Lesson Summary

In the Connecting Activity, students explore chemical potential energy through the exploration of fossil fuels, with special attention on gasoline. Students learn that this type of energy differs between fuel types and can be transformed into usable and unusable energy. Following a teacher demonstration of a CCC simulation, students explore how pentane combusts and forms new substances. Students use data collected from the simulation and submicroscopic sketches to answer analysis questions.

SWBAT (Students Will Be Able To)

- Identify what chemical potential energy is and how it is converted into usable and unusable energy
- Identify how chemical potential energy and kinetic energy are related
- Explain the relationship between bond formation and the conversion of energy

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

- Students and teachers from many different schools helped design CCC so that the lessons are more helpful and meaningful for all classroom participants.
- Many questions will ask you “what you think” or “to make predictions.” The only answer that is wrong is the answer that is left blank.
- A chemical bond is an attraction between atoms that allows the formation of substances that contain two or more atoms. Chemical changes that occur are a result of bonds breaking and reforming.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is 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. Symbolic keys can help you and others decode your sketches at a later time.
- 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.

Notes

Homework

Upcoming Quizzes/Tests
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Please turn to the next page.
Activity 1: Connecting

Crude oil, a fossil fuel, is pumped from the ground and refined to make many other products including gasoline, diesel fuels, and paraffin wax.

1. How else do humans use products made from fossil fuels?

The energy of fossil fuels comes from ancient sunlight that prehistoric plants and animals transformed into chemical potential energy they used to survive. Over millions of years, these plants and animals decomposed (via several chemical reactions) into fossil fuels. The high temperatures and pressures deep inside the Earth rearranged the atomic structure of the prehistoric plants and animals to transform them into fossil fuels. This transformation produced molecules with even more chemical potential energy than when the organisms were alive.

Chemical potential energy is a form of potential energy “stored” in the bonds of a chemical compound. Chemical potential energy is similar to potential energy. Potential energy is associated with the fixed position of an object in a gravitational field, like a ball resting on top of a basketball hoop. Chemical potential energy is associated with the fixed position of atoms held together by the attractive and repulsive forces of protons and electrons.

Chemical potential energy can be transformed into other forms of energy (e.g., light, heat) when chemical bonds between atoms form. Conversely, kinetic energy and thermal energy can be transformed into chemical potential energy when chemical bonds between individual atoms break. In fossil fuels, chemical potential energy is converted into kinetic and thermal energy when the atoms in molecules of pentane combust with molecular oxygen to form carbon dioxide and water. As the new bonds form in carbon dioxide and water, kinetic and thermal energy is released.
As fast as they go on the highway, a high performance car can only convert 25% of the chemical potential energy of gasoline into usable kinetic energy. A majority of energy is lost to the environment as unusable thermal energy. The amount of heat, represented by the symbol “\( q \)”, that is produced in any reaction depends on the chemical potential energy stored in the substances in the reaction. Different fuels are composed of a variety of compounds with unique amounts of chemical potential energy.

Like car engines, biological organisms convert chemical potential energy of fuels into kinetic energy in order to do work. The most common fuel used by plants and animals is glucose, a carbohydrate that living organisms use to provide energy for survival. The chemical formula for glucose is \( \text{C}_6\text{H}_{12}\text{O}_6 \), and a macroscopic image of liquid glucose is shown in the picture on the right. Like the fossil fuel pentane, glucose is composed of numerous carbon-hydrogen and carbon-carbon bonds. Like the combustion of fossil fuels, glucose combusts to form carbon dioxide and water. As in a car engine, when the new bonds form in carbon dioxide and water, energy is released.

2. Into what energy form(s) does the human body convert the chemical potential energy of sugar? Support your claims with evidence.

