Nuclear Chemistry

Nucleus உள்ள proton, Neutron change ஆகி ஒரு New element form ஆகும். It is called Nuclear reaction.
" " " " Chemistry

Radioactive decay.

Radioactive element Spontaneous transformation by the radiation.

It is related to the Nature of Radioactivity (or) decay process.

Theory of Decay process Rutherford & Soddy

^ ~~~ ~~~ from one Chemical atom to another & Radio active (RA) atoms are emitted in the process

very heavy elements are (RA) & unstable.

The Nucleus breaks with emission of c, β. It is not simultaneous

Ra $\xrightarrow{\alpha}$ radon $\xrightarrow{\alpha}$ Po $\xrightarrow{\alpha}$ Pb $\xrightarrow{\alpha}$ Bi

Nucleus-ൻ്റെ stability ആശ്രയിച്ചിരിക്കുന്നത് No. of proton Neutron-ൻ്റെ അനുപാതത്തെ

Low atomic No. ഉള്ള മൂലകങ്ങളിൽ N/P ratio equal to 1

Higher atomic no ratio increased. 1:6

| Modes of decay | n/p ratio stable ആകും വരെ this process will continue |

α emission.

atomic wt — 4 units less

" No — 2 " "

Daughter element

$U^{234}_{92} \xrightarrow{2He^4} {}_{90}Th^{230} \xrightarrow{\alpha} {}_{88}Ra^{226} \xrightarrow{\alpha} {}_{86}Rn^{222}$

β emission

atomic wt → Same

" No → Increased by one unit

$Th^{234}_{90} \xrightarrow{\beta} Pa^{234}_{91} \xrightarrow{} {}_{92}U^{234}$

Neutron = proton + e^- + Neutrino,

Isotopes	Atomic no	Mass no	Neutrons
Ex: H and H	Same	Diff	Diff
Isobars	Diff	Same	Diff
Isotones	Diff	Diff	Same

nuclear size

They made up of 3 elementary particles

e^-, p, n

Nucleons = neutron + proton
neutrino

Some Stable Particles → e^-, p, positron, anti proton, neutrino, anti neutrino.

unstable particles → neutron, meson, and π particles

Prop of nuclei

Size - Small

dimensions are 10^{-14} m – 10^{-15} m

nuclei are smaller than atom

Radius $R = R_0 A^{1/3}$, R_0 is constant = 1.2×10^{-15} m

II **Mass**

Nucleus = Pro + Neu

Mass = Sum of Pro + Neutron.

$Z \times M_p + (A-Z) M_n$

Z → Atomic No

A → Mass no.,

(A−Z) → Atomic no.,

Mass defect. → Real mass less than Theoritical mass

↓ $= Z \times M_p + (A-Z) M_n -$ real Mass

Density $= \frac{\text{Mass}}{\text{Volume}} = \frac{A \times M_n}{\frac{4}{3}\pi R^3}$

$\frac{4}{3}\pi R^3 = \frac{4}{3}\pi r_0^3 A$

$R = r_0 \times A^{1/3}$

$= \frac{A \times M_n}{4/3 \pi r_0^3 A} = \frac{3 M_n}{4 \pi r_0^3}$.

Charge : Ze → electronic charge of Pro $= 1.6 \times 10^{-19}$

Total no., of +ve charge carried out by nucleus

Spin $= +1/2, -1/2$

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

total " " of nucleus = J(L ± S)

L+S − parallell orientation

L−S = anti "

Total angular momentum $= \sqrt{j(j+1)}\frac{h}{2\pi}$

Nuclear force

Two forces

1. Electrostatic (repulsive)
2. Nuclear force (attractive)

Nucleus → +ve charge → repulsive

Electrostatic force (Total magnetic moment) 3 10 Latches

+ve-ly charged protons. So they repulsive.

$\mu = \gamma \hbar I = g_n \mu_n I$

Blw the Nucleus.

γ – nuclear gyro magnetic ratio

(2) Nuclear force — blw the nucleons

It is called exchange force

g_n – nuclear Landé's splitting factor

Continuous exchange of some particles.

(μ_n – nuclear magneton)

(2) greater than (1); Nucleon interact with proton,

Meson theory — e'nic charge changes frm one nucleon to another. So pro. changes to neutron, neutron change to proton

All Nucleons Surrounded By Nore Mesons.

Meson Maybe Neutral, +ve, -ve

Meson clouds [illegible] Neu, Proton

[illegible] composition diff [illegible].

π meson is exchanged blw the ~~nucleus~~ Nucleons

This exchange is responsible for all Nuclear binding force.

Nutral π Meson exchange [illegible]

The force blw n-n, p-p & n-p.

~~Neutr blw pro~~ negative meson exchange [illegible] neutron, proton force [illegible]

~~The force blw Neu & pro. is the result of~~ exchange of ~~-ve Meson blw them~~

Neutron emits -ve π meson & convert into Proton

$n \rightarrow p + \pi^-$

B Adsorption Process

-ve π meson convert into Neutron.

