JEE MAIN

MODERN PHYSICS - PART 4

FORMULAE

RADIOACTIVITY

Now that's how you REVISE

-Mohit Goenka, IIT Kharagpur

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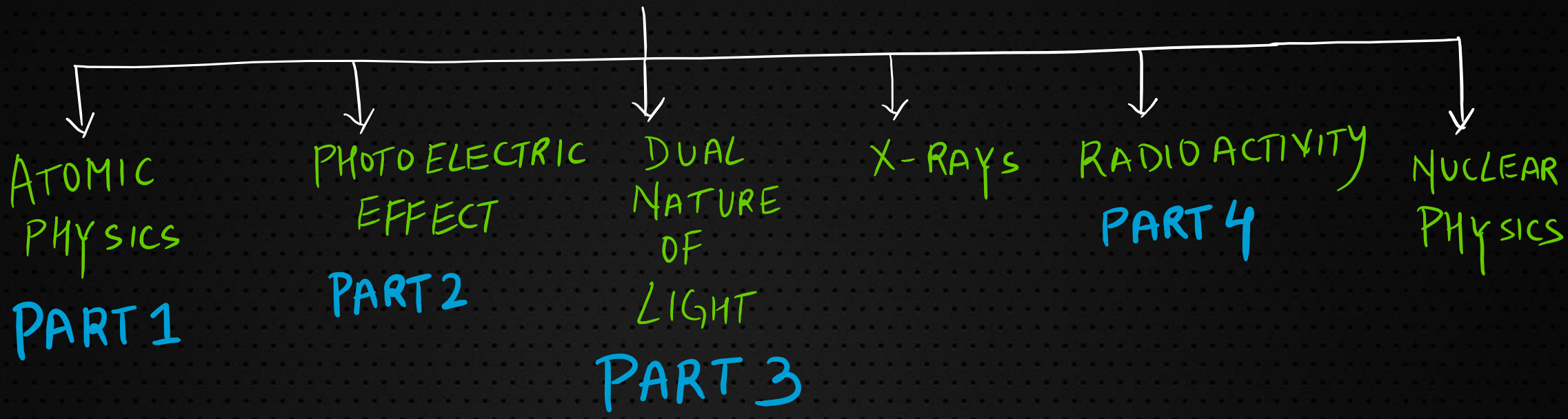
MODERN PHYSICS



1. RADIOACTIVITY (ACTIVITY, UNITS)

(a) Unstable nucleus disintegrate spontaneously.

(b) This phenomena of disintegration is called "ACTIVITY", A_c

Also known as decay rate

$A_c = -dN/dt$

$X \longrightarrow Y$

Parent Nucleus — Daughter Nucleus

(c) UNIT of Activity is dps (decay per sec)

- 1 Bq (Becquerel) = 1 dps
- 1 Ci (Curie) = 3.7×10^{10} dps = 3.7×10^{10} Bq
- 1 Ru (Rutherford) = 10^6 dps

2. RADIOACTIVE DECAY LAW ($X \xrightarrow{\lambda} Y$)

X → ACTIVE NUCLEI

(a) Activity $\propto$ Number of Active nuclei

$-\frac{dN}{dt} \propto N \Rightarrow -\frac{dN}{dt} = \lambda N$ {Activity, $A_c = \lambda N$}

λ → Decay Constant (tells how fast decay occurs)

Integrate ↓

Radioactive decay eqn ←

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

(i) N_0 is NO of Nuclei at $t = 0$

(ii) $A_c = A_{c0} e^{-\lambda t}$

3. HALF LIFE TIME (T)

↳ time taken to become half

At $t=0, N=N_0$

$t=T, N=\frac{N_0}{2}$

$\Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda T}$

$\Rightarrow \boxed{T = \frac{\ln 2}{\lambda}}$ or $\frac{0.693}{\lambda}$

NOTE: Radioactive decay eqn in terms of T:

$N = N_0 e^{-\lambda t} \Rightarrow N = N_0 e^{-\frac{\ln 2}{T} t}$

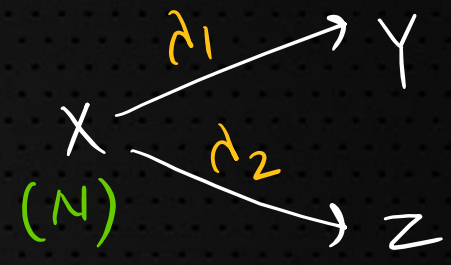
$$\boxed{N = N_0 (2)^{-t/T}}$$

and, $A_c = A_{c0} (2)^{-t/T}$

4. MEAN LIFE TIME

$$\boxed{\tau = \frac{1}{\lambda}}$$

5. SIMULTANEOUS DECAY



$A = \lambda_1 N + \lambda_2 N$

$\Rightarrow -\frac{dN}{dt} = N(\lambda_1 + \lambda_2)$

$$\boxed{N = N_0 e^{-(\lambda_1 + \lambda_2) t}}$$

6. RADIOACTIVE SERIES

$$A_1 \xrightarrow{\alpha_1} A_2 \xrightarrow{\alpha_2} A_3 \cdots A_n$$

A_n → Stable end product

Artificial as $T_{1/2}$ is too Low and so don't exist in nature

	SERIES	PARENT	END PRODUCT
$4n$	THORIUM	$_{90}Th^{232}$	$_{92}Pb^{208}$
$4n+1$	NEPTUNIUM	$_{93}Np^{237}$	$_{83}Bi^{209}$
$4n+2$	URANIUM	$_{92}U^{238}$	$_{82}Pb^{206}$
$4n+3$	ACTINIUM	$_{92}U^{235}$	$_{82}Pb^{207}$