Name Date



# Nuclear Reactions

*Textbook pages 312–325*

## *Before You Read*

Nuclear reactors supply energy to many parts of Canada. Summarize what you already know about nuclear reactions in the lines below.

### What is nuclear fission?

**Nuclear fission** is a nuclear reaction in which a nucleus breaks apart, producing two or more smaller nuclei, subatomic particles, and energy. For example, for Uranium-235,

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 3\,^{1}_{0}n + \text{energy}$$

Heavy nuclei tend to be unstable because of the repulsive forces between their many protons. In order to increase their stability, atoms with heavy nuclei may split into atoms with lighter nuclei. The fission of a nucleus is accompanied by a very large release of energy. Fission is the source of energy for all nuclear power generation used today; however, the radioactive daughter products are a significant waste disposal problem. ✔

### How do nuclear reactions work?

In typical chemical reactions, the energy produced or used is so small that there is very little change in mass. There are no changes in the nuclei of the reactants, so the identities of the atoms do not change. Chemical reactions involve electrons and rearrangements in the way atoms and ions are connected to each other.

***Mark the Text***

**Summarize**

As you read this section, highlight the main point in each paragraph. Then write a short paragraph summarizing what you have learned.

✔ ***Reading Check***

Why do heavy nuclei tend to be unstable?

A **nuclear reaction** is a process in which an atom's nucleus changes by gaining or releasing particles or energy. A nuclear reaction can release protons, neutrons, and electrons, as well as gamma rays. In nuclear reactions, a small change in mass results in a very large change in energy.

Scientists can *induce,* or cause, a nuclear reaction by making a nucleus unstable, causing it to undergo a reaction immediately. Bombarding a nucleus with alpha particles, beta particles, or gamma rays induces a nuclear reaction. An example of an induced reaction is given below. Nitrogen-14 is bombarded with alpha particles, producing oxygen and protons.

$$ {}^{4}_{2}\alpha + {}^{14}_{7}\mathrm{N} \longrightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{1}p $$

When some nuclei undergo fission, they release subatomic particles that trigger more fission reactions. This ongoing process in which one reaction initiates the next reaction is called a **chain reaction**. The number of fissions and the amount of energy released can increase rapidly and lead to a violent nuclear explosion. Uranium-235, which is used in Canadian nuclear reactors, undergoes such a reaction. Keeping the chain reaction going in a nuclear power plant, while preventing it from racing out of control, requires precise monitoring and continual adjusting.

## What are the rules for writing nuclear equations?

A **nuclear equation** is a set of symbols that indicates changes in the nuclei of atoms during a nuclear reaction. The following rules can be used when you write a nuclear equation.

1. The sum of the mass numbers on each side of the equation stays the same.
2. The sum of the charges (represented by atomic numbers) on each side of the equation stays the same.

### What is nuclear fusion?

**Nuclear fusion** is a nuclear reaction in which small nuclei combine to produce a larger nucleus. Other subatomic particles as well as energy are released in this process. Fusion occurs at the core of the Sun and other stars where sufficient pressure and high temperatures cause isotopes of hydrogen to collide with great force. This forces two nuclei of hydrogen to merge into a single nucleus, releasing an enormous amount of energy. The fusion reaction that occurs in the Sun is given below.

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n + \text{energy}$$

We do not currently have the technology to extract energy from fusion reactions. One of the difficulties is achieving and containing the high temperatures and pressures required to bring about fusion.✔

**✔ *Reading Check***

Identify the main difference between fission and fusion.

