Connected Chemistry
Thermodynamics Unit
Lesson 6: Exploring the Second Law

Student's Lesson at a Glance

Lesson Summary

This lesson is composed of four activities. In the Connecting Activity, students are introduced to the Second Law of Thermodynamics, otherwise known as the Law of Entropy. Using a rubber band and a water glass as a demonstration, the process by which chemical potential energy is transformed as ordered systems become disordered is explored. Following the demonstration, students explore from a submicroscopic perspective how chemical potential energy and entropy are related through the Second Law of Thermodynamics. Students use of a CCC simulation of a piston to guide them through this exploration. Students use collected data and their submicroscopic sketches to answer analysis questions. In the final activity, students research and present their answers about four statements on entropy and share evidence to support their claims through a whole-class discussion.

SWBAT (Students Will Be Able To)

- Identify and explain the Second Law of Thermodynamics
- Define entropy and how it applies to systems
- Explain how chemical potential energy and entropy are related

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 designed CCC so that the lessons are more helpful and meaningful for all classroom participants.
- Many questions ask you "what you think" or "to make predictions." The only answer that is wrong is the answer that is left blank.
- Prefixes and suffixes on words can help you discover the meaning of a word.
- 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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Activity 1: Connecting

Take a rubber band and stretch it out. Hold it steady.

1. What form(s) of energy is (are) associated with stretching the rubber band?

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2. If you release the rubber band, what energy is transformed into what other energy?

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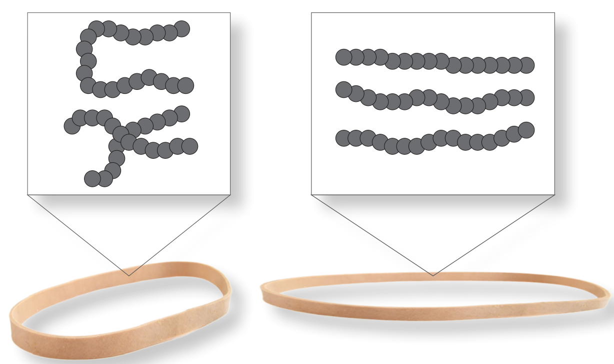
The **Second Law of Thermodynamics** states that the potential energy of a system will always decrease after an energy transformation occurs. As the potential energy of a system decreases, the system often becomes more disordered. The process of moving from an ordered to a disordered state is called **entropy** (represented with the symbol *S*). Entropy is measured in units of Joules per kilogram per Kelvin (J/kg•K).



The Second Law of Thermodynamics is also known as the **Law of Entropy.** In a spontaneous transformation, energy is always transformed from an ordered state to an unordered and chaotic state. For example, the rubber molecules in a stretched rubber band are aligned side-by-side in an ordered state. When you release the rubber band, it snaps back into place as the rubber molecules return to a disordered state.

The picture to the right shows rubber molecules in both an unstretched and stretched rubber band. The rubber band's molecules are mainly composed of carbon atoms lined up in chains. Carbon is shown as black atoms; other molecules, such as hydrogen and sulfur, are not shown.

3. According to what you just read, is the potential energy of the rubber band higher when it is stretched or unstretched? *Support your claim with evidence, and sketch a potential energy diagram for each example. Be sure to label the axes on the diagrams.*

To further understand entropy, think about a water glass on the submicroscopic level. The water glass is composed of a very specific arrangement of molecules that are ordered together into one single shape. If the water glass is smashed and breaks into hundreds of tiny pieces, its molecules become divided by a physical process into disordered pieces of many different shapes and sizes. Although the glass pieces are still made of the same compounds, the system has become more disordered.

4. In the smashing the glass example, what do you think has happened to the entropy of the glass? *Support your claim with evidence.*

5. Are particles in a solid more or less ordered than particles in a liquid? *Explain your answer.*

Activity 2: Demonstrating the Second Law

Demonstration: *Use Simulation 3, Set 1*

- Your teacher will display a simulation representing part of the system inside a car engine. In this activity, you will look specifically at how chemical potential energy and entropy change in the system according to the Second Law of Thermodynamics.
- *Sketch a diagram of the system and record the initial data including labels from the monitors in the chart below once piston settles.*
- *Your teacher will explain how to proceed with the simulation in Activity 3.*

Create a submicroscopic sketch of the simulation	Record Data from Monitors			
	Volume		Temperature	
	KE of Piston		Thermal Energy	
	Chemical Potential Energy		Entropy of System	
	Total E		Explain your drawing below.	
Key				

Activity 3: Simulating the Second Law

Simulation: *Use Simulation 3. Set 1*

- *Working in your small group, use the same simulations as your teacher. Begin by pushing the spark button and allow the simulation to run for 2-3 seconds before pausing. Create a submicroscopic sketch of the system and record data values, including labels, as you did with your teacher.*
- *Push play for the reaction to continue. Allow the reaction to run for an additional 10-15 seconds before pausing. Create a submicroscopic sketch of the system and record data values including labels.*

<table>
<tr><td rowspan="7">Observation 1</td><td rowspan="7">Sketch a submicroscopic representation of the molecules in the simulation. Include the piston</td><td colspan="4">Record Data from Monitors</td></tr>
<tr><td>Volume</td><td></td><td>Temperature</td><td></td></tr>
<tr><td>KE of Piston</td><td></td><td>Thermal Energy</td><td></td></tr>
<tr><td>Chemical Potential Energy</td><td></td><td>Entropy of System</td><td></td></tr>
<tr><td>Total E</td><td></td><td>Time</td><td></td></tr>
<tr><td colspan="4">Create a written explanation of your drawing including symbols meaning</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="7">Observation 2</td><td rowspan="7">Sketch a submicroscopic representation of the molecules in the simulation. Include the piston</td><td colspan="4">Record Data from Monitors</td></tr>
<tr><td>Volume</td><td></td><td>Temperature</td><td></td></tr>
<tr><td>KE of Piston</td><td></td><td>Thermal Energy</td><td></td></tr>
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<tr><td colspan="6">Key</td></tr>
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1. As the volume of the system changed, how did the kinetic energy of the piston change while moving? *Support your claim with evidence.*

2. As the kinetic energy of the piston changed, how did the entropy of the system change? *Support your claim with evidence.*

3. Using your observations from each trial and the information in the paragraph above, explain how the total entropy of the system changes as the piston is pushed up.

4. Why does the piston move after the spark is introduced?

Activity 4: Teacher Facilitated Discussion

Read the following statements and decide if they are true or false. Be ready to share your answers with your class and support your claims with evidence.

Circle your answer and support your claim with evidence.

1. The total entropy of a living organism increases over the lifespan of an organism.

True or **False**

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2. Cleaning up a messy room violates the Second Law of Thermodynamics.

True or **False**

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3. When a car stops moving because it is out of fuel, all of the energy associated with the fuel has been destroyed. **True** or **False**

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4. Kinetic energy is always the same as thermal energy.

True or **False**
