Connected Chemistry
Nuclear Unit
Lesson 3: Fusion

Student's Lesson at a Glance

Lesson Summary

This lesson has three activities. Students learn in the introduction that stars, such as the Sun, have such extreme conditions that fusion reactions occur. Students discover that fusion is the joining of two lighter nuclei into a more massive one. Following a teacher demonstration in which two different hydrogen nuclei are fused, students use the same simulation to make helium-4 (He-4), beryllium-8 (Be-8), carbon-12 (C-12), and oxygen-16 (O-16) from the lighter nuclei provided. Students create subatomic sketches and gather data to answer analysis questions. In Part 2 of the activity, students are provided with the five outcomes of the fusion of two C-12 nuclei to explore how elements heavier than iron are formed. In the final activity, students have an opportunity to watch a video, to research fusion reactions, and to present on the controversial topic of cold fusion.

SWBAT (Student will be able to)

- Describe how elements are created from fusion reactions.
- Define and describe the process of fusion.
- Describe the flow of energy in a nuclear reaction.

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

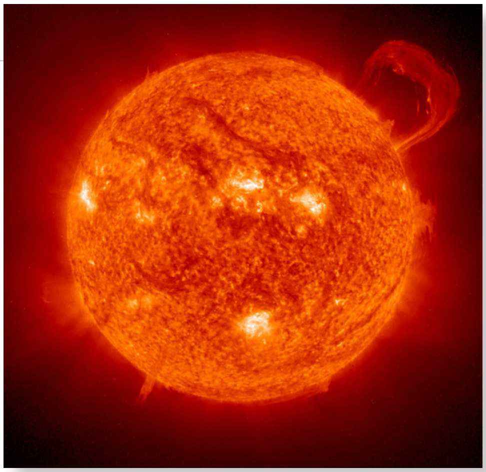
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Keys can help you and others decode your sketches at a later time.
- Arrows will be helpful in showing both the direction and velocity in your submicroscopic sketches. In nuclear you may use zig zag arrows to represent energy. Make sure to define the meaning of arrows in your key.
- There is a periodic table and list of common elements used in the back of this book. You will need to refer to the periodic table often.
- Remember all elements are isotopes. The isotopes on the periodic table are the most commonly occurring. Isotopes have the same number of protons, but different number of neutrons.
- When making subatomic observations, location of the particles in the simulation does not indicate the phase of matter.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting



1. In your own words, define what the term "fuse" means.

At the center of our Solar System is a star that has contributed extensively to sustaining life on Earth for millions of years. Recall that the energy of the Sun has been captured in fossil fuels. This energy is in the form of chemical potential energy that we convert so we can heat our homes and power machines. Another way that the Sun produces large of amounts of energy for the Earth is in the form of heat and light through a process called **fusion**. This process releases energy that is responsible for creating all the known elements. Fusion is the process by which two or more atomic nuclei are fused together to form a single more massive nucleus. During the fusion of nuclei, a large quantity of energy is released.

Inside the Sun and other stars, the temperature, pressure, and gravity are so extreme that hydrogen nuclei are forced together as part of a fusion process to form helium. This releases more energy that fuels additional fusion reactions in the Sun. When a star consumes all of its hydrogen, helium nuclei begin to fuse to form carbon. The fusion process continues to form all the essential elements of life, including nitrogen and oxygen. Inside the star, the final element that is created from fusion is iron. Iron cannot fuel additional fusion reactions in the star, and all nuclear reactions in the star eventually stop. When this happens, the star "dies." As the star dies, a large explosion called a *supernova* occurs, which releases enough energy to fuse the iron nuclei into many of the other known elements. Fusion is not easily achieved outside of the environment of stars. Scientists have tried for many years to create the precise conditions that would allow a fusion reaction to take place on Earth. Hypothetically, properly harnessed fusion reactions could provide limitless sources of power for the entire human population and make our reliance on non-renewable and environmentally damaging resources unnecessary.

2. How likely would it be for a fusion reaction to occur in the Sun, if the temperature of the Sun were to suddenly decrease? *Support your claim with evidence.*

3. What are the products of a fusion reaction?

4. Why does a star need to become a supernova to form elements more massive than iron?

Activity 2: Demonstrating Fusion

Demonstration: *Use Simulation 3, Set 1*

During the fusion process, multiple isotopes of an element can be formed. Recall that the temperature and pressure inside the Sun and other stars is extremely high, which permit fusion reactions to occur. This simulation creates conditions that allow fusion to occur.

