \text{ MeV} = \frac{5.342}{931.5} = 0.0057 \text{ amu}$$

Applying the principle of conservation of energy, mass of ${}_{92}X^{232}$ = m_y + m_α + 0.0057 amu
= 228.03 + 4.003 + 0.0057 = 232.0387 amu
Since ${}_{92}X^{232}$ contains 92 protons and 140 neutrons , binding energy = mass defect
= 92(1.008) + 140(1.009) – 232.0387
= 1.9573 amu = 1.9573 × 931.5 = 1823 MeV **[1]**

Q.67. (a) $E_n = \dfrac{-13.6Z^2}{n^2}$

Excitation energy = $\Delta E = E_3 - E_1 = -13.6 \times (3)^2 \left[\dfrac{1}{3^2} - \dfrac{1}{1^2}\right]$

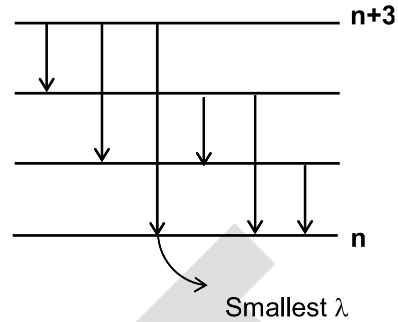
= +13.6 ×(9) [1 - 1/9] = 13.6 × (9) (8/9) = 108.8 eV.

Wavelength $\lambda = \dfrac{hc}{\Delta E} = \dfrac{(6.63\times10^{-34})(3\times10^8)}{108.8(1.6\times10^{-19})}$ = 114.3 A°

(b) From the excited state (E_3), coming back to ground state, there can be ${}^3C_2$ = 3 possible radiations.

Q.68. (a) If x is the difference in quantum number of the two states

then ${}^{x+1}C_2 = 6 \Rightarrow x = 3$



Now, we have $\dfrac{-z^2(13.6\ \ eV)}{n^2} = -0.85eV$ ...(i)

and $\dfrac{-z^2(13.6eV)}{(n+3)^2} = -0.544eV$ .. .(ii)

solving (i) and (ii) we get

n = 12 and z = 3

(b) Smallest wavelength λ is given by

$\dfrac{hc}{\lambda} = (0.85 - 0.544)eV$

Solving, we get

$\lambda \approx 4052$ nm.

Q.69. $h\nu_1 = 13.6 \times (2)^2 \times 1.6 \times 10^{-19}\left[\dfrac{1}{n^2} - \dfrac{1}{(n+1)^2}\right]$

$h\nu_f = 13.6 \times (2)^2 \times 1.6 \times 10^{-19}\left[\dfrac{1}{n^2} - \dfrac{1}{\infty}\right]$

$h(\nu_f - \nu_1) = \dfrac{13.6 \times (2)^2 \times 1.6 \times 10^{-19}}{(n+1)^2}$ $\nu_f - \nu_1 = 3.3 \times 10^{15}$ (given)

$\Rightarrow (n + 1)^2 = 4 \Rightarrow n = 1$

$\dfrac{hc}{\lambda_1} = 13.6 \times (2)^2 \times 1.6 \times 10^{-19}\left[\dfrac{1}{1} - \dfrac{1}{4}\right]$.

$\Rightarrow \lambda_1 = 303\ A^0$.

Q.70. Moseley's law

$\dfrac{1}{\lambda} = R(z-1)^2\left(1 - \dfrac{1}{n^2}\right)$ for K- lines where n =2,3,4,....................

(a) For K-absorption edge

$(z-1) = \sqrt{\dfrac{1}{\lambda R}}$

or z = $\sqrt{\dfrac{1}{(0.171 \times 10^{-10})(1.097 \times 10^7)}} + 1 = 74$

The element is Tungsten.

(b) K_α-line $\dfrac{1}{\lambda_\alpha} = R(74-1)^2\left[1 - \dfrac{1}{2^2}\right]$

$\lambda_\alpha = 0.228A^\circ$

K_β -line $\dfrac{1}{\lambda_\beta} = R(74-1)^2\left[1 - \dfrac{1}{3^2}\right]$

$\lambda_\beta = 0.192\ A^0$

$K\gamma$ - line $\qquad \dfrac{1}{\lambda\gamma} = R(74-1)^2\left[1-\dfrac{1}{4^2}\right]$

$\lambda\gamma = 0.182A°$

(c) Cut off wavelength

$\lambda_{min} = \dfrac{hc}{E} = \dfrac{(6.63\times10^{-34})(3\times10^{8})}{100\times1.6\times10^{-19}} = 12$