Nuclear Chemistry!

Radioactivity :- → continuous and spontaneous emission of invisible radiation from naturally occuring heavy unstable nuclei.

① → accidently discovered by French scientist Henry Becquerel in 1896.

→ He was studying the properties of X-rays in connection with fluorescence of sample of potassium uranyl sulphat $K(UO_2)(SO_4)_2$

→ Sample ⟶ on photographic plate covered with black paper

↓

Eventually black spots / fog started appearing on photographic plate.

↓

Blackening was due to certain invisible penetrating radiation. 'Becquerel Rays'.

② Later Madam Curie and her husband Pierre Curie found natural ore of uranium eg. Pitchblende (U_3O_8).

ore was more radioactive than uranium salt.

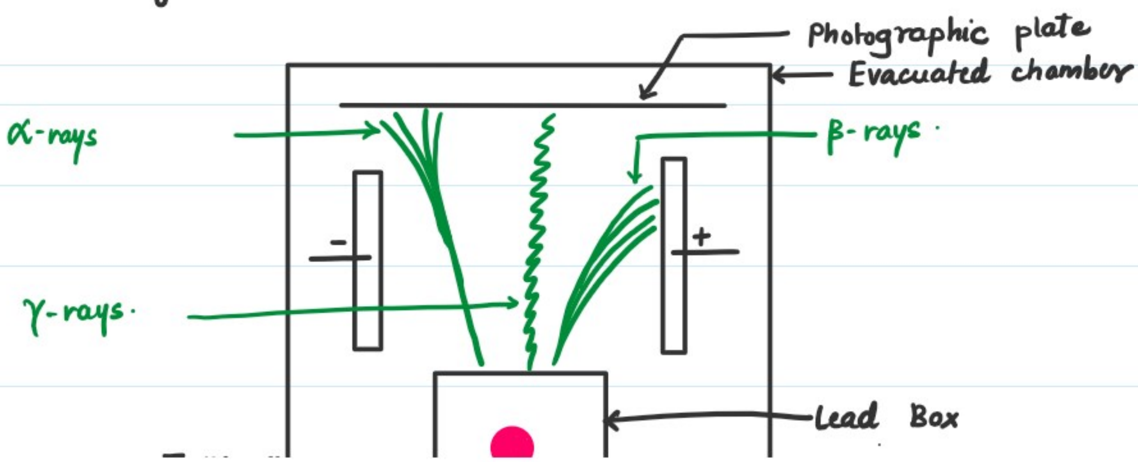
This led to discovery of Polonium & Radium.

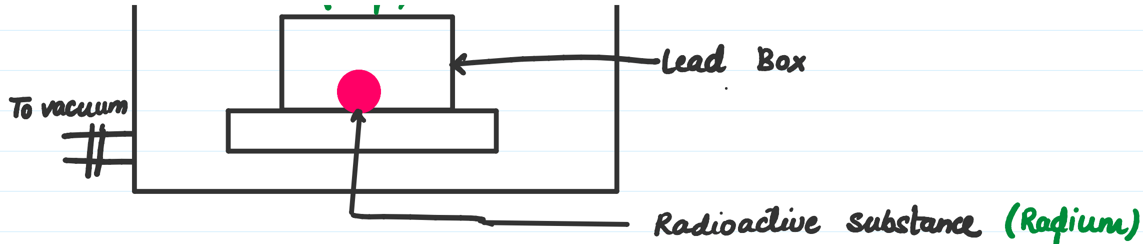
'Radioactivity' was coined by Madam Curie.

- Radioactivity is an inherent property of nucleus itself and is independent of external factors like temperature, pressure, catalyst, chemical field, electrical field, magnetic field, etc.

* Type of Radiations :-

→ Rutherford & Villard in 1889.





subjected to invisible electric and magnetic field.

3 different type of Radiations.

1. α-Rays :-
→ positively charged ; large mass
→ attracted towards negatively charged plate
→ deflected by small amt in magnetic field.

2. β-rays :-
→ negatively charged ; negligible mass
→ attracted to positively charged plate.
→ deflected by large amount in magnetic field.

