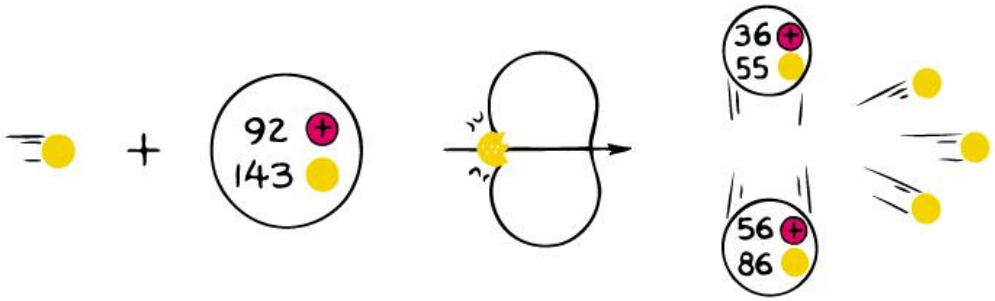
Chapter 34

Nuclear Fission & Fusion

Nuclear Fission

Fission: The splitting apart of a heavy nucleus in to lighter nuclei with the release of energy. For example:



$$^{1}_{0}n + {}^{235}_{92}\mathrm{U} \rightarrow {}^{91}_{36}\mathrm{Kr} + {}^{142}_{56}\mathrm{Ba} + 3({}^{1}_{0}n)$$

The liberated neutrons can go on to initiate further fission events that in turn liberate more neutrons that cause even more fission events, and so on.

This can result in a *chain reaction*.

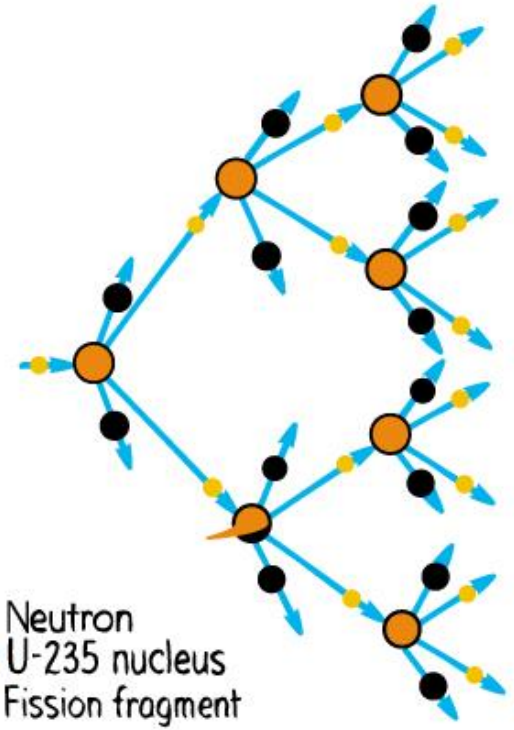
Chain Reaction

A self-sustaining reaction is which one event go on to initiate further events.

If (on average) each event initiates one further event, then the reaction is said to be critical.

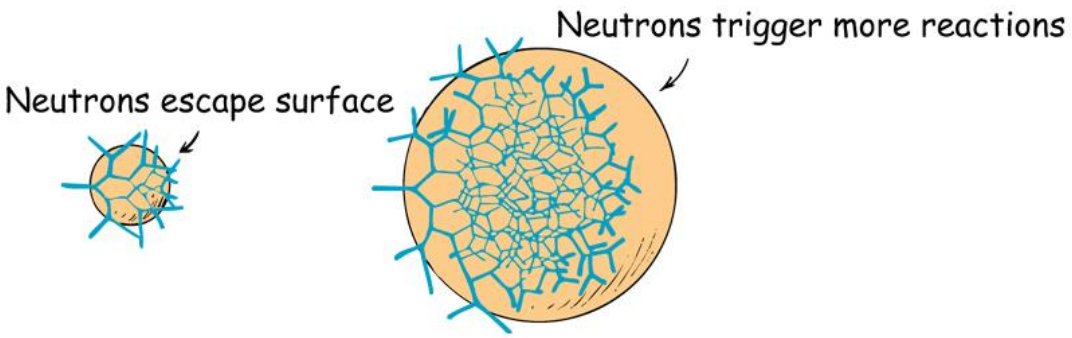
If each event initiates more than one further event (as shown in the figure), then the reaction is said to be supercritical and can build up explosively.

