Chapter 11: Atomic Structure and Radioactivity

Q1.

Sol: $r_n = a_0 \times \frac{n^2}{Z}$, (a_0 = Bohr radius = 0.529 A^0)

For hydrogen atom, Z = 1

$\therefore r_1 = a_0 (1)^2 = a_0 = 0.529\ A^0 = 0.529 \times 10^{-8}$ cm **Ans**

$r_{10} = a_0(10)^2 = 100\ a_0 = 100 \times 0.529 \times 10^{-8} = 0.529 \times 10^{-6}$ cm **Ans**

Q2.

Sol: $V_n = 21.78 \times 10^6$ m/s. $\frac{Z}{n}$

In hydrogen atom, Z = 1

$\therefore V_1 = 2.178 \times 10^6 \times \frac{1}{1} = 2.17810^6$ m/s $= 2.178 \times 10^8$ cm/s **Ans**

$V_{10} = 2.178 \times 10^6 \times \frac{1}{10} = 2.178 \times 10^5$ m/s **Ans**

Q3.

Sol: (1) $He \longrightarrow He^+ + e^-$, I. E_1

(2) $He^+ \longrightarrow He^{2+} + e^- = I.E_2$

I.E. = Energy (minimum) required to remove e^- from an atom (from nth orbit)

$= -E_{nth}$

With the help of Bohr theory we can final energy of single e^- system only.

Since **He** is a $2e^-$ system so we can't calculate I.E_I where He^+ is a 1 e^- system.

$\therefore E_{(He+)} = -13.6ev \frac{Z^2}{n^2}$

For $He^+ \rightarrow 1s^1$: (n = 1 &Z = 2)

$E = -13.6\ ev\ \frac{(2)^2}{(1)^2} = -54.4ev$

$\therefore$ I.E .(2) $= -E_n = +54.4$ ev /atom.

1. E_2 / mole $= \frac{54.4 \times 1.6 \times 10^{-19}}{4.2} \times 6.023 \times 10^{23}$ cal/mole = 182100 cal **Ans**

Q4.

Sol: I. E. $= -E_n = -13.6 \frac{Z^2}{n^2}$ ev

For H-atom, Z = 1, & e^- in ground state ($1S^1$) $\Rightarrow$ n = 1

$\therefore$ I. E. = +13.6 ev/atom

I.E / mole = 13.6 ev $\times 6.023 \times 10^{23} = 8.189 \times 10^{2+}$ ev / mole **Ans**

Q5.

Sol: $\frac{1}{\lambda}=R_H.Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

For hydrogen atom Z = 1,

Also $R_H = 109737\ cm^{-1}$

$\therefore \frac{1}{\lambda}=109737\,cm^{-1}\left(\frac{1}{2^2}-\frac{1}{5^2}\right)=109737\,cm^{-1}\times\left(\frac{1}{4}-\frac{1}{25}\right)$

$= 109737\left(\frac{29}{100}\right)=1097.37\times 20\,cm^{-1}$

$\therefore\ \nu=\frac{c}{\lambda}=3\times10^{10}\,cm/s\times 1097.37\times 21$

$=6.913\times10^{14}/sec=6.913\times10^{4}\,Hz$ **Ans**

Q6.

Sol: 7 mg of C^{14}

no. of atoms $=\frac{\text{weight}}{\text{At.wt.}}\times$ Avogadro no.

$=\frac{7\times10^{-3}}{14}\times6.023\times10^{23}=3.0115\times10^{20}$

Total no. of neutrons $=(14-6)\times3.0115\times10^{20}=24.08\times10^{20}$ **Ans**

Mass of neutrons = no. of neutrons × weight of 1 neutrons.

$=24.08\times10^{20}\times1\ amu=24.08\times10^{20}\times\frac{1}{6.023\times10^{23}}=4mg$ **Ans**

Q7.

Sol: $\lambda=5800A^0$

Wave number $=\frac{1}{\lambda}=\frac{1}{5800\times10^{-8}\,cm}=\frac{10^6}{58}cm^{-1}$

Frequency $=\frac{c}{\lambda}=3\times10^{10}\times172413=5.172\times10^{14}HZ$ **Ans**

Q8.

Sol: Energy required to shift 1 e^- from first Bohr orbit to six Bohr orbit

In H – atom Z = 1

$\Delta E=13.6ev\left(\frac{1}{1^2}-\frac{1}{6^2}\right)=13.6ev\times\frac{35}{36}$

$=\frac{13.2\times1.6\times10^{-19}}{4.2}=5.03\times10^{-19}cal/atom$

$\therefore \Delta E/_{mole}=5.03\times10^{-19}\times6.023\times10^{23}=30.48\times10^{4}cal$

$\Delta r=r_6-r_1=0.529\ A^0\ (n_2^2-n_1^2)$

$=0.529\times(6^2-1^2)=0.529\times35A^0=18.515\ A^0$

$$\nu = \frac{\Delta E}{h} = \frac{13.2\times1.6\times10^{-19}}{6.626\times10^{-34}} = 3.187\times10^{15}\ HZ$$ **Ans**

Q9.

Sol: I.E. = – (Energy of e^- in ground state in atom)

13.6 ev = 1 (E_e – hydrogen atom)

$E_{\substack{n=1\\Z=1}} = -13.6ev$

$$\therefore\ I.E_{He^+} = -\left\{-13.6ev.\frac{(2)^2}{(1)^2}\right\};\ For\ He^+, Z=2$$

$I.E_{He+} = 54.4$ ev **Ans**

$$I.E_{42+} = -\left\{-13.6ev.\frac{3^2}{(1)^2}\right\} = 13.6ev\times9 = 122.4ev$$ **Ans**

Q10.

