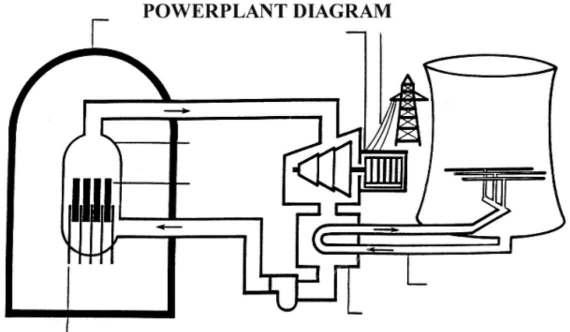
POWERPLANT DIAGRAM



Boiling Water Reactor (BWR)

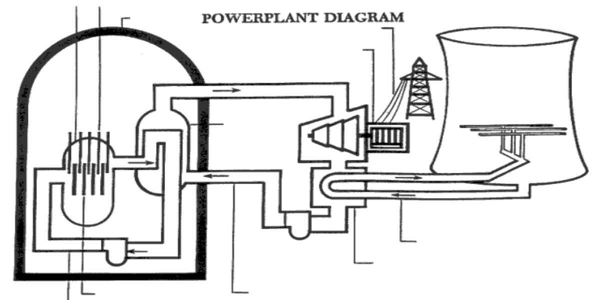
A. Identify the powerplant parts by writing the number of the correct powerplant part on the blank.

1. containment building
2. turbine-generator
3. control rods
4. cooling water loop
5. transmission lines
6. reactor
7. condenser
8. nuclear fuel

B. Color the separate loops using a different color for each loop. Then use the following symbols to show what is in each loop or part of a loop.

= steam   = water   = steam converted back to water

POWERPLANT DIAGRAM



Pressurized Water Reactor (PWR)

A. Identify the powerplant parts by writing the number of the correct powerplant part on the blank.

1. reactor
2. control rods
3. cooling water loop
4. containment building
5. steam-generator
6. turbine-generator
7. transmission lines
8. condenser
9. first water loop
10. second water loop
11. nuclear fuel

B. Color the separate loops using a different color for each loop. Use the following symbols to show what is in the loop or part of the loop.

= steam   = steam converted back to water   = cooling water

= water in first loop

Review of Nuclear Physics-I

Chemical Energy ⇒ Rearrangement of Electrons

Nuclear Energy ⇒ Rearrangement of Nucleons

Rutherford's Model

Protons, Neutrons, Electrons

	Mass	Charge
Proton	$1.67261 X10^{-24}$ g	$+1.60219 X10^{-19}$Columbs
Electron	$9.10956 X10^{-28}$g	$-1.60219 X10^{-19}$Columbs
Neutron	$1.67492 X10^{-24}$g	0

Review of Nuclear Physics-II

$^{A}_{Z}X$

Z - No of Protons

A - No of Protons + No. of Neutrons

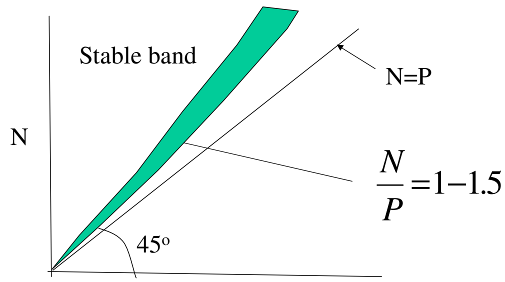
Isotope – Same Z, different A

⇨ Enormous Hollow space

⇨ Large number of neutrons for collisions of occur.

Radius of Nucleus	~	10^{-15}m
Radius of Atom	~	10^{-10}m
Density of Nucleus	~	10^{17} Kg/m3
Density of Atom	~	10^{3} Kg/m3

Stability of Nucleus-I



Unstable ⟶ Radiation ⟶ Stable

Fission ⟶ Neutron expulsion

Radioactivity ⟶ Transformation of unstable nucleus by Spontaneous emission of radiation

Stability of Nucleus-II

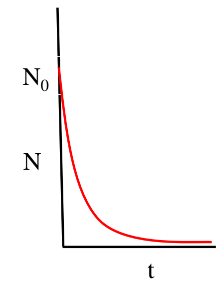
Postulate Probability of nuclear disintegration is constant.

