Nuclear Reactions

Artificial (Induced) Transmutation

- If a nucleus cannot decay by itself, it can be made to decay if energy is supplied to it
- The energy is supplied by a fast moving particle colliding with the nucleus
- Rutherford (and his associate Blackett) discovered the transmutation of nitrogen

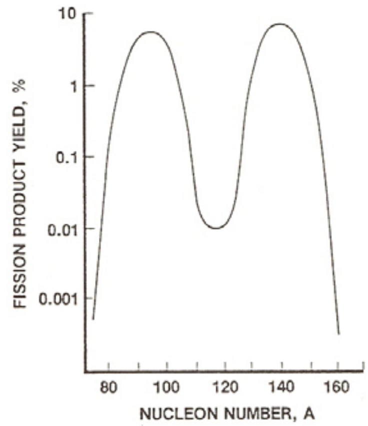
$$^{14}N + \alpha \rightarrow {}^{17}O + p$$

Nuclear Fission

- The process in which a heavy nucleus splits into lighter nuclei and releases energy
- The most common fission reaction involves ^{235}U

$$n + {}^{235}U \rightarrow {}^{236}U^* \rightarrow 2.3n + P_1 + P_2$$

P1 and P2 vary from one fission to another. Statistically they can be described by the following distribution



- The amount of energy released from this fission reaction (and any other one) can be found by the mass difference between the original atoms and the products
- For the ^{235}U reaction the energy is approximately 190 *MeV*

Nuclear Fusion

- The process of joining two light nuclei into a heavier nucleus and releasing energy
- An example of a fusion reaction is

$$^{2}H + {}^{2}H \rightarrow {}^{3}He + n$$

or

$$d + d \rightarrow {}^{3}He + n$$

- This reaction releases 3.2 *MeV*

- For fusion to occur, very large temperatures are required
- This is necessary to overcome the electrostatic repulsion between the two nuclei
- The enormous temperature causes the nuclei to move fast enough so as to approach each other sufficiently for fusion to occur

- The high temperature and pressures in the interior of stars make ideal places for nuclear fusion
- The following fusion reaction occurs in our sun

$$\left.\begin{cases} p + p \rightarrow d + \beta^{+} + \overline{\upsilon} + 0.4\ MeV \\ p + d \rightarrow {}^{3}He + 5.5\ MeV \end{cases}\right\} \times 2$$

$${}^{3}He + {}^{3}He \rightarrow {}^{4}He + 2p + 12.9\ MeV$$

In total, this reaction produces 24.7 MeV