Sol: For lowest frequency in Lyman series, Lyman series has e^- transition from n = 2 to n = 1.

$$\Delta E = +13.6ev(1)^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right) = 10.2ev$$

$h\nu = 10.2ev$

$$\nu = \frac{10.2\times1.6\times10^{19}}{6.626\times10^{-34}} = \frac{2.176\times10^{-18J}}{6.626\times10^{-34J}}$$

$\nu = 0.3284\times10^{+16} = 3.284\times10^{15}$ HZ **Ans**

$\Delta E = 10.2ev\times1.6\times10^{-19}J = 2.176\times10^{-18}J$ **Ans**

$$\lambda = \frac{C}{\nu} = \frac{3\times10^8}{3.284\times10^{15}} = 9.14\times10^{-8}m$$ **Ans**

$$\Delta E_{li^{2-}} = \Delta E_H(Z^2) = 2.176\times10^{-18}(3)^2$$

$$= 1.958\times10^{-17}\ J$$ **Ans**

Q11.

Sol: $$density = \frac{\text{mass of 1 Nucleus}}{\text{Volume of 1 Nucleus}}$$

$$= \frac{40\times1.672\times10^{-24}g}{\frac{4}{3}\pi R^3} = \frac{40\times1.672\times10^{-24}g}{\frac{4}{3}\times\pi\times(R_0(A)^{1/3})^3}\ \because R = Ro(A)^{1/3}\ R_0 = 1.4\times10^{-13}cm$$

$$= \frac{40\times1.672\times10^{-23}g}{\frac{4}{3}\pi\times2.74\times10^{-49}\times40}$$

$$\frac{16.72\times10^{-25}}{11.488\times10^{-39}} = 1.758\times10^{14}g/cm^3 = 1.8\times10^{14}g/cm^3$$

Ans

Q12.

Sol: $E_n = \frac{-Z^2B}{n^2}$; where $B = 2.179\times10^{-18}$ J

(a) For lowest energy level: n = 1

For He^+ ; Z = 2

$E_1 = -2.179\times10^{-18}\times(2)^2 = 8.716\times10^{-18}$ J **Ans**

(b) For n = 3 & For Li^{2+}, Z = 3

$$E_3 = -2.179\times10^{-18}\times\frac{(3)^2}{(3)^2} = -2.179\times10^{-18}\text{J}$$ **Ans**

Q13.

Sol: $\frac{1}{\lambda} = R_H.Z^2\left(\frac{1}{n^2}-\frac{1}{2^2}\right)$

$$\frac{1}{434\times10^{-7}\text{cm}} = 109737\times(1)^2\left\{\frac{1}{n^2}-\frac{1}{4}\right\}$$

Calculating & taking the nearest integral value

n = 5 **Ans**

Q14.

Sol: $\nu = 1\text{hZ}$

$$\Delta E = h\nu = 6.626\times10^{-34}\text{J.S.}\frac{1}{\text{sec}} = 6.626\times10^{-34}\text{J/atom}$$

$$\therefore \Delta E/_{\text{mole}} = 6.626\times10^{-34}\times6.023\times10^{23}$$

$= 3.99\times10^{10}$ J / mole **Ans**

Q15.

Sol: $\Delta x.\Delta p \geq h/_{4\pi}$

$$\Delta x \geq \frac{h}{4\pi.\Delta p}$$

If $\Delta P = 0 \Rightarrow \Delta x \to \infty$

Q16.

Sol: $\Delta x.\Delta p = h/_{4\pi}$

$\Delta x.m.\Delta v = h/_{4\pi}$ (Since $\Delta p = \Delta(mv) = m\Delta(v)$ because mass is constant)

$$\Delta v = \frac{h}{4\pi.m.\Delta x} = \frac{6.626\times10^{-34}}{4\times3.14\times2000\times10} = \frac{5.25}{2}\times10^{-39}$$ **Ans**

Q17.

Sol: $\Delta x.mDv = h/_{4\pi}$

$$0.1\times10^{-9}\times9.11\times10^{-31}\times\Delta V = \frac{6.626\times10^{-34}}{4\times3.14}$$

$$\Delta V = \frac{6.626\times10^{-34}}{4\times3.14\times9.11\times10^{-41}} = 0.0579\times10^{7} = 5.79\times10^{5}\ \text{m/s}$$ **Ans**

Q18.

Sol: $K + F \longrightarrow K^{+} + F^{-}$, $\Delta H = 19\text{kcal} = 19\times10^{3}\times4.2\text{J}/\text{mole}$

I.E = 4.3 ev

E.A. = ?

we have

$$\Delta H/_{atom} = I.E + (-E.A)/_{atom}$$ [Since electro affinity has –ve sign as that of enthalpy change in the reaction.]

$$\frac{4.2\times19\times10^{3}}{6.023\times10^{23}} = (4.3 - E.A)1.6\times10^{-19}$$

$$\frac{4.2\times19\times10^{-20}}{6.023\times1.6\times10^{-19}} = 4.3 - E.A$$

$4.3 - E.A. = 0.828$

$E.A. = 4.3 - 0.828 = 3.47$ ev **Ans**

Q19.

Sol: $e\Delta v_{min} = K.E._{max} = \Delta E = \frac{hc}{\lambda}$

$$\Delta V_{min} = \frac{6.626\times10^{-34}\times3\times10^{8}}{590\times10^{-9}\times1.6\times10^{-19}}$$

$\therefore \Delta v_{min} = 2.11$ volt **Ans**

Q20.

