Nuclear Reactions

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Units & Constants

$m_p = 1.007825$ amu

$m_n = 1.008665$ amu

$931.49\ MeV = 1\ amu$

$1\ MeV = 1.6 \times 10^{-13}\ J$

$1\ amu = 1.6 \times 10^{-27}\ kg$

Avagadro's Number

6.022×10^{23} atom/mol

Nuclear Equation

Hydrogen and dueterium (H-2) fuse in stars.

atomic mass →

atomic number →

$$^{1}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He$$

The total mass number and atomic numbers **must** be equal on both sides.

Ex.

$$^{36}_{15}P + \underline{\ ^{12}_{6}C\ } \rightarrow ^{25}_{12}Mg + ^{6}_{3}Li + ^{14}_{6}C + 3\,^{1}_{0}n$$

Exo/Endo-Thermic Reactions

Exothermic – A reaction where energy is a product.

Reactants will have a higher mass

- Can be spontaneous (decays)

Endothermic - A reaction where energy is a reactant

Products will have more mass

- Only known to happen in super nova sized events

Decays

$^4_2\alpha = ^4_2He$ is shot from the nucleus of a heavy radio isotope.

$^0_{-1}\beta$ → A neutron (udd) Flips one of its quarks to become a proton (uud)

$^0_0\gamma$ → High energy light

Example: ^1_1H and ^2_1H reaction

$$^1_1H + ^2_1H \rightarrow ^3_2He$$

^1_1H: 1.007825

^2_1H: 2.014101

^3_2He: 3.016029

Total Reactant Mass: 3.021926 = Total Product Mass: 3.016029 + Energy (by change in mass)

$$\Delta m = 0.005897 \text{ amu}$$

How much energy is this?

$$0.005897 \text{amu} \times 931.49 \frac{\text{MeV}}{\text{amu}} = 5.4930 \text{ MeV}$$

$$5.4930 \text{MeV} \times \frac{1.6 \times 10^{-13} \text{J}}{\text{MeV}} = 8.7888 \times 10^{-13} \text{ J}$$

If we had 1 mol of each reactant

($\sim 1g$ of ${}^{1}_{1}H$) and ($\sim 2g$ of ${}^{2}_{1}H$)

$$8.7888\times10^{-13}\times6.022\times10^{23} = 5.292\times10^{11}\ J$$

$\sim 3g$ of Reactant gives 529 GJ

529,000,000,000 J