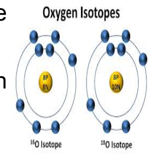
Ch 31- Nuclear Physics

- **Nucleus** ⟶ #p + #n = atomic number = A (A-Z = #n)
- **Atomic mass unit** = u = 1.66×10^{-27} kg
  - > 1 p = 1.007276 u
  - > 1 n = 1.008665 u
  - > 1 e = 0.00055 u
- **Radius of Nucleus - different for each atom but SAME density means BIGGER R = BIGGER MASS**
  - > **$R = (1.2 \times 10^{-15})(A^{1/3})$ m**

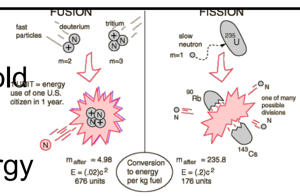
Energy in Nucleus

- Held together by **Strong Nuclear Force**
- + do NOT want to stay together
- various amounts of neutrons help stabilize
  - > IF N = Z = stable
  - > higher mass than 83 = more unstable
- **isotope** = same atom (same protons) different neutrons, some more stable than others
- average mass of atom on periodoic table



Binding Energy

- energy needed to hold nucleus together
- tear apart = get energy back
- mass of sum of the parts ≠ mass of the whole
  - **$E = \Delta mc^2$ (in JOULES!!!!)**
  - **1 u = 931.5 MeV = 1.67×10^{-27} kg**



Example:

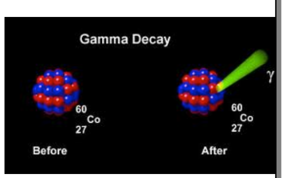
- 2H + 2N combine to form 1 Helium
- 2(1.0078u) + 2 (1.0087u) = **4.0330 u**
- Appendix F shows He = **4.0026 u**
- **mass defect = 4.0330 u - 4.0026 u** = .0304 u (931.3 Mev/u) = 28.3 MeV = binding energy
- **Energy/nucleon** = 28.3 MeV/4 = 7.08 MeV/nucleon

Radioactivity **- atoms spontaneously give off particles to become more stable, mass and charge must always be conserved**

Types of decay

1) **Gamma (Y)** = photon, no mass, no charge

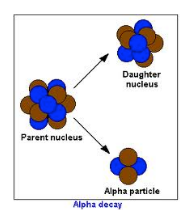
ex. $^{232}_{90}Th \longrightarrow ^{228}_{88}Ra + ^{4}_{2}\alpha$



2) **Alpha Decay (α)** = Helium nucleus (m = 4u, q = 2e)

ex. $^{222}_{88}Ra \longrightarrow ^{4}_{2}He + ^{218}_{86}Rn$

$^{238}_{92}U \longrightarrow ^{234}_{90}Th + ^{4}_{2}\alpha$

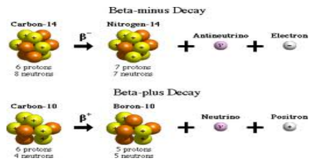


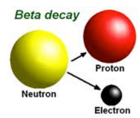
3) **Beta Decay (β)** = electron (m=0, q = -1e)

ex. ${}^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta$

$${}^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu}$$

antineutrino given off at same time as n turns p and e





Half-life ($T_{1/2}$) - The time it takes for HALF a sample of nuclei to decay (NOT MASS!!!)

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{.693}{\lambda}$$

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

$$\frac{\Delta N}{\Delta t} = \lambda N_o = A_o$$

$$A = A_o e^{-\lambda t}$$

N = number of nuclei

λ = decay constant sec^{-1}

A = activity = disintegrations/sec = Bq

Other units for A:

Curie = Ci = 3.7 x 10^{10} Bq

Roentgen = R = due to x-rays and gamma rays only, 1 R = 2.8 x 10^{-4} Ci

Gray = Gy = absorbed dose by biological material = J/kg

Radians = Rd = like Gy but 1 Rd = .01 Gy

Rem = how affects body compared to stada x-ray

Carbon Dating

- Based on living tissue replacing C constantly
- **Normal A = .23 Bq, $T_{1/2}$ = 5730 yrs**
- **Activity decreases with time**