The body produces energy in a process called cellular respiration that includes the following combustion reaction:

\[
\text{C}_6\text{H}_{12}\text{O}_6 \text{(aq)} + 6 \text{O}_2 \text{(g)} \rightarrow 6 \text{CO}_2 \text{(g)} + 6 \text{H}_2\text{O} \text{(l)} + 2800 \text{ kJ heat}
\]

3. Draw a potential energy diagram of cellular respiration. Be sure to label the axes of your diagram.

5. The combustion of gasoline and glucose reactions both convert chemical potential energy into kinetic energy. 100 calories would be enough for a person on a bicycle to ride three miles; however, driving in a car the same person would only be able to travel 280 feet. Which reaction is more energy efficient? Support your claim with evidence.

Activity 2: Demonstrating Chemical Potential Energy

Demonstration: Use Simulation 4, Set 1

In a car engine, fuel combusts inside a cylinder. In the ensuing reaction, the formation of new bonds in carbon dioxide and water produces a tremendous amount of energy. The release of chemical potential energy increases the kinetic energy of the gases inside the cylinder. Expansion of these gases pushes the piston, thus the potential energy of the piston is converted into kinetic energy.

- In the simulation, your teacher will add pentane (a type of liquid fuel) and oxygen gas together and run the simulation for ten seconds. Do not worry if the simulation runs a few seconds over.
- Before the simulation starts, sketch a submicroscopic diagram of the system, record your submicroscopic observations, and record the initial data from the monitors in the simulation.
- Your teacher will then change the heat level to modify the temperature of the system, start the reaction, and run it for ten seconds. Do not worry if the simulation runs a few seconds over.
- Sketch a diagram of the system after pausing the reaction, record your submicroscopic observations, and record the final data from the monitors in the simulation.
### Sketch a submicroscopic representation of the reaction

#### Heat Level 2

<table>
<thead>
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<tbody>
<tr>
<td>Temperature of System</td>
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<tr>
<td>Total Energy of System</td>
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<tr>
<td>$q$</td>
</tr>
<tr>
<td>Chemical Potential Energy</td>
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<tr>
<td>Kinetic Energy</td>
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Pentane
Oxygen

**Explain your drawing, including your symbols**

Carbon Dioxide
Water

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### Sketch a submicroscopic representation of the reaction

#### Initial

<table>
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<tbody>
<tr>
<td>Temperature of System</td>
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</tbody>
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Pentane
Oxygen

**Explain your drawing, including your symbols**

Carbon Dioxide
Water

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**Key**
Activity 3: Simulating Chemical Potential Energy

Simulation: Use Simulation 4, Set 1

- In your small groups, adjust the heat dial to level 5 in the simulation.
- Before the simulation starts, sketch a diagram of the system, record your submicroscopic observations and record the initial data from the monitors in the simulation.
- Run the simulation for 10 seconds. Do not worry if the simulation runs a few seconds over.
- Sketch a diagram of the system and record the data from the monitors in the simulation after pausing.

<table>
<thead>
<tr>
<th>Heat Level 5</th>
<th>Sketch a submicroscopic representation of the reaction</th>
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<td>Explain your drawing, including your symbols</td>
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<td>Carbon Dioxide</td>
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<td>Water</td>
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Key

6. What is the balanced chemical equation for the reaction? Make sure to include phases.
7. Why do you have to heat the system to get the reaction to occur? *Support your claim with evidence from the simulation.*

8. Would the products of the combustion reaction have more or less chemical potential energy than the reactants?

9. How can you explain the difference in chemical potential energies between the products and the reactants?

10. Circle one answer for each statement, and support your claim with evidence.

   - After combustion, the system became more ordered / less ordered.
   - The entropy of the system increased / decreased.

**Lesson Reflection Questions**

11. In a potential energy diagram, the reactions and products have different energies. How is it possible for a reaction to obey the First Law of Thermodynamics when the values differ between products and reactants? *Support your claim with evidence.*

12. The simulation did not have an output for thermal energy. Describe what you think happened to the thermal energy after the heat was added to the system. *Be sure to provide evidence for your answer at the submicroscopic level.*