Sol: we have; $\Delta E = \frac{hc}{\lambda}$

$$\Rightarrow \lambda = \frac{hc}{\Delta E} = \frac{6.626\times10^{-34}\times3\times10^{8}}{4.4\times10^{-19}} = 4.5\times10^{-7}\ \text{m}$$ **Ans**

Q21.

Sol: $\Delta x.\Delta p \geq h/_{4\pi}$ (uncertainty principle)

$\Delta x = 0.01\text{mile} = 16.093$ m

$\Delta p = 0.0025$ miles per hour $= \frac{0.0025\times1609.3}{3600}$ m/s

$$\Delta x.\Delta p = 16.093\times3\times10^{3}\,\frac{0.0025\times1609.3}{3600} = 53.955$$ which is much greater than $h/4\pi$.

Q22.

Sol: $\Delta V = 1000\ \text{ev} = 1.6\times10^{-19}\,\text{J}\times1000 = 1.6\times10^{-16}$

$\therefore$ K.E of $e^{-} = e\Delta V = (1.6\times10^{-19})\times(1.6\times10^{-16})$

$$\therefore \frac{P^2}{2m} = K.E$$

$$P^2 = 2 \times 9.11 \times 10^{-31} \times (1.6^2 \times 10^{-35})^2$$

$$P = \sqrt{1.822} \times 10^{-15} \times 5.06 \times 10^{-18} = 1.35 \times 5.06 \times 10^{-33} = 6.83 \times 10^{-34}$$

$$\therefore \lambda_{de-broglie} = \frac{h}{P} = \frac{6.626 \times 10^{-34}}{6.83 \times 10^{-34}} = 9.70\ m$$ **Ans**

Ans is different in the book which will comes by taking potential difference 1000 V, but in question itself it is given equal to 1000 ev.

Q23.

Sol: $\lambda = \frac{h}{P} = \frac{6.626 \times 10^{-34} J.S.}{mV.}$

$$= \frac{6.626 \times 10^{-34}}{1.0 \times 10^3 kg \times \frac{50 \times 1000}{3600}} = \frac{6.626 \times 10^{-34} \times 36}{5.0 \times 10^5} = 4.77 \times 10^{-38}\ m$$

is too small to consider so the motion of particle can't be taken as wave motion.

Q24.

Sol: $\Delta x \le 0.005 nm$

$\Delta x \le 5 \times 10^{-12} m$

$M_e = 9.11 \times 10^{-31}$ kg

$\Delta x, \Delta p = h/4\pi$

$\Delta x, m\Delta v = h/4\pi$

$$\Delta V = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 5 \times 10^{-12} \times 9.11 \times 10^{31}} = 0.01158 \times 10^9 m/s$$

$\Delta V = 1.158 \times 10^7 m/s$

ΔV of this magnitude can't be possible for e^- because e^- has maximum speed 10^7 m/s

Q25.

Sol: Let n is the no. of photons

$\therefore$ total energy = no. of photons × energy / photon

$$10^{-17} = n \times \frac{hc}{\lambda}$$

$$n = \frac{10^{-17} \times 495 \times 10^{-9}}{6.626 \times 10^{-34} \times 3 \times 10^8} = 24.9$$

$\therefore n = 25$ [Because no. of photons should be always integer]

Q26.

Sol: Shape is same for both 1s & 2s orbital but energy will be different. Also the 2s orbital will have 1 radial node, where as 1S orbital has no radial nodes.

$2p_x$ & 2py both have same shape and energy, however they different orientation in space & also have different planar nodes.

Q27.

Sol:

(a) With n = 3

With lust e^- filled in n = 3,

We have maximun 18 e^- because after filling

$1s^2 2s^2 sp^6 3s^2 3p^6$ we have to fill 4s first before 3d. So the answer should be = 18. However if we think the maximum no. of e^- that can be filled in n = 3 = 2+8+18 = 28 & according to question the last e^- that can go inside n = 3 we have maximum no. of e^-s will be = 30.

$1S^2 2S^2 2P^6 3S^2 3P^6 4S^2 3d^{10} = 30$ **Ans**

(b) n = 3, l = 1 i.e., upto 3p orbital

$1S^2 2S^2 3P^6 3S^2 3P^6 \rightarrow 18$ **Ans**

(c) n = 3, l = 1 & ml = -1

Upto 3Px

$1S^2 2S^2 2P^6 3S^2\ 3Px^2\ 3P^2\ Py^2$

Upto 3Px $\rightarrow$ only 16^{th} e^- are present in 3px

Note :- In general condition there is no difference in energy, so e^- will be filled in 3p orbital as follow.

$1S^2 2S^2 2P^6 3S^2$	↑↓	↑	↑
12 e^-	3P×	3py	$3P_z$
	4^{th} e^-		

Total 16 e^- **Ans**

(d) n = 3, l = 1, m = -1 & $s = +\frac{1}{2}$

$1S^2 2S^2 2P^6 3S^2$

	↑		
12 e^-	3px = s = +1/2		

Total = 13 e^- **Ans**

Q28.

Sol: (a) $c = \nu\lambda$, wave speed, wave length & frequency are purely wave properties, so describing behaviour of wave motion.

(b) $E = mc^2 \rightarrow$ mass is particle property, so representing particle behaviour.

(c) $r = \frac{n^2 a_0}{Z}$ = radius, definite position is done for particle, so describing particle behaviour

(d) $E = h\nu \rightarrow \nu$ is wave property, so this equation is describing a wave-function.