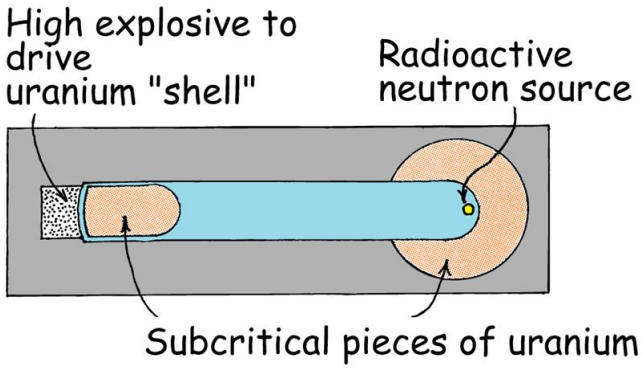
If each event initiates less than further event, then the reaction is said to be subcritical and will die out.



Fission Bomb

In a subcritical mass, the liberated neutrons escape to the surface so no chain is sustained. If two subcritical masses are pushed together to create a supercriticial mass (as they are in a fission bomb), an enormous explosion will result.

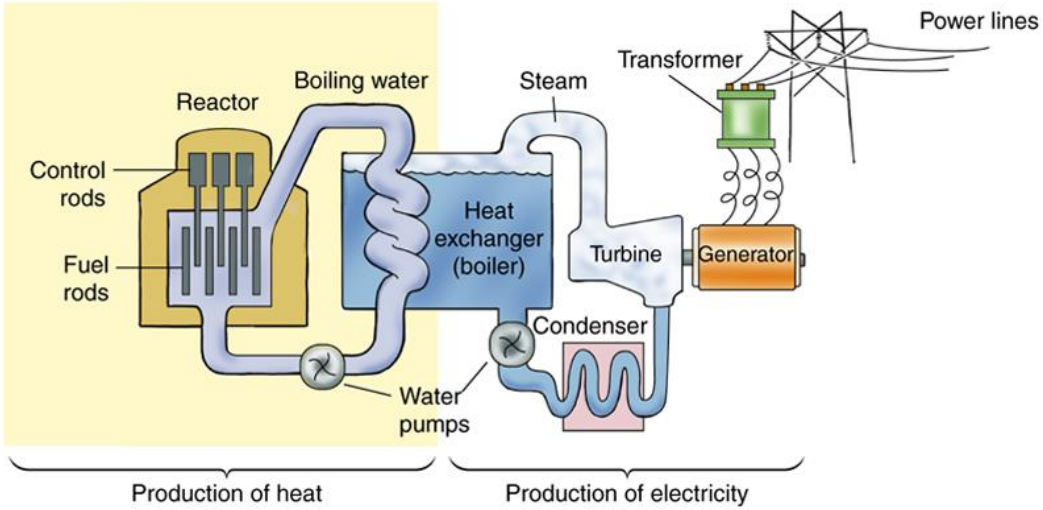




Fission Reactor

The energy released is used to boil water to make steam that will turn a turbine that will spin magnets in coils (or coils in magnets) to generate electricity.

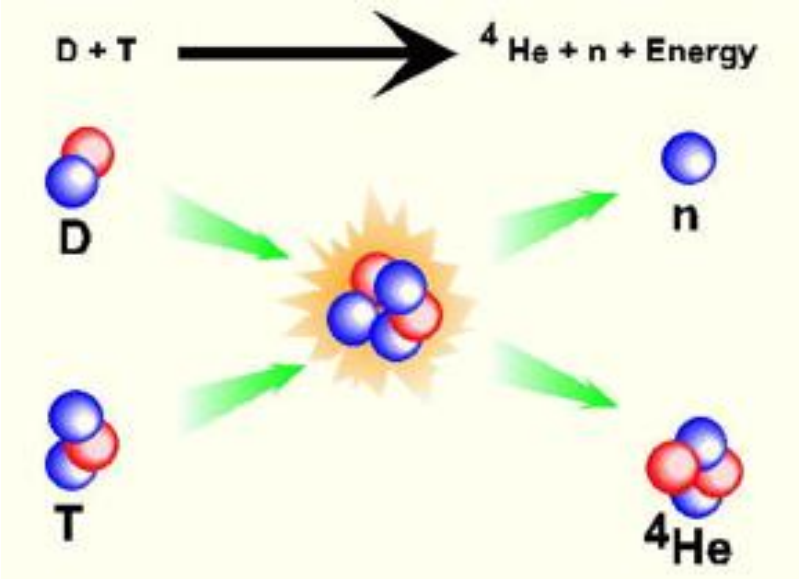
Critical mass



Nuclear Fission & Fusion

Fusion: The combining of light nuclei to form a heavier nucleus with the release of energy.

Example: $^{2}H + {}^{3}H \rightarrow {}^{4}He + n + energy$



Mass-Energy Equivalence

The amount of energy that an object by virtue of its mass is given by Einstein famous equation:

$$E = mc^2.$$

This basically says that mass is a like "congealed" energy. In nuclear reaction the energy released comes at the expense of mass: $E_{released} = \Delta mc^2$.