$P + \pi^- \rightarrow N$

II Reverse process proton emits +ve meson

Neutron receiving the π^+ meson

$P \rightarrow n + \pi^+$; $n + \pi^+ \rightarrow P$

Thus all force of ~~Attractive~~ ~~force~~ attraction.

It is larger than electrostatic force

It give stability to the nucleus.

N/P ratio

Except Hydrogen

Nuclei contain Neutron & Proton

Stable nucleus N/P ratio equal to 1 upto $_{20}Ca^{40}$.

& N/P is greater than/for heavy nuclei

Artificial radio activity.

Stable element bombarded with High egy α particle.

It become radioactive

To emit radiation continuously

It is called artificial or Induced radio activity → Curie & her husband

B, Mg, Al bombard with α-Particles Pro, & Neutron emitted.

These reaction is known as (α, p) & (α, n) rx.

Pdt nuclei are unstable

It is emit the positron to get stable Nucleus.

$_5B^{10} + \underset{(_2He^4)}{{}_1\alpha} \rightarrow [{}_7N^{13}] + {}_0n^1 \longrightarrow {}_6C^{13} + \beta^+$

$_{12}Mg^{24} \longrightarrow {}_{14}Si^{27} + {}_0n^1 \rightarrow {}_{13}Al^{27} + \beta^+$

$_{13}Al^{27} \rightarrow {}_{15}P^{30} + {}_0n^1 \rightarrow {}_{14}Si^{30} + \beta^+$

Detection & Measurement of Radioactivity

1. Ionization chamber

It is filled in two metal plates separated by air

Radiation pass this Chamber

It knocks e^- from gas molecules

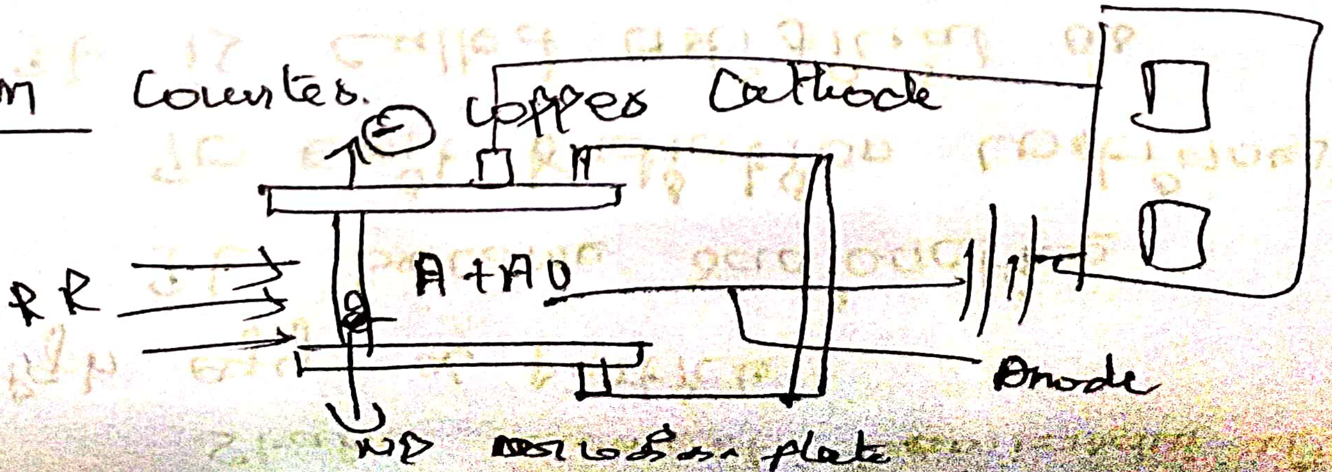
+ve ions formed

The free e^- migrate to anode & +ve into cathode

Current pass b/w the plates

This current measured by ammeter.

GM Counter.



Cu cylinder – cathode

Scattering < Elastic / Inelastic

Projectile particles scatted by the target

1. Elastic : Exchange of kinetic egy (ie) egy of b/w target nucleus & projectile
   No change in total potential egy.

Inelastic

Kinetic egy is not conserved.

2. Transmutation தனிம மாற்றம்.

3. Fission

$$_{92}U^{235} + _0n^1 \rightarrow _{42}Mo^{95} + _{57}La^{139} + 2\,_0n^1 +$$

Nuclear reaction

$$\underset{\text{target}}{x} \longrightarrow \underset{\text{projectile}}{a} \longrightarrow \underset{\text{ejectile}}{b} + \underset{\text{product}}{y}$$

Rutherford effect

$$_7N^{14} + _2He^4 \longrightarrow _8O^{17} + _1H^1$$ very first Nuclear reaction

N bombared with α to get oxygen

ransmutation

Projectile → egy (ener) to form an Intermedi-ate called cpd Nucleus b/w target Nucleus & projectile

$_6C^{12} + _2He^4 \rightarrow _8O^{15} + _0n^1$ (α, n type)

(α, n), (α, p), (p, α) (p, n) (d, n) (d, α) (n, p) (n - 2n)

$_7N^{14} + _2He^4 \rightarrow _8O^{17} + _1H^1$

$_3Li^7 + _1H^1 \rightarrow _2He^4 + _2He^4$

Stripping

Target → product Nuclei w/o formation of Intermediates are called Stripping rx

Ex (d, p) (d, n) (t, p) (t, d) (α, p) rx

Spallation

Projectile → high egy

It is interact with target, it is excited.