(e) $\lambda = \frac{h}{mv} : \lambda \rightarrow$ wave property

m $\rightarrow$ particle property

$\therefore$ so it is describing both particle & wave behavour

Q29.

Sol: (a) n = 4, l = 0, m = 0 & $S = +\frac{1}{2} \rightarrow$ 4S orbital

(b) n = 3, l = 2, m = +1 & $S = +\frac{1}{2} \rightarrow$ 3d orbital

(c) $n = 3, d = 2, m = -2$ & $S = = -\frac{1}{2} \rightarrow 3d$ orbital

(d) $n = 3, l = 1, m = +1$ & $S = -\frac{1}{2} \rightarrow 3p$ orbital

$\therefore$ Energy order $3P < 4s < 3d$

$d < a < b = c$

Q30.

Sol: $\lambda = 554 nm$

$$\text{Energy lost} = \frac{hC}{\lambda} \times N_A = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{554 \times 10^{-9}} \times 6.023 \times 10^{23}$$
$$= 2.16 \times 10^5 J = 216 KJ \quad \textbf{Ans}$$

Q31.

Sol: $2{}_1^1p + 2{}_0^1n \longrightarrow {}_2^4He$

$$\Delta E = \Delta mc^2$$
$$= (2.mp + 2.mn - mHe)\ C^2$$
$$= (2 \times 1.00728 + 2 \times 1.00\,8867 - 4.0015)C^2$$
$$= 0.030794 \times 931.5 \text{ Mev}$$
$$= 28.69 \times 10^6 \times 1.6 \times 10^{-19} J. = 45.89 \times 10^{-13} J$$

$$\Delta E/\text{mole} = \Delta E/_{\text{atom}} \times 6.023 \times 10^{23} = 2.74 \times 10^{12} J$$

$C_2H_6(g) + O_2(g) \longrightarrow 2CO_2 + 3H_2O;\ \Delta H = -1427.81 kJ/mol$

Let n is the no. of moles required to give same amount of energy as produced in the formation of 1 mole of He-atom.

$$\therefore 2.74 \times 10^{12} = n \times 1427810 J$$

$$n = \frac{2.74 \times 10^{12}}{1.43 \times 10^6} = 1.92 \times 10^6$$

$\therefore$ Volume at 725 mm of Hg & 25^0 C.

$$\therefore \frac{nRT}{P} = \frac{1.92 \times 10^6 \times 0.0821 \times 298}{\frac{725}{760}} = 46.97 \times 10^6 \times \frac{760}{725} = 4.92 \times 10^7 \text{ lit}$$

Ans

Q32.

Sol: $A = 1.7 \times 10^{-5}$ curie

$$N\lambda = 1.7 \times 10^{-5} \times 3.7 \times 10^{10} \text{ dis/sec} ----- (1)$$

In 1 mg sample of Tc – 99

$$\text{no. of atoms} = \frac{1 \times 10^{-3}}{99} \times 6.023 \times 10^{23} = 6.084 \times 10^{18}$$

$$\therefore (1) \Rightarrow 6.084 \times 10^{18} \times \lambda = 1.7 \times 3.7 \times 10^5$$

$$\lambda = \frac{1.7 \times 3.7 \times 10^5}{6.084 \times 10^{18}} = 1.034 \times 10^{-13} s^{-1}$$

Ans

Q33.

Sol: $t_{1/2} = 12.3$ years

$$\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693}{12.3 \times 365 \times 24 \times 3600} S^{-1}$$

$$N = \frac{2.5 \times 10^{-6}}{3.02} \times 6.023 \times 10^{23}$$

$$\therefore A = N\lambda = \frac{2.5 \times 6.023}{3.02} \times 10^{17} \times \frac{0.693}{12.3 \times 365 \times 24 \times 3600}$$

$$= 4.986 \times 10^{17} \times 1.786 \times 10^{-9}$$

$$= 8.905 \times 10^{8} \text{ dis / sec} = \frac{8.905 \times 10^{8}}{3.7 \times 10^{10}} Ci = 0.02406\, Ci$$

Ans

Q34.

Sol: (a) $^{238}_{92}U$

$\therefore n = A - Z = 238 - 92 = 146$

$\frac{n}{Z} = \frac{146}{92} > 1.54$

So it we try to decrease $\frac{n}{Z}$ ratio by changing its mass no. b $\propto$ –decay.

$\therefore$ Stability region $1 < \frac{n}{Z} < 1.54$

(b) $^{8}_{5}B$

$n = A - Z = 8 - 5 = 3$

$\frac{n}{Z} = \frac{3}{8} < 1$

$\therefore$ So it will try to increase $\frac{n}{Z}$ ratio which can be done by either β^{+} – decay or electron – Capture.

(c) $^{68}_{29}Cu$

$n = 68 - 29 = 39$

$\frac{n}{Z} = \frac{39}{29} < 1.54$

Hence the atom is in the stability region, However has no. of proton & neutron both odd which is an unstable case. So it will undergo β – decay to have both n & Z- even.

Q35.

Sol: 28% decay means, 72% remains

Now,

$$N = N_0 \left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$72 = 100\left(\frac{1}{2}\right)^{\frac{1.52hr}{t1/2}}$$

$$\left(\frac{72}{100}\right) = \left(\frac{1}{2}\right)^{\frac{1.52h}{t1/2}}$$

Taking log as both side & solving

$$t1/2 = 3.21hr$$

Ans

Q36.

