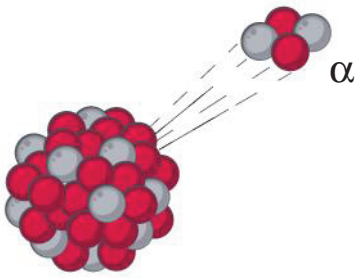
Warm-Up | Nuclear Fission and Nuclear Fusion

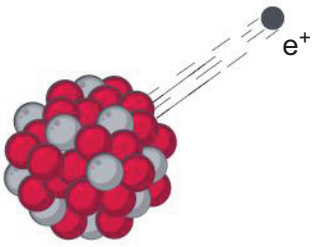
Review of Decay Processes

- Alpha decay
    - A helium nucleus is emitted.
    - The atomic mass of the parent nucleus decreases by 4.
    - The atomic number of the parent nucleus decreases by 2.



Review of Decay Processes

- Alpha decay
- Beta decay
    - Beta-plus decay
        - A proton decays into a neutron, emitting a positron.
        - The atomic mass of the parent nucleus is the same as the atomic mass of the daughter nucleus.
        - The atomic number decreases by 1.



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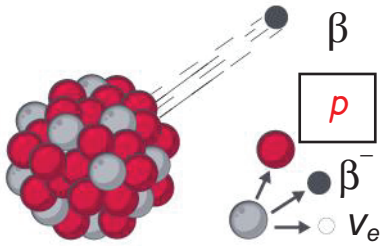
Review of Decay Processes

- Alpha decay
- Beta decay
  - Beta-plus decay
  - Beta-minus decay
    - A neutron decays into a proton, emitting an electron.
    - The atomic mass of the parent nucleus is the same as the atomic mass of the child nucleus.
    - The atomic number increases by 1.



Lesson Objectives

By the end of this lesson, you should be able to:

- Explain and compare fission and fusion [reactions].
- Relate the role of nuclear fusion to the production of essentially all elements heavier than [helium].

Science Practice: Justify the need for peer review in science.

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W2K

Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

E transuranium element

C chain reaction

B nuclear fusion

A nuclear fission

D critical mass

A. the process in which a heavy nucleus is split into two large fragments of comparable mass to form smaller and more stable nuclei, resulting in the release of great amounts of energy

B. the process in which lighter atomic nuclei combine to form a heavier, more stable nucleus, resulting in the release of great amounts of energy

C. a self-sustaining series of chemical reactions in which the products of one reaction are the reactants in the next reaction

D. the amount of fissionable material capable of sustaining a constant rate of fission

E. an element that has an atomic number greater than 92, is produced in a laboratory, and is radioactive

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Slide 1

Lesson Question

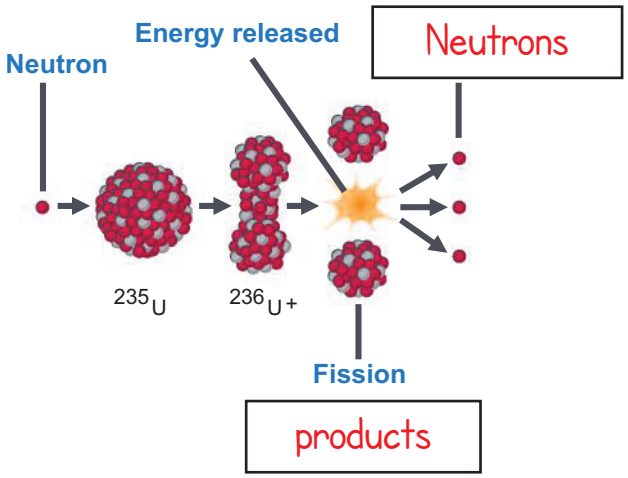
What occurs when a nucleus is split and when nuclei combine?

Slide 2

Fission

Nuclear **fission** is the process in which a heavy nucleus is split into two large fragments of comparable mass to form more stable and smaller nuclei, resulting in the release of great amounts of energy.

- Radioactive waste is produced.
- It occurs naturally but not explosively.



Fission Processes

Examples:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{38}Sr + ^{140}_{54}Xe + 2\,^{1}_{0}n$$

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{55}Cs + ^{94}_{37}Rb + 2^{1}_{0}n$$

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{145}_{57}La + ^{88}_{35}Br + 3^{1}_{0}n$$

Notice that the total atomic numbers and mass numbers are equal on both sides of the equation.

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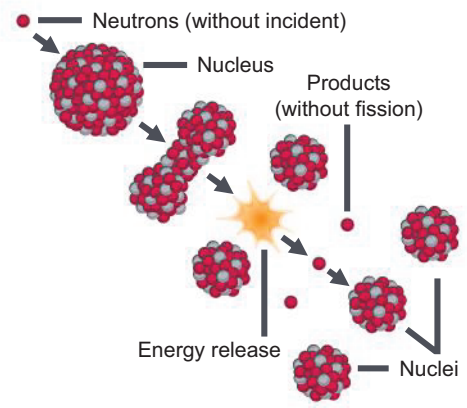
Slide 2

Chain Reaction

A **chain reaction** is the self-sustaining fission reaction spread by neutrons that occurs in nuclear reactors and bombs.

