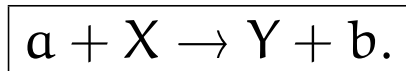


Upcoming topics

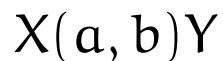
- Reactions and cross-sections
- Fission
- Fusion
- Radiation and matter
- Detectors

Nuclear reactions

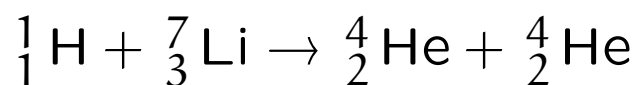
Bombard nuclei and change their structures. Suppose we have target nucleus X, incoming particle a, resulting in nucleus Y and particle b:



This is also written



For example ${}^7\text{Li}(p, \alpha){}^4\text{He}$ is



Conservation laws for reactions

Conservation of mass number Nucleons before must equal nucleons after.

Conservation of charge Total $q_{\text{after}} = q_{\text{before}}$.

Conservation of E , \vec{p} , and \vec{L} .

Reaction energy Q

Total kinetic energy released or absorbed in the reaction.

$$M_X c^2 + K_a + M_a c^2 = M_Y c^2 + K_Y + M_b c^2 + K_b$$

So, solving for the change in K :

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

$Q > 0$ exothermic.

$Q < 0$ endothermic.

For endothermic, more than Q is required to proceed: there must be some excess provided to conserve momentum. The minimum is the threshold energy $K_{th} > |Q|$.

Reaction cross-section

Imagine a beam of particles incident on a thin foil of thickness x . Each target nucleus X has an effective area σ called the **cross-section** for that reaction. Let the foil have area A .

R_0 = rate at which particles hit foil.

R = rate at which reaction events occur.

n = nuclei/volume, each with σ .

Total nuclei in foil will be nAx , total area exposed to beam (for the reaction) will be σnAx , so the reaction rate is

$$\frac{R}{R_0} = \frac{\sigma nAx}{A} = \sigma n x.$$

The reaction will remove particles from the beam, so the number remaining after a distance x in the foil will be

$$N = N_0 e^{-n\sigma x}$$

Cross-sections have dimensions of area. The common unit is

$$1 \text{ barn} = 10^{-28} \text{ m}^2.$$

This is of order of the geometric area of a nucleus.

Cross-sections vary with both the specific reaction and with the incident K , and can range from much more to much less than the geometrical area of the target particle.