Sol: $^{232}_{90}Jh \xrightarrow{-6\alpha} {}^{232-6\times4}_{90-6\times2}A \xrightarrow{-4\beta} {}^{x}_{y}Pb$

$x = 232 - 6\times4 = 208$
$y = 90 - 6\times2 + 4 = 82$ **Ans**

Q37.

Sol: $^{238}_{92}U \xrightarrow{-\alpha \text{ particle}} {}^{238-4\times1}_{92-2\times1}X = {}^{234}_{90}X$

Ans- (b)

Q38:-

Sol:- $^{257}_{103}Lr$

256 is divisble by 4, so 257 belongs to (4n + 1) series

$^{254}_{99}Es$, 252 is divisible, by 4, so 254 belongs to (4n + 2) series

$^{243}_{95}Am$, 240 is divisible, by 4, so 243 belongs to (4n + 3) series

Q39.

Sol: A = 7 count per min

A_0 = 15.3 count / min

$$A = A_0\left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$\frac{7}{15.3} = \left(\frac{1}{2}\right)^{\frac{t}{5770\ years}}$$

taking logrithim on both side & calculating

t = 6520 years.

Q40.

Sol: $t1/2$ = 1620 years = $1620\times365\times24\times60$ sec

$$\therefore \lambda = \frac{0.693}{t1/2} = \frac{0.093}{8.5\times10^{+8}} = 8.138\times10^{-10}\ sec^{-1}$$

$$\therefore A = \lambda N = 8.14 \times 10^{-10} \frac{\times 1 \times 10^{-3}}{226} \times 6.023 \times 10^{23}$$

$A = 2.16 \times 10^{9}$ dis / minute **Ans**

Q41.

Sol: $\left(\frac{^{206}Pb}{^{238}U}\right)_t = \frac{0.23}{1} = \frac{23}{100}$

$t\frac{1}{2}$ of Uranium $= 4.5 \times 10^{9}$ years

$$\therefore \frac{^{206}Pb_t}{^{238}U_t} + 1 = \frac{23}{100} + 1$$

$$\frac{^{206}Pb_t + ^{238}U_t}{^{238}U_t} = \frac{123}{100}$$

$$\frac{^{238}U_{t=0}}{^{238}Ut} = \frac{123}{100} \quad \Rightarrow \frac{^{238}Ut}{^{238}U_{t=0}} = \frac{100}{123}$$

$$\therefore N_t = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$$\frac{N_t}{N_t} = \frac{100}{123} = \left(\frac{1}{2}\right)^{\frac{t}{4.5 \times 10^{9}}}$$

taking logarithm & calculating, we have

$t = 1.34 \times 10^{9}$ years **Ans**

Q42.

Sol: $A_t = A_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$$2.1 \times 10^{4} = 7 \times 10^{4} \left(\frac{1}{2}\right)^{\frac{t}{3.8}}$$

$$\frac{3}{10} = \left(\frac{1}{2}\right)^{t/3.8}$$

Calculating for t, by taking logarithm, we have

$t = 6.6$ days **Ans**

Q43.

Sol: $t\frac{1}{2} = 3.83$ days

$t = 10$ days

$$N_t = N_0 \left(\frac{1}{2}\right)^{t/t\frac{1}{2}}$$

$$N_t = N0\left(\frac{1}{2}\right)^{\frac{10}{3.83}}$$

$$\Delta N + N_0 - N_t = No\left\{\left(\frac{1}{2}\right)^{\frac{10}{3.83}-1}\right\}$$

$$\frac{\Delta N}{N0} = \left\{\left(\frac{1}{2}\right)^{\frac{10}{3.83}} - 1\right\} = 0.164$$

Ans

Q44.

Sol: $A(\text{dis/sec}) = 3.608\times10^{10}$

$Wt = 1g$

Also, At. Wt. = 226 g

$$\therefore A = \lambda N = \lambda \times \frac{1g}{226g} \times 6.023\times10^{23} = 3.608\times10^{10}$$

$$\Rightarrow \lambda = 1.35\times10^{11} S^{-1}$$

$$\therefore t\frac{1}{2} = \frac{0.693}{\lambda} = 5.13\times10^{10}\ \text{sec}$$

Ans

Q45.

Sol: $t\frac{1}{2} = 1620\ \text{year}$

$$\lambda = \frac{0.693}{1620\times365\times24\times3600} s^{-1} = 1.356\times10^{-11}$$

Also if w is the wt of radium required to have Activity of 1 millicurie

$$A = 1\times10^{-3} Ci = 1\times10^{-3}\times3.7\times10^{10}$$
$$= 3.7\times10^{7} = \lambda N$$

$$3.71\times10^{7} = 1.356\times10^{-11} \times \frac{w}{226} \times 6.023\times10^{23}$$

$$W = \frac{3.7\times10^{7}\times226}{8.17\times10^{12}} = 102.35\times10^{-5} g$$
$$= 1.0235\times10^{-3}\ g$$

Ans

Q46.

Sol: similar way as in Q = 45

We have w = 0.2234 mg **Ans**

Q47.