3. γ-rays :-
→ no charge ; negligible mass.
→ unaffected by electric and magnetic field

→ All these ionization radⁿ have enough energy to ionize atoms

→ They can easily remove e^-

Properties	α-Rays	β-Rays	γ-rays.
Nature :-	carry → 2 unit +ve charge → 4 unit mass	carry → 1 unit -ve charge → negligible mass	donot carry charge or mass.
Representⁿ :-	^4_2He	$^0_{-1}e$	electromagnetic radⁿ.
same as :-	Helium nuclei	Electrons.	electromagnetic radⁿ.
Velocity :-	$\left(\frac{1}{10}\right)^{th}$ to $\left(\frac{1}{20}\right)^{th}$ of velocity of light	90% of velocity of light	same as velocity of light
Penetration power	low can pass Al foil of 0.01mm thickness	100 times more than α can pass Al foil of 0.1 cm thickness	100 times more than β. can pass through lead box — 8 cm thick iron sheet - 25 cm thick

power	can pass Al foil of 0.01mm thickness	can pass Al foil of 0.1 cm thickness	can pass through lead box — 8 cm thick, iron sheet - 25 cm thick	
Ionising Power	→ high → heavy mass ⇝ high KE	→ medium → light weight ⇝ low KE	→ low → negligible weight → 0	
Relative IP	10000	100	1	
Kinetic energy	Very High	High	Low	
Effect on photographic plate	effect on photographic plate	affect higher than α-particle.	very little effect	
Effect on ZnS screen	produce certain luminosity on ZnS screen	very little effect	very little effect on ZnS screen.	
Effect on emission	Atomic no → ↓ 2 Atomic mass no → ↓ 4	Atomic no → ↓ 1 Atomic mass no → no change	Atomic no. and mass no. unchanged.	} Group displacement law.
	- displaced to left of PT by 2 groups	- displaced to right of PT by one group.	- change in positⁿ in PT	

β - emission ⟶ electron should be ejected.

$$^1_0n \longrightarrow {}^1_1p + {}^0_{-1}e$$

${}^1_1p$ → get added in nucleus

${}^0_{-1}e$ → β-ray

Parent element (unstable) ⟶ **New element** = Daughter element. (stable) (unstable) (stable)

(Radiation)

↓

(α, β, γ - rad^n)

Radiation will continue till a stable nuclei is formed.

*** Isotopes :-**

→ same element with same atomic no. & different atomic mass no.

eg. ${}^{1}_{1}H, {}^{2}_{1}H, {}^{3}_{1}H$

${}^{16}_{8}O, {}^{17}_{8}O, {}^{18}_{8}O$

${}^{35}_{17}Cl, {}^{37}_{17}Cl$

*** Isobars :-**

→ different element with same mass no. & diff atomic no.

eg. ${}^{14}_{6}C, {}^{14}_{7}N$

${}^{40}_{18}Ar, {}^{40}_{19}K, {}^{40}_{20}Ca$

${}^{209}_{83}Bi, {}^{209}_{82}Pb$

*** Isotones :-**

→ diff. element with diff atomic no. & atomic mass no.

→ same no. of neutron.

eg. ${}^{31}_{15}P, {}^{32}_{16}S$

${}^{2}_{1}H, {}^{3}_{2}He$

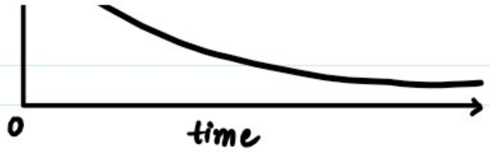
* Radioactivity ⟶ Radioactive decay / disintegration ⟶ this will observe first order kinetics

→ $t_{1/2} = \frac{0.693}{\lambda}$ $\lambda = \frac{2.303}{t} \log \frac{N_0}{N_t}$

λ = decay constant (same like 'k')

N_0 = no. of particles at time t = 0

N_t = no. of particles at time t.



→ Rate of disintegration decreases with time.
→ Time required for complete disintegration would be infinity.

* Nuclear Stability :-

Stable nucleus ⟶ non-radioactive
Unstable nucleus ⟶ emission of rad^n ⟶ stable nucleus.

1. Neutron to Proton Ratio (Belt of Stability)
2. Odd - Even Rule
3. Magic no. of neutrons
4. Binding energy per nucleons

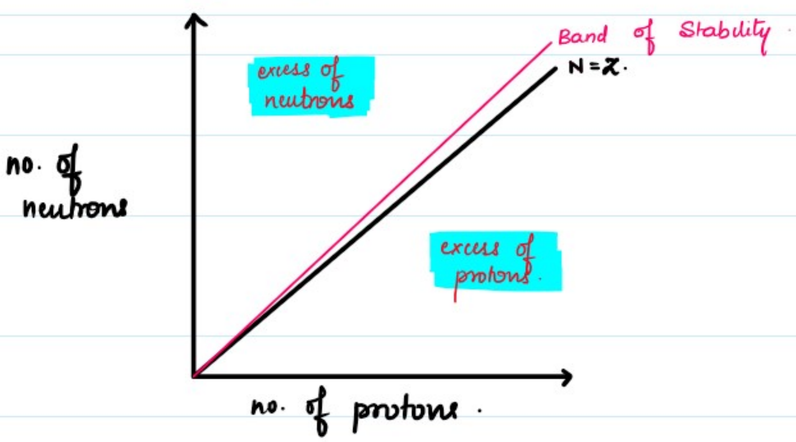
} help you in prediction of nuclear stable.

