Fission and Fusion

Aim

- to compare and contrast nuclear fission and nuclear fusion

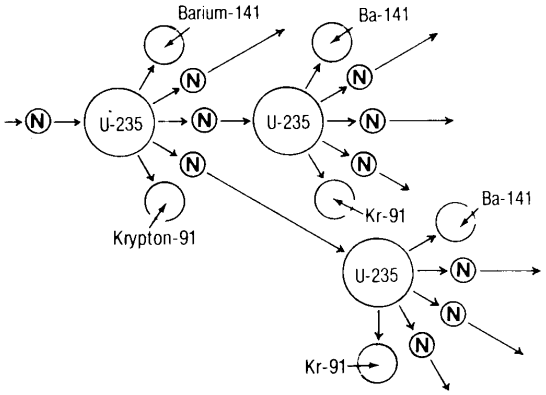
Notes

Fission

- ★ Definition - a nuclear reaction in which a heavy nucleus splits into two lighter nuclei releasing neutrons and a tremendous amount of energy
  - ☆ Cause - initiated by capture of a neutron fired at the nucleus of an atom
  - ☆ the lighter elements that form from fission are more stable than the parent element due to greater binding energy per nucleon
- ★ Chain Reaction
  - ☆ A reaction in which the neutrons released by fission of one nucleus trigger fission in other nuclei nearby
    - ✯ Uranium-235 is unstable and splits into two smaller nuclei plus neutrons and energy.
    - ✯ The rate of fission can be increased by firing a neutron at the uranium atom

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + Energy$$

    - ✯ the neutrons released in the reaction can cause additional reactions



  - ☆ Importance
    - ✯ an uncontrolled chain reaction results in a nuclear explosion (atomic bomb)
    - ✯ a controlled chain reaction can be used as a source of energy (nuclear reactor)

Fusion

- Definition - nuclear reaction in which the nuclei of two different isotopes of hydrogen combine
  - D-T reaction - in fusion reactors

    $${}_{1}^{3}H + {}_{1}^{2}H \rightarrow {}_{2}^{4}He + {}_{0}^{1}n + Energy$$

    - deuterium is obtained from heavy water extracted from water
    - tritium is manufactured by a nuclear reaction

      $${}_{3}^{6}Li + {}_{1}^{0}n \rightarrow {}_{1}^{3}H + {}_{2}^{4}He$$

  - Proton-proton chain - in stars

    $${}_{1}^{1}H + {}_{1}^{1}H \rightarrow {}_{1}^{2}H + {}_{+1}^{0}e$$

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

    $${}_{2}^{3}He + {}_{2}^{3}He \rightarrow {}_{2}^{4}He + 2{}_{1}^{1}H$$

- Importance
  - energy released in fusion is greater than the energy released in fission
    - mass of new nucleus is less than the sum of the light nuclei
    - the difference in mass is the amount of mass that was converted to energy (**$E = mc^2$**)
    - the energy provides for the greater binding energy per nucleon and the greater stability of the heavier nucleus formed
  - principle behind the hydrogen bomb and source of energy for stars
- High energy requirements - in order for nuclei to combine they need enough energy to overcome the forces of repulsion between like charges
  - the magnitude of the repulsion increases with the charge
  - only small nuclei with small charges can be used in fusion reactions
  - temperatures of 10^9°C are needed to provide the high activation energy needed for fusion

Answer the questions below by circling the number of the correct response

1. Which type of reaction occurs in a nuclear power plant and in an atomic bomb?
   (1) fusion (3) oxidation
   (2) fission (4) combustion

2. Which type of reaction occurs in stars such as the sun?
   (1) fusion (3) oxidation
   (2) fission (4) combustion