Sol: No. of atoms $= \frac{1g}{226g} \times 6.023\times10^{23}$

$$t\frac{1}{2} = 1600\ \text{years}$$

$$\lambda = \frac{0.693}{1600 \times 365 \times \times 24 \times 3600} = 1.37 \times 10^{-11}\ sec^{-1}$$

$$N = \frac{602.3 \times 10^{21}}{226}$$

$$\therefore A = \lambda N = 1.37 \times 10^{-11} \times \frac{602.3 \times 10^{21}}{226} = 3.66 \times 10^{10}\ dps$$

It Na, let w is the weight which gives same rate of dps.

$$N = \frac{W}{24} \times 6.023 \times 10^{23}$$

$$t_{1/2} = 15hr$$

$$\lambda = \frac{0.693}{15 \times 3600} = 1.28 \times 10^{-5}$$

$$\therefore A = \lambda N = 1.28 \times 10^{-5} \frac{\times 60.23w}{24} \times 10^{22}$$

$$3.66 \times 10^{10} = 3.21\ W \times 10^{17}$$

$$W = \frac{3.66 \times 10^{10}}{3.21 \times 10^{17}} g = 1.136 \times 10^{-7} g$$

Ans

Q48.

Sol: $\left(\frac{14c}{12c}\right)_t = 0.7\left(\frac{14c}{12c}\right)_0$

^{14}C convert into ^{12}C after disintegration

$\therefore {}^{14}C_t + {}^{12}C_t = {}^{14}C_0 + {}^{12}C_0$ (at time t, total atoms will be same as t = 0)

$$\left(\frac{14c}{12c}\right)_t + 1 = \frac{14c_0}{12c_t} + \frac{12c_0}{12c_t}$$

Not required to calculate $^{14}C_t$ in terms of ^{14}Co we can just apply disintegration law to the ratio itself-

$$\left(\frac{14c}{12c}\right)_t = \left(\frac{14c}{12c}\right)_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$$\frac{\left(\frac{14c}{12c}\right)_t}{\left(\frac{14c}{12c}\right)_0} = \left(\frac{1}{2}\right)^{\frac{t}{5760}}$$

$$0.7 = \left(\frac{1}{2}\right)^{\frac{t}{5760}}$$

t = 2964 years **Ans**

Q49.

Sol: $t = 1$ hr

Volume of He gas at STP = 11.2 lit

$\therefore$ no. of atoms obtained $= \dfrac{11.2}{22.4} \times 6.023 \times 10^{23} = 3.01 \times 10^{23}$

$\therefore$ Disintegration per hr $= 3.01 \times 10^{23}$

Disintegration per sec $= \dfrac{3.01 \times 10^{23}}{3600} = 8.36 \times 10^{-19}$

No. of atoms (given) $= 10 \times 6.023 \times 10^{23} = 6.023 \times 10^{24}$

$\therefore A = \lambda N$

$8.36 \times 10^{+19} = \lambda \times 6.023 \times 10^{24}$

$\lambda = \dfrac{8.36}{6.023} \times 10^{-5} = 1.38 \times 10^{-5}\ S^{-1}$

$\therefore t_{1/2} = \dfrac{0.693}{t1/2} = 49920.86\,\text{sec} \quad \Rightarrow t1/2 = \dfrac{49920.86}{3600}\,\text{hr} = 13.48\,\text{hr}$

Ans

Q50.

Sol: ${}^{60}_{27}Co$ has disintegration per min = 240 atoms / minute

$t1/2$ (Co) = 5.2 years

$A\ (dPS) = \dfrac{240}{60} = 4\,\text{atom/sec}$

$A = \lambda N$

$A = \dfrac{0.693}{5.2 \times 365 \times 24 \times 3600} \times N$

$N = \dfrac{4 \times 5.2 \times 365 \times 24 \times 3600}{0.693} = 9.465 \times 10^{8}$

At = 100 dpm

$\therefore At = A_0 \left(\dfrac{1}{2}\right)^{\frac{t}{t_{1/2}}} \quad \Rightarrow \dfrac{100}{240} = \left(\dfrac{1}{2}\right)^{\frac{t}{5.2}}$

Solving by taking logarithm on both side, we have

$t = 6.6$ years

Ans

Q51.

Sol: $t = 0$, Cpm = 1000

$t = 1$ hr, Cpm = 992

$At = A_0 \left(\dfrac{1}{2}\right)^{t/t_{1/2}}$

$$992 = 1000\left(\frac{1}{2}\right)^{\frac{1hr}{t1/2}} \Rightarrow \frac{992}{1000} = \left(\frac{1}{2}\right)^{\frac{1hr}{t1/2}}$$

$$\log(0.992) = \frac{-1hr}{t1/2}\log 2 \Rightarrow -3.488\times10^{-3} = \frac{-1hr}{t1/2}\times 0.301$$

$$t1/2 = \frac{0.0301}{3.488\times10^{-3}} \doteq 86.3\,hr \quad \therefore t1/2 = \frac{86.3\,hr}{24} = 3.62\,days$$

Ans

Q52.

Sol: $^{208}Pb \rightleftharpoons {}^{232}Jh$

$$\frac{m\left(^{208}Pb_t\right)}{m\left(^{232}Jh_t\right)} = \frac{14}{1} \Rightarrow \frac{n\ ^{208}Pb_t}{n\ ^{232}Jh_t} = \frac{\frac{14}{208}}{1/232} = 15.6/1$$

$$\frac{N\ ^{208}Pb_t}{N\ ^{232}Th_t} + 1 = \frac{15.6}{1} + 1$$

$$\frac{N(^{208}Pb_t + {}^{232}Jh_t)}{N(^{232}Jh_t)} = \frac{16.6}{1}$$

$$\frac{N(232\,Th_0)}{N(232\,Th_t)} = \frac{16.6}{1}$$ (Since all disintegrated Th converts in to Pb)

$$\therefore N(^{208}Pb_t + {}^{232}Th_t) = N(^{232}Th_0)$$

$$\therefore N(^{232}Th_t) = N(^{232}Th_0)\left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$\frac{1}{16.6} = \left(\frac{1}{2}\right)^{\frac{t}{1.39\times10^{10}\,y}}$$

Calculating t, we have

$t = 1.39\times10^{10}\times 4.05 = 5.63\times10^{10}$ years. **Ans**

Q53.

