Atomic Structure

Isotones : elements having same $(A-Z)$

Isosters : species having same no of atoms & e^-s.

Isodiaphers : elements with same $|N-Z|$ (or) $|A-2Z|$

e/m ratio

$e^- = 1.76\times10^{11}\ C/kg = 5.27\times10^{17}\ esu/g = 1.76\times10^{8}\ C/g$

$p^+ = 9.58\times10^{7}\ C/kg = 9.58\times10^{4}\ C/g = 2.87\times10^{14}\ esu/g$

$n = 0$

$\alpha = 4\times p^+$ $\qquad$ $e/m \Rightarrow e^- > p^+ > \alpha > n$

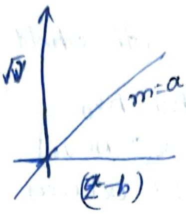
Mosley's experiment

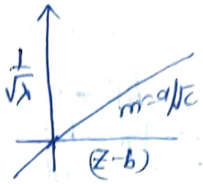
$\boxed{\sqrt{\nu} = a(Z-b)}$

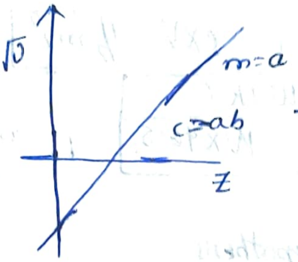
$y = mx$

$\frac{1}{\sqrt{\lambda}} = \frac{a}{\sqrt{c}}(Z-b)$

$\sqrt{\nu} = aZ + (-ab)$







$\rightarrow \frac{\text{size of nucleus}}{\text{size of atom}} = \frac{10^{-15}\ m}{10^{-10}\ m} = \frac{1}{10^5}$

Millikan oil drop exp.

$q = ne^-$

$\Rightarrow$ Mass of moving $e^- \Rightarrow m_v = \frac{m_0}{\sqrt{1-(v/c)^2}}$

Electrostatic force of attraction $F = \frac{Kq_1q_2}{r^2}$, $\frac{1}{4\pi\epsilon_0} \Rightarrow K = 9\times10^9\ Nm^2/c^2$

$r = \frac{2KZe^2}{KE}$ $\qquad$ $PE = \frac{-2KZe^2}{r}$, $K.E = \frac{KZe^2}{r}$

$\Rightarrow$ Planck Quantum theory : $E = h\nu = \frac{hc}{\lambda} = nh\nu = hc\bar{\nu}$ $\quad (\bar{\nu} = 1/\lambda)$

$h = 6.625\times10^{-34}\ Js = 6.625\times10^{-27}\ Erg.sec$ $\qquad$ $\boxed{E = \frac{12400\ (eV)}{\lambda\ (\text{in } A^\circ)}}$

$\rightarrow$ Light — $E = mc^2$ $\quad$ $\lambda\uparrow\ \nu, \bar{\nu}, E\downarrow$ $\quad$ c = same for all rays

Wavelength range for visible region is $3800\ A^\circ$ to $7600\ A^\circ$

$\rightarrow$ Bohr's atomic model : $\qquad$ $\boxed{1eV = 23\ Kcal}$

$mvr = \frac{nh}{2\pi}$ $\qquad$ $1eV = 96.5\ kJ/mol$

$1eV = 1.602\times10^{-19}\ J$

$E_n = -2.18\times10^{-18}\ J\ (Z^2/n^2) = -1312\times\frac{Z^2}{n^2}\ kJ/mol$

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

$= -313.6\ kcal/mol\ (Z^2/n^2)$

$\Delta E = 13.6\ Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

radius $r_n = 0.529\times\frac{n^2}{Z}\ A^\circ$

$V_{e^-} = 2.18\times10^6\times\frac{Z}{n}\ m/s$

revolution $= \frac{V}{2\pi r} = 0.657\times10^{16}\times Z^2/n^3$

$T = \frac{2\pi r}{V} = 1.52\times10^{-16}\times\frac{n^3}{Z^2}$

$KE : PE : TE = 1 : 2 : 1$

$TE = -\frac{Ze^2}{2r}$

$KE = \frac{Ze^2}{2r}$, $PE = -\frac{Ze^2}{r}$

$$\frac{K q_1 q_2}{r^2} = \frac{mv^2}{r}$$ (Columbic force)

→ **Spectral lines:**

Limiting line → n_1 to ∞.

$$\frac{1}{\lambda} = \bar{\nu} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2$$

$R_H = 109700\, cm^{-1}$. $\frac{1}{R_H} = 912$ Å

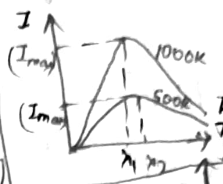
→ no. of spectral lines when e^- de excited $\frac{n(n-1)}{2}$ R_H = Rydberg const.