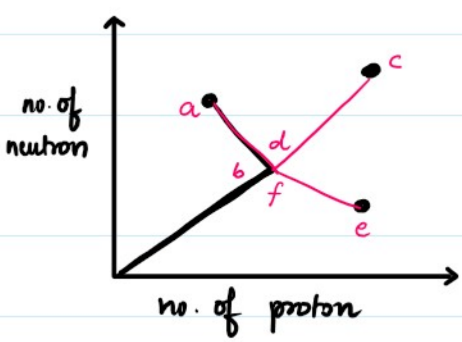
1) Neutron - Proton Ratio :-

Neutron ↓ no charge ↳ enforces nuclear force.
Proton ↓ + charge ↳ Repulsion b/w protons

Repulsion b/w protons is less than nuclear force.

As Z increases, no. of neutrons also increase but not in linear relationship.





Arrow ab :- High neutron to proton ratio
:- β- emission

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:- β- emission
:- Increase 'Z' and A remain same

Arrow cd :- $Z > 83$.
α- particles will be emitted
'A' and 'Z' will decrease

Arrow ef :- low neutron to proton ratio.
Positron emission or electron capture
Decrease 'Z' and A remains same.

2. Odd - Even Rule :-

Neutron	Proton	Stability
Odd	odd	Unstable
Even	Odd	Less stable
Odd	Even	More stable
Even	Even	Stable

3. Magic numbers :-

2, 8, 20, 50, 82, 126 ⟶ magic no.

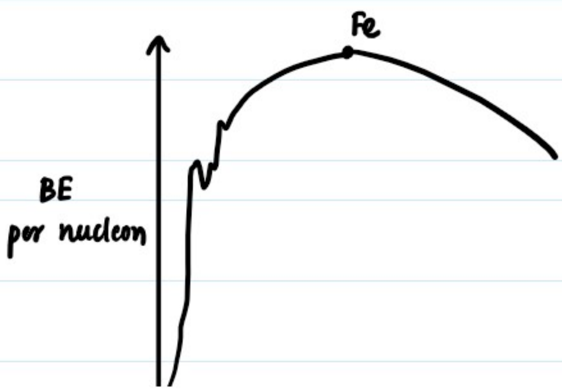
If no. of protons or no. of neutron equal to a magic number, then nuclei is unusally stable.

4. Binding energy per nucleon :-

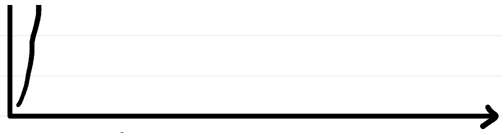
$(m_p + m_n) > m_{nucleus}$.

$$\text{Mass defect} = \Delta m = [Z(m_p + m_e) + (A - Z)M_n] - \underline{M}$$

M → mass of combined nucleus.



- BE increases with increase in atomic no. & then decreases
- It is not a smooth curve
- sharp peaks are observed where no. of proton = no. of neutrons.



'no. of proton = no. of neutrons.

* Units of Radiation Dose :-

1) Absorbed Dose :-

→ amt of energy deposited in unit mass of tissue.

→ $\frac{dE}{dm}$ = Dose.

→ rad = 100 erg/g → Gray = 100 rad.

→ Physical dose or external dose.

2) Dose equivalent. (H)

→ product of absorbed dose & Quality factor

H = QD.

Q = 20 α - particle
Q = 1 β -particle
Q = 10 to 20 neutrons.

→ sv (Sieverts) = 100 rem.

*

	Radioactivity	Absorbed Dose	Dose Equiv.	Exposure
Common Unit	Curie (Ci)	Rad	Rem	Roentgen (R)
SI unit.	Becquerel (Bq)	Gray (Gy)	Sievert (Sv)	c/kg.

* Roentgen (Rem) equivalent Man	— unit of equivalent absorbed dose	Rem = Rad × Q.
Sievert (Sv)	— unit of equivalent absorbed dose	1 Sv = 100 Rem Sv = Gy × Q
Rad (Radiation absorbed dose)	— unit of absorbed dose	1 rad = 100 erg/g
Gray	— measure of deposition of energy in tissue	1 Gray = 100 rad
Curie (Ci)	— traditional unit of radioactivity	1 Ci = 37 billion dps

Curie (Ci)	– traditional unit of radioactivity	1 Cu = 37 billion dps
Becquetel (Bq)	– SI unit of radio activity	1 Bq = 1 dps = 27 pCi.
Dps	– disintegration per second.	

Thank-You!