Sol: $A \rightleftharpoons B$

$$\frac{A_t}{B_t} = \frac{3.1\times10^{9}}{1}$$

$t_{1/2}B = 6.45$ years.

$\lambda_A[A] = \lambda_B[B]$

$$\frac{\lambda_A}{\lambda_B} = \frac{[B]}{[A]} \Rightarrow \frac{t_{1/2}A}{t_{1/2}B} = \frac{[A]}{[B]} = 3.1\times10^{9}$$

$t_{1/2}B = 3.1\times10^{9}\times 6.45 = 1.9995\times10^{10}$ years **Ans**

Q54.

Sol: $\Delta E = \Delta mc^2$, $\Delta E \propto \Delta m$

For ${}^{58}_{28}Ni$, $\Delta m = (28 \times 1.00728 + (58-28) \times 1.00867 - 57.941)$ amu = 0.553 amu

For ${}^{55}_{25}Mn$, $\Delta m = \{25 \times .100728 + (55-25) \times 1.00867 - 54.939\} = 0.5031$ amu

$\therefore \Delta E$ =B.E. will be move for the case ${}^{58}_{28}Ni$ **Ans**

Q55.

Sol: B.E / Nucleus = 7.575 MeV

$\therefore$ B.E.= $7.576 \times 238 = 1803.08$ MeV

$\therefore \Delta mC^2 = 1803.08\,MeV$

$\Rightarrow (92 \times 1.00728 + (238\text{-}92) \times 1.00867 - m\ U^{238})\ C^2 = B.E.$

$\Rightarrow$ $m\,239.93C^2 - m(U^{238})C^2 = 1803.08\,Mev$

$m\,U^{238} = 237.93amu$

Objective problems

Q1. Ans-(a)

$$\lambda = \frac{C}{\nu} = \frac{3\times10^8 m/s}{6\times10^{14}/s} = \frac{1}{2}\times10^{-6} m = 5\times10^{-7} m = 500\,nm$$

Q2.Ans-(d)

$$\frac{E_1}{E_2} = \frac{hc/\lambda_1}{hc/\lambda_2} = \frac{\lambda_2}{\lambda_1} = \frac{4000}{2000} = 2:1$$

Q3. Ans-(d)

H.C.F For -1.6×10^{-19}, -2.4×10^{-19}, -4×10^{-19}

-0.8×10^{-19}

Since charge will be quantized. i.e ,. any charge will be integral multiple of some smallest basic charge

$\therefore -1.6\times10^{-19}$, -2.4×10^{-19}, -4×10^{-19}

$\therefore$ Basic unit of chare will be -0.8×10^{-19} coulomb.

Q4. Ans- (b, c)

Q5.Ans -(b) H^+ is not a single e^- species

Q6. Ans -(b)

$$r_n = r_0\frac{n^2}{Z} \Rightarrow r_3 = r(3)^2 = 9r\left(A/q, \frac{r_0}{Z} = r\right)$$

Q7. Sol - (a)

$$v_n = v_1 \times \frac{Z}{n},\ V_4 = V = \frac{V_1}{4} \Rightarrow V_1 = 4V$$

Q8. Ans-(d)

$$E_n = -13.6ev.\left(\frac{Z^2}{n^2}\right) = \frac{-E_1}{n^2}[I.E._1 = -E_1 = 13.6eV \Rightarrow E_1 = -13.6eV]$$

$$\therefore E_2 = \frac{-13.6ev}{4} = -3.4ev$$

$\therefore I.E_2 = -E_2 = 3.4$ ev.

Q9. Ans -(b)

$$E_{He^+} = E_{H^-}(Z)^2 = -3.41\times(2)^2 = -13.64ev$$

Q10. Ans -(c)

$$r_n \propto n^2$$

Q11. Ans -(d)

$$\frac{\Delta E_{1-2}}{\Delta E_{2-3}} = \frac{13.6\left(1-\frac{1}{4}\right)}{13.6\left(\frac{1}{4}-\frac{1}{9}\right)} = \frac{13.6\times 3/2}{13.6\times\frac{5}{36}} = \frac{3}{4}\times\frac{36}{5} = \frac{2}{5}$$

Q12. Ans -(a)

For ℓ

$$m_\ell = -\ell \text{ to } +\ell$$

Q13. Ans - 4P; for any P orbital, $\ell = 1$.

Q14. Ans -(b) 2d because in n = 2, $\ell = 2$ can't possible

So d- orbital can't possible

Q15. Ans -(b), (a)

For n= 4, ℓ can be only 0,1, 2, 3 ---

For 4 f orbit also & must be 3, which is not given in a option also, so m (a) is not possible

Q16. Ans -(c)

$n = 3, \ell = 2 \quad \Rightarrow$ 3d orbital

So maximum no. of $e^- = 2(2\ell + 1) = 2(2\times2+1) = 10\ e^-$

Q17. Ans -(c)

no. of orbitals $= n^2 = 9$

Q18. Ans -(c)

According to Pauli exclusion principle maximum no. of e^- in any orbital is equal to 2.

So, $1S^7$ can't be possible

Q19. Ans -(d)

α -particle were used which was nothing but He-nuclei.