→ Rydberg constant varies for element ($R \times Z^2$) (n to ground)

→ Lyman, Balmer, Paschen, Brackett, Pfund, Humphrey — n_2 to n_1 = $n_2 - n_1$

$n=1$ U.V, $n=2$ visible, $n=3$ near IR, $n=4$ far IR

Black Body Radiation



$I_{max} \propto (1/\lambda)$ depends on T

⇒ **P.E.E**

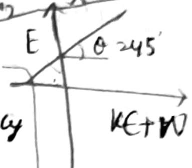
→ Min. frequency required (threshold frequency)

$KE = h\nu - W = h\nu - h\nu_0$

$\boxed{W = E_0 = h\nu_0 = hc/\lambda_0 = hc\bar{\nu}_0}$

→ $\nu \geq \nu_0$ only P.E.E occurs

W = work function
ν_0 = threshold frequency
V = stopping potential



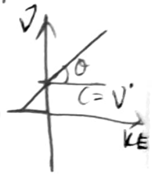
$\boxed{E^\circ (eV) = \frac{12400}{\lambda(Å)}}$

$\boxed{K.E = e \times V = \frac{1}{2}mv^2}$

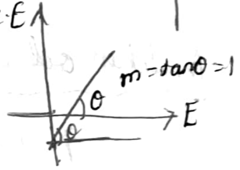
$\boxed{Q = W + K.E}$

$\boxed{I.E = W \times 96.5}$

best metal ∝ size of metal



$E = \frac{nhc}{\lambda}$ (n = no of photons)



⇒ **De Broglie hypothesis:**

$$\lambda = \frac{h}{mv} = \frac{h}{p} = \frac{h}{\sqrt{2mKE}} = \frac{h}{\sqrt{2eVm}}$$

e → charge of e^-
V → stopping potential

$$\lambda \text{ of } e^- \approx \sqrt{\frac{150}{V(\text{volts})}}\ Å$$

⇒ **Heisenberg uncertainity principle:**

$\Delta x \cdot \Delta p \geq h/4\pi$ (or) $(\Delta x)(\Delta v) \geq \frac{h}{4\pi m}$ (or) $(\Delta x)(\Delta v) \geq \frac{\lambda^2}{4\pi}$

⇒ **Schrodinger equation**

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E-V)\psi = 0$$

ψ = wave function (height (or) depth of wave)

ψ – value (+ve, –ve, 0) continuous, single values

⇒ ~~Wave mechanical model~~

Principal Quantum no.

① Size & energy of orbit

② Max. no of e^-s in an orbit $= 2n^2$
Max. no of orbitals $= n^2$

Angular momentum $= \frac{nh}{2\pi}$

Azimuthal Q. no:

→ No of e^-s in subshell $= 2(2l+1)$

→ No of orbitals in subshell $= (2l+1)$

$l = 0$ to $(n-1)$.

→ Orbital angular momentum $= \sqrt{l(l+1)}\,\frac{h}{2\pi}$ $\psi^2 = \bar{e}$ probability

Rules for filling of $\bar{e}$:

1. Pauli — No 2 $\bar{e}$'s in orbital have all Q. no same
2. Aufbau — filling of $\bar{e}$'s in order of $(n+l)$ value
3. Hund — Pairing of $\bar{e}$'s only if all orbitals are singly filled

Node: Space where find of $\bar{e}$ probability is zero

Radial node — angular node $= l$

$(n-l-1)$ **Nodal plane**: Plane where finding of $\bar{e}$ is zero

Ex: P_x — N.P YZ

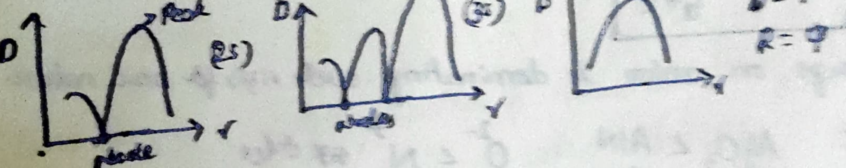
Radial probability distribution curves:

D vs r

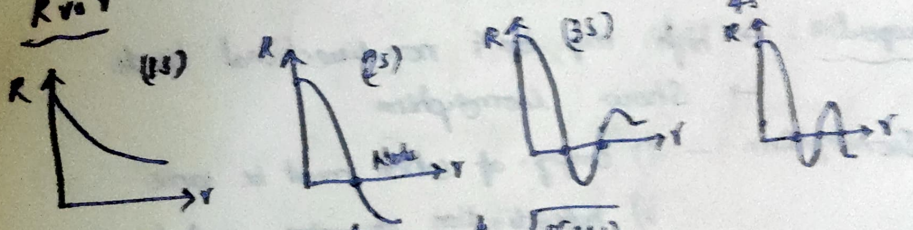
R.N $= n-l-1$

peaks $= n-l$

$D = 4\pi r^2 R^2 = 4\pi r^2\, dr\, \psi^2$



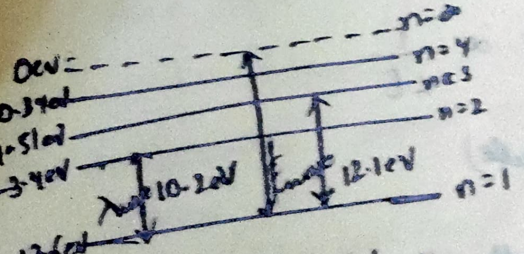
R vs r



→ Spin angular momentum $= \frac{h}{2\pi}\sqrt{s(s+1)}$

Spin magnetic momentum $(\mu) = \sqrt{n(n+2)}$ n = no of unpaired $\bar{e}$'s

Energy level diagram



$n_1 = 1$, $n_2 = \infty$ $n_1 = 1$, $n_2 = 2$

E_{max}, λ_{min} E_{min}, λ_{max}

* No of waves in a orbit $= n$

$n = \frac{2\pi r}{\lambda} = \frac{\text{circumference}}{\text{wavelength}}$

$\psi_{3,2,1,m}$ — n, l