- Neutrons from one fission reaction trigger more fission reactions.

Critical **mass** is the amount of fissionable material capable of sustaining a constant rate of fission.



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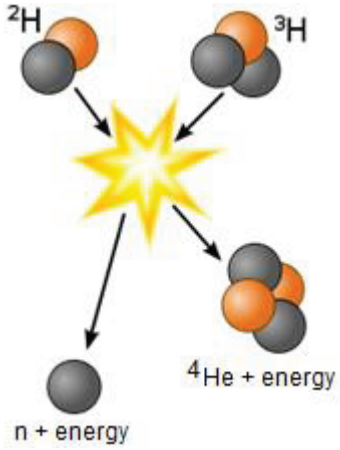
Fusion

Nuclear fusion is the process in which lighter atomic nuclei combine to form a more stable, heavier nucleus, resulting in the release of great amounts of energy.

- It has high activation energy.
- It does not produce radioactive waste.
- It is not currently plausible as an energy source on Earth.
- It occurs constantly in stars.



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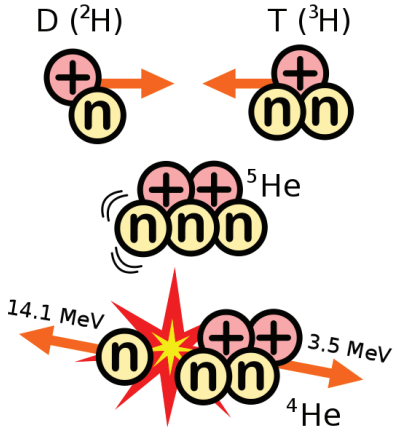
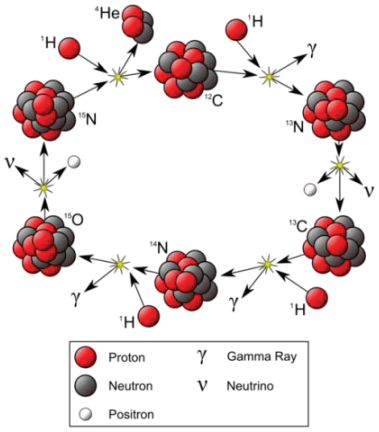
Examples of Fusion Reactions



A hydrogen-2 nucleus, which is one proton and one neutron, collides with a [hydrogen-3] nucleus with two neutrons to form a [helium-5] nucleus.



In this cycle, a carbon-12 nucleus is struck by a proton to become [nitrogen-13]. Nitrogen-13 can release a [positron] to become [carbon] again.

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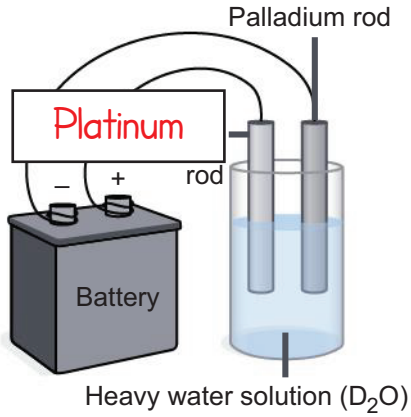
Cold Fusion

- The theory of cold fusion states that fusion reactions that can generate [energy] can be carried out at room temperature.
- The theoretical process involves deuterium [(H-2)] with palladium or other metals.
- This process produces minimal waste.
- This theory is controversial, and most scientists think it is impossible.



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The Cold Fusion Controversy

Stanley Pons and Martin Fleischmann claimed that they were able to create energy through fusion at room [temperature].

- Number of neutrons measured from experiment were not consistent with expected numbers during fusion [reactions].
- The presence of helium, which is a [product] of fusion reactions, was not measured.
- The results of a similar experiment had conflicting and inconclusive results but were ignored by the [two] scientists.
- The scientific community was not able to test this study's validity.

Summary | Nuclear Fission and Nuclear Fusion

Lesson Question

What occurs when a nucleus is split and when nuclei combine?

Answer

(Sample answer) When a nucleus splits, nuclear fission takes place, in which two large fragments of comparable mass are formed, which are more stable and smaller nuclei. When nuclei combine, nuclear fusion takes place, in which a more stable, heavier nucleus is formed. Both processes release large amounts of energy.

Slide 2

Nuclear Fission versus Nuclear Fusion

Fission:

- involves the splitting of an [atom] by a neutron.
- drives nuclear power plants.
- releases large amounts of energy.
- produces waste products that are [radioactive].

Fusion:

- involves combining two small atoms to produce a larger atom.
- plays a role in the production of essentially all elements heavier than helium.
- takes place in [stars], such as the Sun.
- releases large amounts of energy.
- produces waste products that are not dangerous.
- is not currently plausible as an energy source on [Earth].

Summary | Nuclear Fission and Nuclear Fusion

Use this space to write any questions or thoughts about this lesson.