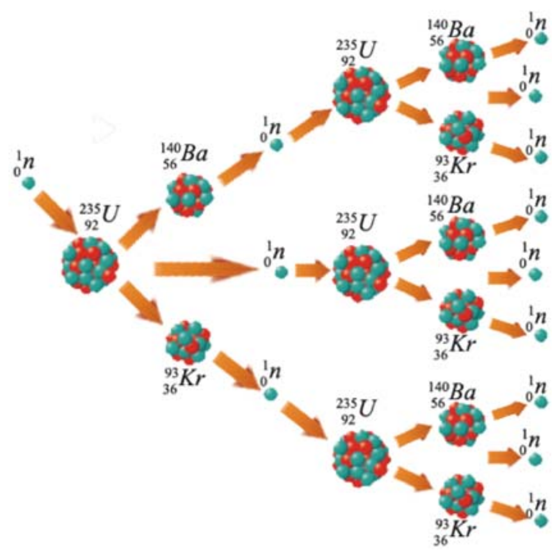
Name ________________________________

Date __________________ Period _____

Fission and Fusion

Fission and fusion are opposites, but they both involve nuclear reactions and have the potential to provide tremendous amounts of energy. Fission is a nuclear reaction in which a heavy nucleus splits into two lighter nuclei releasing neutrons and a tremendous amount of energy. It is 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. Very few elements can undergo fission. Uranium–235 is one of the few that can. Below is a possible fission reaction.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{56}Ba + ^{93}_{36}Kr + 3^{1}_{0}n + Energy$$



Since uranium releases neutrons when it splits, these neutrons can be captured by other uranium atoms causing them to split. This results in a chain reaction. A chain reaction is a reaction in which the neutrons released by fission of one nucleus trigger fission in other nuclei nearby. 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 is a nuclear reaction in which the nuclei of two different isotopes of hydrogen combine. There are two types: [1] the D-T reaction in fusion reactors; and [2] the proton-proton chain in stars. In the D-T reaction, deuterium combines with tritium.

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

Deuterium is obtained from heavy water extracted from water and tritium is manufactured by a nuclear reaction.

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

The proton-proton chain in stars consists of a series of three nuclear reactions. This is the reaction that makes stars shine. It is an extremely important reaction, because the energy released in fusion is greater than the energy released in fission. The mass of the new nucleus formed by fusion is less than the sum of the light nuclei that fused. The difference in mass is the amount of mass that was converted to energy (**E = mc²**). Unfortunately, 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, so 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, so the reaction basically occurs only in stars.

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

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Answer the questions below based on your reading and on your knowledge of chemistry.

1. Which type of reaction occurs in a nuclear power plant and in an atomic bomb? ________________________
2. Which type of reaction occurs in stars such as the sun? ____
3. How is fission different than alpha or beta decay? ____
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   ____
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4. What characteristic of fission makes a chain reaction possible? _____________________________________
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5. If fusion releases more energy than fission, why isn't fission used as a source of energy on earth? _________
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   ____
   ____
6. What is the fuel that runs fusion in stars? ____
   ____
7. Why is fusion only possible with small nuclei? ____
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8. What is the net loss of hydrogen for each full cycle of the proton-proton chain? Explain. _______________
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