2.4 Chemical Reactions and Enzymes

Lesson Objectives

- Explain how chemical reactions affect chemical bonds.
- Describe how energy changes affect how easily a chemical reaction will occur.
- Explain why enzymes are important to living things.

Lesson Summary

Chemical Reactions  Everything that happens in an organism is based on chemical reactions. A chemical reaction is a process that changes one set of chemicals into another set of chemicals.

- The elements or compounds that enter into the reaction are the reactants.
- The elements or compounds produced by the reaction are the products.
- Chemical reactions involve changes in the chemical bonds that join atoms in compounds.

Energy in Reactions  Some chemical reactions release energy; others absorb energy.

- Chemical reactions that release energy often occur on their own.
- Chemical reactions that absorb energy require a source of energy. The energy needed to get a reaction started is called the activation energy.

Enzymes  An enzyme is a protein that acts as biological catalyst. A catalyst is a substance that speeds up the rate of a chemical reaction. Catalysts work by lowering a reaction’s activation energy.

- In an enzyme-catalyzed reaction, the reactants are known as substrates. Substrates bind to a part of an enzyme called the active site and remain bound to the enzyme until the reaction is complete, when the products are released.
- Temperature, pH, and regulatory molecules can affect the activity of enzymes.

Chemical Reactions

1. What is a chemical reaction?
   It is a process that changes one set of chemicals into another set of chemicals.

2. Complete the table about chemicals in a chemical reaction.

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactants</td>
<td>the elements or compounds that enter into a chemical reaction</td>
</tr>
<tr>
<td>Products</td>
<td>the elements or compounds that are produced by a chemical reaction</td>
</tr>
</tbody>
</table>
Energy in Reactions

3. **THINK VISUALLY** The graphs below show the amount of energy present during two chemical reactions. One of the reactions is an energy-absorbing reaction, the other is an energy-releasing reaction. Label the type of reaction for each, label the energy level for the reactants and products, then draw an arrow on each to show the energy of activation.

Type of reaction: **energy-absorbing reaction**

**Course of Reaction**

Type of reaction: **energy-releasing reaction**

**Course of Reaction**

4. What is released or absorbed whenever chemical bonds form or are broken? 

**energy**

5. What is the energy of activation? 

**energy needed to start a chemical reaction**

6. Of the two reactions shown, which one is more likely to start spontaneously and why? 

**energy-releasing reaction** because it **may not need energy to start the reaction, an energy-absorbing reaction always does**

Enzymes

7. How does the addition of a catalyst affect the energy of activation of a chemical reaction? 

*It lowers the energy of activation, making the reaction occur faster.*

8. What type of catalysts affect biochemical reactions? 

**enzymes**

9. What makes proteins the ideal types of compounds to act as enzymes? 

*Proteins are large molecules that are able to bend into many different shapes. This enables the formation of active sites with specific shapes for specific substrates.*
Use the diagram to answer Questions 10–11.

10. THINK VISUALLY | Label the enzyme, the active site, and the products in the diagram.

11. Write what is happening at each numbered part of the diagram.

   (1) Substrates bind to enzyme.
   (2) Substrates are converted into products.
   (3) Products are released.

For Questions 12–13, refer to the Visual Analogy comparing the action of enzymes to a lock and key.

12. VISUAL ANALOGY | How is a substrate and its enzyme like a lock and its key?
   Just as only a certain key will fit into a lock, only a certain substrate will fit into the active site of an enzyme.

13. What is being unlocked in this analogy? the bonds in the reactants

Apply the Big idea

14. In terms of an organism and how it interacts with its environment, what is the benefit of having controls on the chemical reactions that take place in its body?
   Conditions vary in the environment, for example when food is available or when seasonal changes occur. Such controls enable the organism to respond to different conditions.
Chapter Vocabulary Review

Crossword Puzzle  Use the clues below to fill in the spaces in the puzzle with the correct words.

Across
1. element or compound that enters into a chemical reaction
4. process that changes one set of chemicals into another
7. positively charged subatomic particle
8. substance formed by the chemical combination of elements
11. positively or negatively charged atom
12. carbon compound that stores and transmits genetic information
14. the center of an atom
16. bond formed when electrons are shared between atoms
17. macromolecule formed when monomers join together

Down
2. negatively charged subatomic particle
3. compound that forms hydroxide ions in solution
5. bond formed when one or more electrons are transferred from one atom to another
6. monomer of nucleic acid
9. monomer of protein
10. compound that forms hydrogen ions in solution
13. atom of an element that differs in the number of neutrons compared with other atoms of the same element
15. basic unit of matter
THE GHOSTLY FISH

Marketing a Natural “Antifreeze”

A protein able to prevent organic matter from freezing could have enormous commercial value. As with other inventions and innovations, a company that develops such a protein—or devises a unique method for producing such a protein—should have the right to patent it. A patent is a government order that grants an inventor exclusive rights to the use of the invention. In other words, a patent prevents anyone other than the inventor from profiting from the invention. A patent application may be hundreds of pages long. That’s why every application must start with a brief description of the invention. This brief description is called an abstract. An abstract that might be written for a patent application for an antifreeze production process is shown below.

Abstract

Description of invention: A method for synthesizing a protein that lowers the freezing temperature of water. Such proteins are not unusual in nature. Called “antifreeze proteins” (AFPs) or “Ice Structuring Proteins” (ISPs), they are produced in certain species of fish, plants, and insects. One AFP, produced in nature by fish but commercially by genetically modified yeast, is already being used in frozen products such as ice cream and sherbet.

The method described herein produces a type of insect-derived AFP. Fish-derived AFPs can reduce the freezing point of water by as much as 1.5˚ Celsius. This insect-derived AFP reduces the freezing point of water to −10˚ C. The process uses genetically modified algae to produce a threonine- and cysteine-rich 9 kDa protein that is produced naturally by the spruce budworm (Choristoneura fumiferana).
1. What is the inventor trying to patent?
   *a method for synthesizing a protein that lowers the freezing temperature of water*

2. What commercial application does AFP already have? How is this AFP produced commercially?
   *One AFP is used in frozen products such as ice cream and sherbet. It is produced commercially by genetically modified yeast.*

3. Why do you think the patent applicant wants to use insect-derived AFP rather than fish-derived AFP?
   *The insect-derived AFP reduces the freezing point of water to –10° C. Fish-derived AFPS can reduce the freezing point of water by only 1.5° Celsius.*

4. Why would this process need algae?
   *The process uses genetically modified algae to produce a protein.*

5. Why did the patent applicant research the spruce budworm?
   *This budworm naturally produces the protein needed in the process.*

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**AFP Ad Campaign**

The skills used in this activity include *information and media literacy, critical thinking and systems thinking, and creativity and intellectual curiosity.*

Work with a partner to use Internet or library resources to research the effects of extreme cold on the human body. Think about how these reactions would change if the body contained the AFP described in the patent application. What safety concerns would have to be addressed if a person had to ingest an AFP? What are the commercial applications for an AFP treatment that is safe for humans to ingest? Who would want to use it? Choose one type or group of potential users.

*Create an ad campaign aimed specifically at that group of people and designed to convince them to get the AFP treatment.*

*Evaluate students’ ad campaigns based on the correct choice for the AFP application; the accuracy of the information it contains, including an explanation of why the AFP is safe to use; and its visual appeal to its potential audience.*