

# Physics Summary Final

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## Mass Defect and Binding Energy

### Mass Defect :

- The difference between the sum of the masses of the individual nucleons and the actual mass.

### Binding Energy :

- The energy difference between the separated nucleons and the assembled nucleus.
- represents the energy required to hold protons and neutrons together in a nucleus.
- If the binding energy is zero, it indicates that there is no net attractive force acting to keep the nucleons (protons and neutrons) together.

### Extra Points :

- a nucleon has a proton and neutron.
- Strong nuclear force holds proton in the nucleus.
- Relationship between mass and energy :  $E = mc^2$

### Formula :

$$\text{Total mass} = Z \times m_H + N \times m_n$$

- **Z** : atomic no. (number of protons)
- **m<sub>H</sub>** : mass of hydrogen
- **N** : number of neutrons (A - Z)
- **m<sub>n</sub>** : mass of neutron

$$\Delta m = T.m - M_{\text{atom}}(\text{actual measured mass in } \underline{\text{Given}})$$

$$\text{B.E. (in MeV)} = \Delta m(\text{in u}) \times 931.494 \text{ MeV/u}$$

### Binding Energy per Nucleon (B.E./A)

- $\text{B.E.} / A = \text{Total Binding Energy} / \text{Mass Number}$

- mhydrogen atom 1.007825 u
- mneutron 1.008665 u
- mdeuterium atom 2.014102 u
- mhelium atom 4.002603 u

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## Nuclear Decay and Reactions

### Radioactive decay :

- is the emission of energy in the form of ionizing radiation.

### Radiation :

- is the energy that comes from a source and travels through space at the speed of light.

### 3 modes of nuclear decay : \*you go in-terms of the **Atomic No.**

1. **Alpha decay** : Helium nuclei; alpha particles( ${}^4_2\text{He}$ ) being emitted.

- **Mass no.** : Decreases by 4; and **Atomic no.** : decreases by 2

#### Example :

Emitted	Bombarded
${}^{238}_{92}\text{U} \Rightarrow {}^{234}_{90}\text{Th} + {}^4_2\text{He}$	${}^{222}_{86}\text{Rn} + {}^4_2\text{He} \Rightarrow {}^{226}_{88}\text{Ra}$

2. **Beta decay** : Antineutrino and  $\beta$ -particles( ${}^0_{-1}\text{e}$ ) are being emitted.

- **Mass no.** : does not change; and **Atomic no.** : increases by 1(Bc changing of 1 neutron to portion)

#### Example :

Emitted	Bombarded
${}^{14}_7\text{N} + \beta^- + \bar{\nu}_e \Rightarrow {}^{14}_6\text{C}$	${}^{14}_6\text{C} \Rightarrow {}^{14}_7\text{N} + \beta^- + \bar{\nu}_e$

3. **Gamma Decay** : Redistribution of energy with nucleus.  $\Rightarrow \gamma$  | Results in no isotope change

- **Mass no.** and **Atomic no.** : do not change.

#### Example :

Emitted	Bombarded
${}^{99m}_{43}\text{Tc} \Rightarrow {}^{99}_{43}\text{Tc} + \gamma$	${}^{99}_{43}\text{Tc} + \gamma \Rightarrow {}^{99m}_{43}\text{Tc}$

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## Nuclear Decay Series

- This is an application/solving Lesson

- ' $\searrow$ '  $\Rightarrow$  Alpha Decay; ' $\rightarrow$ '  $\Rightarrow$  beta Decay
  - The previous product becomes the next reactant.
- The are 8 alpha decays, and 6 beta decays.
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## Half Life

**Half life** : \*denoted by t

- The time required for half of the atoms in any given quantity of a radioactive isotope for decay.

**Practical Applications of Half life** : \*momerize 4

- Radioactive Dating
- Nuclear Medicine
- Pharmacology
- Environmental Science
- Nuclear Power
- Food Preservation

## Formulas :

$$t = \text{No. of days passed} / \text{Half life}$$

$$\text{Remaining} = \text{original} \left(\frac{1}{2}\right)^t$$

## Units of Radioactivity :

- **Curie** : corresponds to activity of 1 gram of Radium 226
- Original unit
  - 1 Curie =  $3.7 \times 10^{10}$  radioactive decay per second
- SI unit is Becquerel
  - 1 Bq = 1 radioactive decay per second =  $2.703 \times 10^{-11}$  Ci
  - Also as a measure of quantity of radioactive material
    - i.e. the no. of atoms that will produce 1 Ci of radiation is

$$N = 3.7 \times 10^{10} / \lambda$$

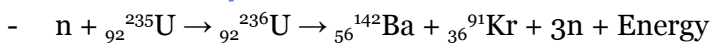
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## Nuclear Fission and Fusion

**Nuclear Fission** : \*decomposition of nucleus

- the division nucleus into 2 or more fragments.
- **How it happens** :
  - Large nucleus is bombarded with a small particle.
  - The nucleus splits into smaller nuclei and several neutrons.
  - Large amounts of energy are released
- The released energy is around 173 MeV
- **Central rods** absorb fast neutrons to make them slower and reduce their speed to initiate nuclear fission.
  - Because fast neutrons don't cause **nuclear fission**.
- A **moderator** slows down fast neutrons.

**Nuclear Fission Equation** :



**Chain Reaction** :

- occurs when a critical mass of uranium undergoes fission.

\*speed of neutrons;  $c = 3 \times 10^8$

Fast Neutrons	Slow Neutrons
$c/7$	$c/8$

**Nuclear Power Plants** :

- Fission is used to produce energy
- control rods in the reactor absorb neutrons to slow and control the chain reactions of fission.

**Nuclear Fusion** : \*occurs at extremely high temps (10M C°)

- Light-mass nuclei combine to form a heavier, more
- Fusion releases more energy than Fission.

**Nuclear Fusion Equation** :

- Proton proton cycle



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