Population	N
Time	dt
Disintegration	dN

$$\frac{dN}{Ndt} = \text{Constant} = -\lambda \quad (1)$$

I-order ODE — One condition

Initial Value — $N = N_0$ at $t = 0$



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

Stability of Nucleus-III

Half life $T_{1/2} \Rightarrow \frac{N}{N_0} = 0.5$

$$\therefore \frac{N}{N_0} = 0.5 = e^{-\lambda T_{1/2}}$$

$$\Rightarrow \lambda T_{1/2} = \ln 2$$

$$\text{or} \quad T_{1/2} = \frac{0.693}{\lambda}$$

$$N = N_0 e^{\frac{-0.693\,t}{T_{1/2}}}$$

$\Rightarrow$ 5 - half lives $\Rightarrow \frac{N}{No} = 0.0313$

$\Rightarrow$ 10 – half lives $\Rightarrow \frac{N}{No} = 0.00978$

Stability of Nucleus-IV

Every disintergration → Radiation

$\therefore \frac{dN}{dt} \rightarrow$ Rate of emission of Radiation $= \lambda N$

Activity

Units → Bequrrel =1 dps or s^{-1}

1 – curie = 3.7 X10 ^{10} Bq

≡ 1g of Radium

Analysis of Decay Chain-I

Fission Products are Radio active

$A \rightarrow B \rightarrow C \rightarrow D........$

- Practical chains are long
- 3 chain has all the characteristics

$A \rightarrow B \rightarrow C$ (Stable)

Population Balance

Rate of change= Production Rate – Destruction Rate

$$\frac{dN_A}{dt} = 0 - \lambda_A N_A \qquad \frac{dN_B}{dt} = \lambda_A N_A - \lambda_B N_B \qquad \frac{dN_C}{dt} = \lambda_B N_B - 0$$

Analysis of Decay Chain-II

$$\frac{dN_A}{dt} = 0 - \lambda_A N_A$$

With $N_A = N_{A0}$ at $t = 0$ $\Rightarrow N = N_o e^{-\lambda t}$

$$\frac{dN_B}{dt} = \lambda_A N_A - \lambda_B N_B \qquad \Rightarrow \frac{dN_B}{dt} + \lambda_B N_B = \lambda_A N_{Ao} e^{-\lambda_A t}$$

Using $e^{\lambda_B t}$ as the integral factor

$$\frac{dN_B}{dt} e^{\lambda_B t} + \lambda_B N_B e^{\lambda_B t} = \lambda_A N_{Ao} e^{(\lambda_B - \lambda_A)t}$$

$$\Rightarrow d\left(N_B e^{\lambda_B t}\right) = \lambda_A N_{Ao} e^{(\lambda_B - \lambda_A)t} dt$$

$$\Rightarrow \left[N_B e^{\lambda_B t}\right]_{In}^{Fin} = \lambda_A N_{Ao} \left[\frac{e^{(\lambda_B - \lambda_A)t}}{(\lambda_B - \lambda_A)}\right]_0^t$$

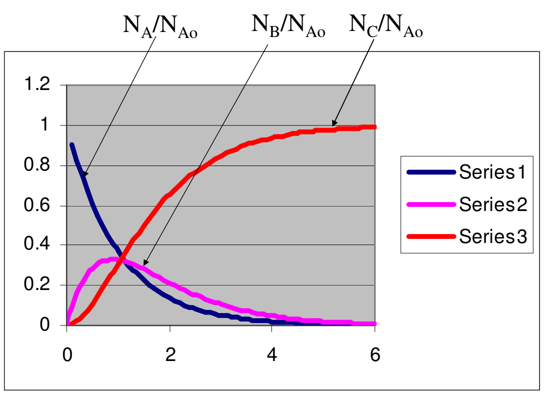
Analysis of Decay Chain-III

With $N_B = N_{B0}$ at $t = 0$

$$\Rightarrow N_B e^{\lambda_B t} - N_{Bo} = \frac{\lambda_A N_{AO}}{\lambda_B - \lambda_A}\left(e^{(\lambda_B - \lambda_A)t} - 1\right)$$

$$\text{or } N_B = N_{Bo} e^{-\lambda_B t} + \frac{\lambda_A N_{AO}}{\lambda_B - \lambda_A}\left(e^{-\lambda_A t} - e^{-\lambda_B t}\right)$$

Since $N_A + N_B + N_C = N_{A0} + N_{B0} + N_{C0}$, we can estimate N_C



$N_{B0}/N_{A0} = 0$, $N_{C0}/N_{A0} = 0$, $\lambda_A / \lambda_B = 0.8$

Special Cases -I

$$N_B = N_{Bo}e^{-\lambda_B t} + \frac{\lambda_A N_{AO}}{\lambda_B - \lambda_A}\left[e^{-\lambda_A t} - e^{-\lambda_B t}\right]$$

For $\lambda_B > \lambda_A$ $e^{-\lambda_B t} << e^{-\lambda_A t}$

- After some time, term 1 vanishes
- In term 2, the second term vanishes

$$\Rightarrow N_B = \frac{\lambda_A}{\chi_B - \lambda_A} N_{Ao} e^{-\lambda A t} = \frac{\lambda_A N_A}{\lambda_B - \lambda_A}$$

Or $\frac{N_B}{N_A} = \frac{\lambda_A}{\lambda_B - \lambda_A}$ Transient Equilibrium

Special Cases -II

For $\lambda_B >> \lambda_A$ $\frac{N_B}{N_A} = \frac{\lambda_A}{\lambda_B} \Rightarrow \lambda_A N_A = \lambda_B N_B$

The above implies that the activities are equal irrespective of the initial activities. This is called Secular equilibrium