Physics 113 -Lecture 18

Nuclear Reactions

Transmutation e.g. lead→gold

$$a + X \rightarrow Y + b$$

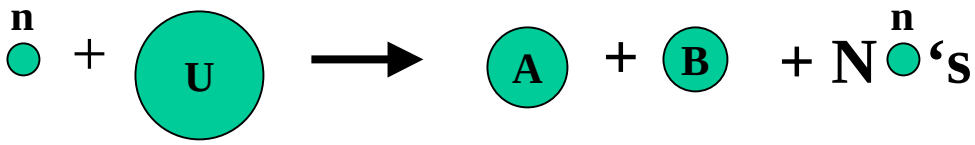
$$Q = (M_a + M_X - M_b - M_Y)c^2$$

$$Q = KE_b + KE_Y - KE_a - KE_X$$

$Q > 0$ Exothermic (Energy Released)

$Q < 0$ Endothermic (Energy Supplied)

Fission Hahn/Strassman



Neutron split uranium into large pieces A and B with the release of many neutrons

$$(1\,\text{MeV})(236\ \text{Nucleons}) \approx 200\ \text{MeV}$$

Chain Reaction

- **each fission releases a large amount of energy**
- **resulting neutrons can catalyze more fissions**

$$f = \frac{\#\ \text{nucleons created causing fission}}{\text{fissions}}$$

Critical mass f=1
Reactor f=1
A-Bomb f>>1

Moderator
- slow neutrons interact more often than fast neutrons
- good moderators deuterium, carbon

Fusion

Sun's Energy (proton-proton cycle)

$$_1^1\mathrm{H} + _1^1\mathrm{H} \rightarrow _1^2\mathrm{H} + \mathrm{e}^+ + \nu_e \quad (.42\ \mathrm{MeV})$$

$$_1^1\mathrm{H} + _1^2\mathrm{H} \rightarrow _2^3\mathrm{He} + \gamma$$

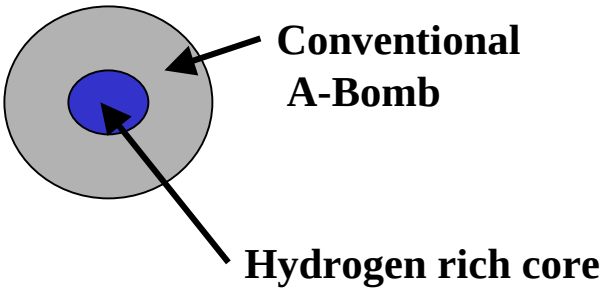
$$_2^3\mathrm{He} + _2^3\mathrm{He} \rightarrow _2^4\mathrm{He} + _1^1\mathrm{H} + _1^1\mathrm{H}\ (12.86\ \mathrm{MeV})$$

Released ~4 MeV/nucleon burned

output $_2^4\mathrm{He}, \mathrm{e}^+, \nu_e, \gamma$

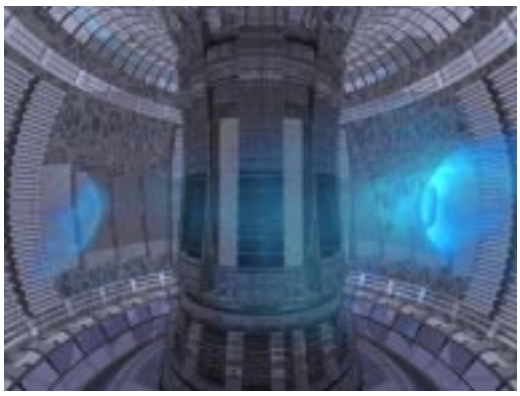
Hydrogen Bomb

- Intense heat from A-bomb starts fusion reactions
- ~100x more powerful than A-bomb



Fussion Reactor

- harness fusion
- cheap hydrogen fuel
- unlimited power
- maybe in 20 years



The Tokomak seen above creates fusion reactions but uses more energy than it creates !