- *Using the simulation, your teacher will select two nuclei to fuse. The product of this fusion must be helium-3 (He-3).*
- *Create a subatomic sketch, record observations and data. Make sure to include a key.*
- *Your teacher will push the play button so that fusion occurs.*
- *After a few seconds pause the simulation, create a final subatomic sketch, record observations and data.*

5. What is the difference between hydrogen-1 (H-1) and hydrogen-2 (H-2)?

6. What would happen if the two smaller nuclei had small kinetic energies before the collision?

	Create a subatomic sketch	Record Your Observations
Initial		
Final	Create a subatomic sketch	Record Your Observations
Key		

Activity 3: Simulating Fusion

Part 1: Simulation: *Use Simulation 3, Set 1*

Using the simulation,you must create three substances: Helium-4 (He-4), Beryllium-8 (Be-8), and Carbon-12 (C-12).

You may select two smaller nuclei at a time to fuse in order to create these substances. You may use two of the same kind.

- *Record the two nuclei needed to make He-4 in the initial box of the nuclei column.*
- *Create a subatomic sketch, record observations. Make sure to include a key.*
- *Push the play button so that fusion occurs.*
- *After a few seconds pause the simulation, create a final subatomic sketch and record observations. Record any additional products in the final box of the nuclei column.*
- *Repeat procedure to make Be-8 and C-12.*

		Initial	Final
Trial 1: He-4	Create a Subatomic Sketch		
	Record your Observations		
Trial 2: Be-8	Create a Subatomic Sketch		
	Record your Observations		

Trial 3: C-12		Initial	Final
	Create a Subatomic Sketch		
	Record your Observations		
Key			

7. Were there any other products made as a result of the fusion of two lighter nuclei? *Support your claim with evidence.*

8. What is the relationship the temperature at which fusion occurs and the size of the nuclei involved? *Support your claim with evidence.*

Part 2: Creation of Heavier Elements

As stars use the last of their helium fuel, if they are massive enough, then they will collapse. When they collapse, even greater temperatures and pressures are reached, which permit other elements to fuse together. The temperatures at which this happens is 600-700 million Kelvin! At this temperature range, two C-12 nuclei can fuse. Their fusion can result in the five possible combinations of products.

- C-12 + C-12 + ***Energy*** → O-16 + 2 He-4
- C-12 + C-12 → Ne-20 + He-4 + ***Energy***
- C-12 + C-12 →Na-23 + ***proton*** + ***Energy***
- C-12 + C-12 + ***Energy*** → Mg-23 + ***Neutron***
- C-12 + C-12 → Mg-24 + ***Energy***

9. Which of these combinations are endothermic? *Support your claim with evidence.*

10. Which of these combinations are exothermic? *Support your claim with evidence.*

Lesson Reflection Questions

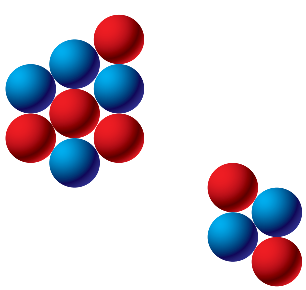
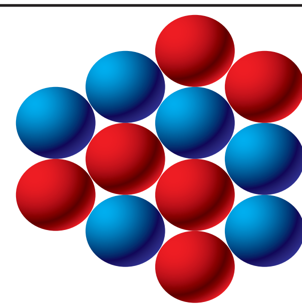
11. Explain the difference between **nuclear fission** and **nuclear fusion**. *Be sure to include a discussion at the subatomic level.*

12. Both nuclear fission and nuclear fusion can be used to produce nuclear energy. Which do you think is the more efficient and better method of energy production? *Be sure to include a discussion about the amount of energy released, the conditions necessary for each process to occur, and the potential impacts on the environment.*

Activity 4: Capstone Activity

13. Consider the following two scenarios. For Scenario 1, determine the initial element(s) and final element(s). The red circles are protons and the blue circles are neutrons. Decide whether the subatomic picture is depicting fusion or fission and provide evidence for your answer. Write a symbolic equation for the nuclear reaction represented in the subatomic pictures in the scenario.

Scenario 1

Before	After
	

Scenario 2

Using the table provided, construct a subatomic picture before and after the nuclear reaction occurs. Determine the identity of the initial element(s) and the final element(s). Decide whether the subatomic picture is depicting fusion or fission and provide evidence for your answer. Write a symbolic equation for the nuclear reaction represented in the subatomic pictures in the scenario.

	Mass Number	Neutrons	Protons
Reactant #1	137	82	55
Product #1	50	31	19
Product #2	85	49	36

Before	After