___________________

___________________

___________________

Name ____________________ Date ____________________

**Cloze Activity**
**Section 7.3**

*Use with textbook pages 312–321.*

# Radioactivity

| **Vocabulary** | | |
|---|---|---|
| CANDU reactor | neutron | proton |
| chain reaction | nuclear fission | subatomic particles |
| energy | nuclear fusion | Sun |
| induced | nuclear reaction | unstable |
| isotope | | |

**Use the terms in the vocabulary box to fill in the blanks. You may use each term only once.**

1. ____________________ is the splitting of a heavy nucleus into two lighter nuclei.
2. Heavy nuclei, like those of uranium-238, tend to be ____________________ due to the repulsive forces between the many protons.
3. Nuclear fission is usually accompanied by a very large release of ____________________.
4. A ____________________ occurs when an atom's nucleus changes by gaining or releasing particles or energy. Atoms are changed from one ____________________ into another, producing different elements.
5. In a nuclear reaction, ____________________, (e.g. protons, neutrons, and electrons) and gamma rays, can be emitted from the nucleus.
6. A nuclear reaction is ____________________ by bombarding a nucleus with alpha particles, beta particles, or gamma rays.
7. A ____________________, ${}^{1}_{1}p$, is the same thing as a hydrogen-1 nucleus.
8. A ____________________, ${}^{1}_{0}n$, has a charge of 0 and a mass number of 1.
9. A ____________________ is an ongoing nuclear reaction in which some products go on to cause more nuclear reactions to occur.
10. The Canadian deuterium uranium reactor, ____________________, is used for nuclear power generation. It is one of the safest nuclear reactors in the world.
11. ____________________ is the process in which two smaller nuclei join together to make a bigger one. This process occurs at the core of the ____________________ and other stars.

*Use with textbook pages 312–321.*

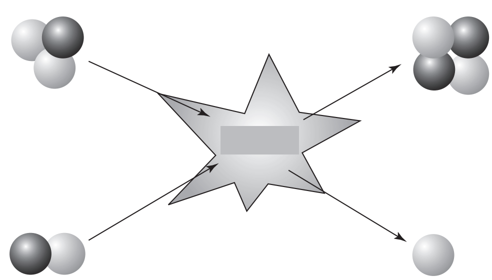
# Comparing nuclear fission and fusion

**1.** Complete the following table.

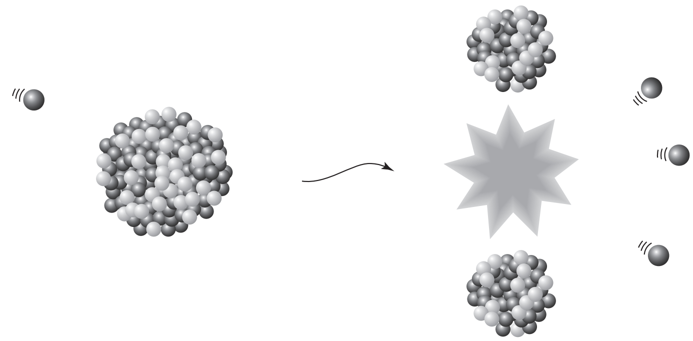
| | Nuclear fission | Nuclear fusion |
|---|---|---|
| Give a description of the process. | | |
| What is produced as a result of this nuclear process? | | |
| Are the products radioactive? | | |
| What is needed for this nuclear reaction to occur? | | |
| Where does this process occur? | | |
| Give an example of a nuclear equation. | | |

**2.** Identify the following diagrams as nuclear fission or nuclear fusion. Label the parent isotope(s), daughter isotope(s), neutron(s), and energy.

(a) ______________________



(b) ______________________



*Use with textbook pages 312–321.*

# Nuclear fission and fusion reactions

Remember the following two rules when working with nuclear equations:

**I.** The sum of the mass numbers does not change.

**II.** The sum of the charges in the nucleus does not change.

Identify each nuclear equation (nuclear fission or nuclear fusion) and then complete the nuclear equation.

1. ${}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \dashrightarrow {}^{143}_{54}\mathrm{Xe} + {}^{90}_{38}\mathrm{Sr} + \_\_\_\_ \; {}^{1}_{0}n$

2. ${}^{2}_{1}\mathrm{H} + \_\_\_\_ \dashrightarrow {}^{1}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H}$

3. ${}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \dashrightarrow {}^{152}_{60}\mathrm{Nd} + \_\_\_\_ + 4\,{}^{1}_{0}n$

4. ${}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \dashrightarrow {}^{3}_{2}\mathrm{He} + \_\_\_\_$