Q20. Ans -(d)

Total no. of nodes = n-1 where n= principle quantum so the orbitals with some no. of nodes has same n-value

Q21. Ans -

For $m_{max} = 3$

$\ell_{max} = 3$

$\therefore$ n = 3 because l varies from 0 to (n-1)

$\therefore$ no of waves made by $e^- =$ n = 4.

Q22. Ans -(a)

Shortest wavelength for maximum energy diff-^{n} which will be in atom of higher atomic no. which is li^{2+}.

Q23. Ans -(b)

For first line of Balmar series.

n = 3 to n = 2

For He^+, Z = 2

$$\lambda = R.(Z^2)\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = R\times 4\left(\frac{9.4}{36}\right) = \frac{20R}{36}$$

Q24. Ans -(a)

$2\pi r = n\lambda$

For n = 1, $\lambda = 2\pi r$

Also $r_3 = r(3)^2 = 9r$

$\therefore 2\pi r_3 = 3\times\lambda_3$

$2\pi\times 9r = 3\lambda_3$

$\lambda_3 = 6\pi r$

Ans

Q25. Ans -(b)

For shortest wavelength, largest energy diff-^{n}

$\therefore \Delta E$ (transition will occur from n $\rightarrow$ infinity to n = 1)

To $\therefore \Delta E = 13.6(ev).\left(1-\frac{1}{0}\right) = 13.6ev$

$$\therefore \lambda = \frac{\Delta E}{hC} = x \quad \therefore x = \frac{13.6ev}{hC}$$

Also longest λ in Balmar series, ΔE from n = 3 to n = 2

$$\Delta E = 13.6ev\times(2)^2\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = 13.6eV\times\frac{5}{36}\times 4$$

$$\lambda = \frac{13.6ev\times 5/9}{hc} = 5x/9$$

Q26. Ans -(c)

no. of radiation = ${}^4C_2 = \frac{4\times 3}{2} = 6$

Q27. Ans -(c)

$$\Rightarrow r_n = r_0\frac{n^2}{Z}; \Rightarrow r_{106} = r_0(106)^2 = 11236r_0$$

Q28. Ans -(b)

In He^{+}, $r_5 = a_0 \frac{(3)^2}{2} = \frac{9}{2} a_0$

In Li^{2+}, $r_5 = a_0 . \frac{(5)^2}{3} = \frac{25}{3} a_0$

Li^{2+} is larger

Q29. Ans -(c)

Q30. Ans -(a)

Because odd protón & odd neutron nuclei are unstable

Q31. Ans -(d)

Because by α–emission, n/p ration decreases.

Q32. Ans -(b)

Isotone has no. of neutrons in its nucleus

$^{x}_{8}X \longrightarrow {}^{17}_{9}Y$

no. of neutrons in y = 17 – 9 = 8

∴ no. of neutrons in X = 8

∴ x = 8 + 8 = 16

Q33. Ans -(c) $t_{1/2}$ doesn't depend on quantity of radioactive substance.

Q34. Ans -(b)

Q35. Ans -(c) Both have same no. of neutrons

Q36. Ans -(b) isobar have same mass no.

Q37. Ans -(b) $^{257}_{103}Lr$ belongs to 4n+1 series so it will decomposition ultimately to an atom having mass no. belongs to (4n+1) series.

Q38. Ans -(d) $m_t = m_0 \left(\frac{1}{2}\right)^{\frac{6}{1.5}} = \frac{m_0}{16} = \frac{32}{16} = 2\,g$

Q39. Ans -(b) half is counted in one half life.

Q40. Ans -(b) $\frac{N}{N0} = \left(\frac{1}{2}\right)^{9/3} = \frac{1}{8}$

Q41. Ans -(a) $\frac{N}{N_0} = \frac{1}{4} = \left(\frac{1}{2}\right)^{\frac{2}{t_{1/2}}}$ (3/4th disintegrates, so remained ¼ th)

$2/t_{1/2} = 2 \quad \Rightarrow \quad t_{1/2} = 1\,hr$

Q42. Ans -(a) equal no. of atoms of Lead & Uranium means half of the material (uranium) converted into lead. So the life of sample = $t1/2$

Q43. Ans -(d) $m = mo\left(\frac{1}{2}\right)^{t/t_{1/2}} \Rightarrow 3 = m0\left(\frac{1}{2}\right)^{12/3} \Rightarrow mo = 3 \times 16 = 48\,g$

Q44. Ans -(a) $N = N_0\left(\frac{1}{2}\right)^{t/t_{1/2}} = N_0\left(\frac{1}{2}\right)^n = N_0 2^{-n}$

Q45. Ans -(b) $A_{mix} = A_1 + A_2$

$$(N_1 + N_2)\frac{0.693}{30} = N_1\frac{0.693}{2} + A_2$$

$\therefore$ To maintain activity same, A_2 must be increased

Q46. Ans -(d) A/q, it is give that the sample has constant activity of 2000 dis/minute. Also the activity of individual fraction will be equal to activity of the mixture. So the total activity will remain equal to 2000 dis/min.

Q47. Ans -(O) $\therefore$ Orbital angular momentum = $\sqrt{l(l+1)}\frac{h}{2\pi}$

Q48. Ans -(a) for de^-, $\ell = 2$

orbital angular momentum = $\sqrt{2\times3}\frac{h}{2\pi} = \frac{\sqrt{6}h}{2\pi} = \sqrt{6}h$

Q49. Ans -(b) by β-emission atomic no. increase & so the N/p ratio decreases. This makes the isotope move stable.

Q50. Ans -(d) E : hν

↓ Wave property — Both are related to each other by this equation.

Particle property