Fragmentation

Fission

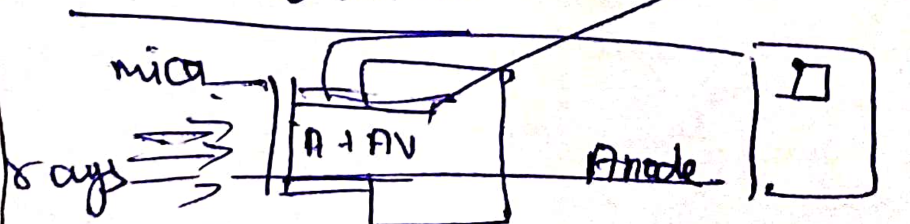
Fussion

Liquid drop model Strt. of the nucleus

Neils Bohr & wheeler (nucleons is considered as Statistical model. It's not considered model Individual charac of Nucleons

1. Spherical shape. Liquid drop
2. density does not depend the volume. Similar to nucleus
3. homogeneity and incompressibility. This implies that the charge density etc... all prop. are same to drops. It has constant density
4. nucleon interact with adjacent nucleon as a liquid drop. So nucleons force are short-range and saturation character
5. Both having surface tension effect. It is compared to potential barrier effect
6. attraction b/w two nucleons independent upon of charge & density. similar to intermolecular force
7. fusion — liquid drop breakup to two drops
   atoms breakup to two pieces
8. Evaporation of liquid ↔

G-M counter. Cu- Cathode



Explain
1. Nuclear fission fussion
2. It can apply to nuclei excited state
3. Atomic mass & egy calculated using this mass
Loss of nucleons for all nuclear reactions

Reactor . Magic No. / α, β emission prop

1. Fissionable material → U^{233}, U^{235}, Th^{232}
2. Moderator → D_2O, Hard water. High to Low
3. Neutron reflector (ന്യൂട്രോൺ ലീക്കേജ് തടയുന്നു) → leakage of neutron Reduced
4. Cooling System
5. Controlled & System. safety

High Scattering cross section ↗ low absorption cross section → good reflectors

4. Reduced the heat.
water, steam, He, CO_2, air → good coolant.

5. This is control the chain reaction.
Pushing the control rod into nuclear reactor.
Rod — [Boron or Cadmium]
having large neutron absorbtion cross section.
Rods absorb neutron and cut the reaction
By pushing rod → Reactor is slow.

Fission.

$$\bigcirc \longrightarrow \circ + \circ$$

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{92}U^{*236} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Egy.$$

fussion.

$$_1H^1 + {}_1H^1 \longrightarrow {}_1H^2 + {}_1e^0 + egy$$

$$_1H^2 + {}_1H^1 \longrightarrow {}_2He^3 + egy$$

$$2He^3 + 2He^3 \longrightarrow 2He^4 + 2\,{}_1H^1 + Egy$$

Nuclear Stability: Explain by more theories.

Indepent particle model

(1) Nuclear Shell Model

e⁻ அமைப்பு போல் ஒழுங்கமைந்துள்ள Nuclear having Shells உள்ளது. It is called Nuclear shell model.

Elements having Even No. of atomic no → is more Naturally occur.

They have more stability &

No. of Isotopes also high

Elements having Even No of Pro, Neutron ஒரு ஜோடியாக [illegible]

போன்றது e⁻ pairing நடைபெறுவது போல Nucleons-ம் ஜோடியாக உள்ளது.

ஜோடியான proton-ன் spin oppsite அமைப்பில் ~~[illegible]~~ Nuclear is highly stable.

Inert gas - 2, 10, 18, 36, 54, 86 Highly stable

2, 8, 20, 50, 82, 126 - Same Nucleons உள்ள Nuclear High Stable. It is called Magic Number

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Pro, new are grouped to shell.

I. nucleons shell do not ~~wit~~ interact with other shell

Nucleon exhibit Independent behaviour of their shell. It's referred as Independent particle model

The shell satisfying Quantum mechanical Condition.

Closed shell. It allow the spin-orbit coupling of each individual nucleons.
But no interaction of other shell) magic no.)

This model explains Nuclear prop, stability, abundance, binding egy, spin mag, moment

Ex $_2He^4$, $_8O^{16}$, $_{14}Si^{28}$, $_{20}Ca^{40}$

∴ Nuclei binding egy ↑ → stable ↑

If element having magic Number it has more isotopes. So stability is high.

Natually occuring element pb Z=82
Bi^{209} N=126 stable ↑

Application Agri

1. Radioactive isotopes → To improve plant growth
p^{32} fertilize

Radioactive Carbon → photosynthesis

Fe → Investigate the disease, chlorosis in the plant.

Ca^{45} → tracer