Connected Chemistry

Thermodynamics Unit

Lesson 4: Exothermic and Endothermic Reactions

Student's Lesson at a Glance

Lesson Summary

In the Connecting Activity, students are introduced to exothermic and endothermic reactions through the use of cold packs and hand warmers. Following a teacher demonstration of one reaction using a CCC simulation, students manipulate the heat level in the simulation to collect data. Students make observations and create submicroscopic representations of the reactions. Students calculate the change in enthalpy for the reaction, determine if the entropy of the system has increased or decreased, determine how energy influenced the reaction, and whether the reaction was endothermic or exothermic. In the final activity of the lesson, students are introduced to potential energy diagrams. Students learn what activation energy is and how activation energy relates with transition state. Students compare and contrast the given potential energy diagrams of an exothermic and endothermic reaction. Using the data collected in Activity 2 and 3, students graphically represent the change in potential energy during each of the reactions.

SWBAT (Students Will Be Able To)

- Define endothermic and exothermic reactions
- Identify how energy flows in endothermic and exothermic reactions
- Describe how endothermic and exothermic reactions appear at a submicroscopic level

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.
- Show your work when doing calculations. Include appropriate labels. These practices will make reviewing for tests and checking your work easier.
- 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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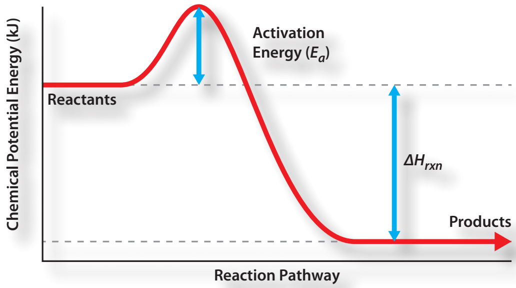
Activity 1: Connecting

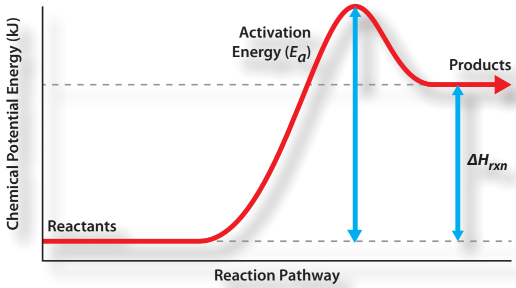
Athletes and trainers often use cold packs to soothe sore muscles and treat sprains. Like hand warmers, cold packs are activated by bending the package. However, unlike hand warmers, cold packs become very cold once activated. Although many reactions release energy to form products, some reactions absorb energy to form products. These reactions, such as the reaction occurring inside cold packs, are examples of an **endothermic** reaction. Reactions such as the one occurring inside the hand warmer are **exothermic** reactions.

1. What does the prefix *exo* mean?

2. What does *thermic* refer to?

In an **exothermic** reaction, like in the hand-warmer or the combustion of fuels, energy is released to the surroundings through the formation of products. In the cold pack reaction, energy is absorbed from the surroundings. When we touch the cold pack, the reaction absorbs heat from our body, which makes us feel cold. When calculating the ΔH_{rxn} for the reaction using Hess's Law, a reaction that has a negative ΔH_{rxn} is exothermic and a reaction that has a positive ΔH_{rxn} is endothermic.





3. Give the potential energy diagrams to the right, explain which is endothermic and which is exothermic. *Provide evidence for your answer. Be sure to include a discussion about bonding in your answer.*

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Activity 2: Graphically Representing the Energy of a Reaction

Part 1

Fuels do not combust with oxygen spontaneously; the reaction requires additional energy from a spark, match, or lighter. **Activation energy** is the additional amount of energy needed by the reaction to move forward. This energy is absorbed by the bonds in the reactants and breaks them into a **transition state**. Bonds are able to be reformed and energy is released.

Potential energy diagrams are useful for showing the flow of energy in a reaction. The diagrams also show the activation energy, represented as the symbol E_a. Since some reactions can move forward and backward, the activation energy has been included for the forward and reverse in the diagram on page 37.

Look at the two potential energy diagrams for a standard exothermic and endothermic reaction. Use them to answer the analysis questions that follow.

4. In the exothermic reaction, how does the potential energy change from reactants to products?

5. In the endothermic reaction, how does the potential energy change from reactants to products?

Circle one from each pair of terms.

6. In the exothermic reaction, heat is **released** or **absorbed.** The ΔH value would be **negative** or **positive**.

7. In the endothermic reaction, heat is **released** or **absorbed**. The ΔH value would be **negative** or **positive**.

8. In the exothermic reaction, the products have a **higher** or **lower** chemical potential energy than the reactants.

9. In the endothermic reaction, products have a **higher** or **lower** chemical potential energy than reactants.

10. Why does the potential energy in the exothermic reaction decrease?

11. Why does the potential energy in the endothermic reaction increase?

12. What is the label "reaction pathway" on the graph referring to?

13. What happens to a reaction is no external energy is supplied to a reaction that has a large activation energy?

14. Dynamite is a highly explosive hydrocarbon; however, it can be transported safely from one location to another. What situations should be avoided while transporting dynamite? Explain why these situations should be avoided based on your knowledge of how combustion reactions occur.

Part 2

Using the data from the three previous simulations from Lesson 3, Activity 4 starting on page 29, graphically represent the change in potential energy during each of the three reactions. Use the diagrams in Activity 1 to help you correctly set up your three graphs. Additional graph paper has been provided on pages 96-97 if needed.