5. ${}^{1}_{0}n + \_\_\_\_ \dashrightarrow {}^{90}_{37}\mathrm{Rb} + {}^{143}_{55}\mathrm{Cs} + 3\,{}^{1}_{0}n$

6. ${}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \dashrightarrow {}^{4}_{2}\mathrm{He} + \_\_\_\_$

7. ${}^{1}_{0}n + {}^{256}_{100}\mathrm{Fm} \dashrightarrow \_\_\_\_ + {}^{140}_{54}\mathrm{Xe} + 4\,{}^{1}_{0}n$

8. ${}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \dashrightarrow {}^{106}_{39}\mathrm{Y} + \_\_\_\_ + 3\,{}^{1}_{0}n$

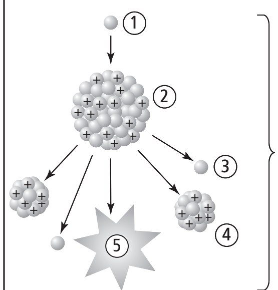
9. ${}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \dashrightarrow {}^{115}_{49}\mathrm{In} + {}^{118}_{43}\mathrm{Tc} + \_\_\_\_ \; {}^{1}_{0}n$

10. ${}^{1}_{0}n + \_\_\_\_ \dashrightarrow {}^{137}_{52}\mathrm{Te} + {}^{100}_{42}\mathrm{Mo} + 3\,{}^{1}_{0}n$

*Use with textbook pages 312–321.*

# Nuclear reactions

**Match each Number on the Diagram of a nuclear reaction on the left with the correct Descriptor on the right. Each Descriptor may be used more than once.**

| Diagram of a nuclear reaction | Descriptor |
|---|---|
| <br>**1.** _____<br>**2.** _____<br>**3.** _____<br>**4.** _____<br>**5.** _____<br>**6.** _____ | **A.** energy<br>**B.** neutron<br>**C.** parent isotope<br>**D.** nuclear fusion<br>**E.** nuclear fusion<br>**F.** daughter isotope |

**7.** What is the symbol for a proton?

**A.** ${}^{4}_{2}\alpha$

**B.** ${}^{0}_{0}\gamma$

**C.** ${}^{1}_{0}n$

**D.** ${}^{1}_{1}p$

**8.** Which of the following is the source of the Sun's energy?

**A.** convection

**B.** nuclear fusion

**C.** nuclear fission

**D.** CANDU reactor

**9.** Which of the following represents a nuclear fusion equation?

**A.** ${}^{234}_{90}\mathrm{Th} \rightarrow {}^{230}_{88}\mathrm{Ra} + {}^{4}_{2}\mathrm{He}$

**B.** ${}^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} + 2\gamma$

**C.** ${}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}n + \text{energy}$

**D.** ${}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3\,{}^{1}_{0}n + \text{energy}$

**10.** What is the total mass number?

$${}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3\,{}^{1}_{0}n + \text{energy}$$

**A.** 92 **C.** 234

**B.** 95 **D.** 236

**11.** How many neutrons are released in this nuclear equation?

$${}^{1}_{0}\mathrm{n} + {}^{239}_{94}\mathrm{Pu} \rightarrow {}^{141}_{54}\mathrm{Xe} + {}^{97}_{40}\mathrm{Zr} + \mathbf{?}\,{}^{1}_{0}\mathrm{n}$$

**A.** 0 **C.** 2

**B.** 1 **D.** 3

**12.** What isotope balances this nuclear reaction?

$${}^{1}_{0}n + {}^{235}_{92}\mathrm{U} \rightarrow \underline{\qquad} + {}^{119}_{50}\mathrm{Sn} + 3\,{}^{1}_{0}n$$

**A.** ${}^{114}_{39}\mathrm{Y}$ **C.** ${}^{114}_{42}\mathrm{Mo}$

**B.** ${}^{117}_{39}\mathrm{Y}$ **D.** ${}^{117}_{42}\mathrm{Mo}$

**13.** What is needed for nuclear fusion to occur?

| | |
|---|---|
| I. | pressure |
| II. | a beta particle |
| III. | high temperature |

**A.** I and II only **C.** II and III only

**B.** I and III only **D.** I, II, and III