- *Label the change in ΔH on the graph.*
- *Label the axes on the graph.*
- *Connect the points with a line similar to the potential energy graphs in Part 1.*
- *Instead of labeling with the words "products" and "reactants", draw one molecule of each product and reactant on the appropriate place on the line you drew on the graph. Label each molecule with the appropriate chemical formula.*
- *Label the transition state on the graph.*
- *Label where the activation energy is measured on the graph.*
- *Fill in the blanks describing each graph.*

Demonstration

15. This reaction is **endothermic** or **exothermic** *(circle one)*.

16. Energy was **released** or **absorbed** *(circle one)*.

17. The products have **less** or **more** *(circle one)* energy than the reactants.

Reaction 1

18. This reaction is **endothermic** or **exothermic** *(circle one)*.

19. Energy was **released** or **absorbed** *(circle one)*.

20. The products have **less** or **more** *(circle one)* energy than the reactants.

Reaction 2

21. This reaction is **endothermic** or **exothermic** *(circle one)*.

22. Energy was **released** or **absorbed** *(circle one)*.

23. The products have **less** or **more** *(circle one)* energy than the reactants.

Activity 3: Simulating Endothermic and Exothermic Reactions

- *Before starting the simulation, sketch the initial reactants in the submicroscopic system, record the data from the monitors, and write down your observations.*
- *Run the reaction for 15 seconds before pausing it. Do not worry if the simulation runs a few seconds over.*
- *Create a sketch of the products that have formed after 15 seconds, record data from the monitors, and write down your submicroscopic observations.*
- *Use your sketches, data and observations to answer the questions and complete calculations below.*

Reaction 1: *Use Simulation 8, Set 2*

	Create a Submicroscopic Sketch of the Simulation	Record Data from Monitors			
Initial		Temperature of System		Entropy of System	
		Enthalpy of Reactants		Enthalpy of Products	
		Moles of Water		Moles of Bicarbonate Ion	
		Moles of Hydrogen Ion		Moles of Acetate Ion	
		Moles of Sodium Ion		Moles of Carbon Dioxide	
		Record Your Observations			

Time: 15s	Create a Submicroscopic Sketch of the Simulation	Record Data from Monitors			
		Temperature of System		Entropy of System	
		Enthalpy of Reactants		Enthalpy of Products	
		Moles of Water		Moles of Bicarbonate Ion	
		Moles of Hydrogen Ion		Moles of Acetate Ion	
		Moles of Sodium Ion		Moles of Carbon Dioxide	
		Record Your Observations			
Key					

24. Create a balanced equation for the reaction. Use Appendix B for enthalpy values.

25. Show how the enthalpy of the reactants was calculated. Use Appendix B for enthalpy values.

26. Show how the enthalpy of the products was calculated.

27. Calculate the ΔH for the reaction using Hess's Law.

28. Did the system become more or less ordered after the reaction? *Support your claim with evidence.*

29. Was this reaction exothermic or endothermic? *Support your claim with two pieces of evidence from the simulation.*

Reaction 2: *Use Simulation 8, Set 3*

- *Create an initial submicroscopic sketch and record data.*
- *Adjust the heat slider to +5, then play the simulation.*
- *Allow the substances to completely react, then pause the simulation to create a submicroscopic sketch and record data from the simulation outputs.*

Initial	**Create a Submicroscopic Sketch of the Simulation**	**Record Data from Monitors**			
		Temperature of System		Entropy of System	
		Enthalpy of Reactants		Enthalpy of Products	
		Moles of Pentane		Moles of Oxygen	
		Record Your Observations			
Time: 15s	**Create a Submicroscopic Sketch of the Simulation**	**Record Data from Monitors**			
		Temperature of System		Entropy of System	
		Enthalpy of Reactants		Enthalpy of Products	
		Moles of Pentane		Moles of Water Vapor	
		Record Your Observations			
Key					

30. Create a balanced equation for the reaction.

31. Show how the enthalpy of the reactants was calculated. Use Appendix B for enthalpy values.

32. Show how the enthalpy of the products was calculated. Use Appendix B for enthalpy values.

33. Calculate the ΔH for the reaction using Hess's Law.

34. Did the system become more or less ordered after the reaction? *Support your claim with evidence.*

35. Was this reaction exothermic or endothermic? *Support your claim with two pieces of evidence from the simulation.*

Activity 4: Capstone Activity

Demonstration: *Use Simulation 8, Set 1*

- *Your teacher will demonstrate how reactions can be classified as endothermic or exothermic with a simulation. Before the teacher starts the simulation, sketch the initial reactants in the submicroscopic system, record the data from the monitors, and write down your observations.*
- *Your teacher will run the reaction for 15 seconds before pausing it. Do not worry if the*

simulation runs a few seconds over.

- *Create a sketch of the products that have formed after 15 seconds, record data from the monitors, and write down your submicroscopic observations. Use your sketches, data and observations to answer the questions and complete calculations below.*

Initial	Create a Submicroscopic Sketch of the Simulation	Record Data from Monitors			
		Temperature of System		Entropy of System	
		Enthalpy of Reactants		Enthalpy of Products	
		Moles of Hydrogen		Moles of Oxygen	
		Record Your Observations			
Time: 15s	Create a Submicroscopic Sketch of the Simulation	Record Data from Monitors			
		Temperature of System		Entropy of System	
		Enthalpy of Reactants		Enthalpy of Products	
		Moles of Water Vapor			
		Record Your Observations			
Key					

36. Create a balanced equation for the reaction.

37. Show how the enthalpy of the reactants was calculated. Use Appendix B for enthalpy values.