ENDOTHERMIC AND EXOTHERMIC CHEMICAL REACTIONS

(MODIFIED FOR ADEED)

Science Concept:

Energy can neither be created nor destroyed, but can be transferred to different forms. (NOTE: This lesson assumes students have a basic understanding of chemical bonding.)

Objectives:

The student will:

- perform lab procedures safely;
- make quantitative observations; and
- explain exothermic and endothermic reactions.

GLEs Addressed:

Science

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[9] SA1.2 The student demonstrates an understanding of the processes of science by hypothesizing, designing a controlled experiment, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions.

[9] SB3.2 The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by explaining that in chemical and nuclear reactions, energy (e.g., heat, light, mechanical, and electrical) is transferred into and out of a system.

Vocabulary:

endothermic - characterized by or formed with absorption of heat <endothermic chemical reactions>

exothermic - characterized by or formed by the giving off of heat <an exothermic chemical reaction>

energy - the capacity (as of heat, light, or running water) for doing work

electromagnetic energy - energy in the form of electromagnetic waves; also : a series of electromagnetic waves (e.g., x-rays, infrared radiation, microwaves and radio waves.)

heat - a form of energy that causes substances to rise in temperature or to go through associated changes (e.g., melting, evaporation, or expansion)

light - electromagnetic radiation of any wavelength (e.g., infrared, visible, ultraviolet, and X-rays) and traveling in a vacuum with a speed of about 186,000 miles (300,000 kilometers) per second; especially : such radiation that is visible to the human eye

Materials:

- Barium hydroxide (20 grams per group)
- Ammonium chloride (10 grams per group)
- 50 ml beaker
- Petri dish
- Safety goggles
- Bleach (250 grams per group)
- Water
- Ammonium nitrate (25 grams per group)
- Sodium sulfite (25 grams per group)
- 400 milliliter beakers (one per group)

- Stirring rods
- Thermometer (one per group)
- Chemical handwarmers

Activity Procedure:

Gear Up

Process Skills: observing and inferring

1. Perform the following demonstration:
   a. Set the top of a petri dish on the laboratory bench
   b. Place 1 milliliter of water on the dish.
   c. Place 20 grams of barium hydroxide in a clean, dry 50-milliliter beaker.
   d. Add 10 grams of ammonium chloride to the barium hydroxide in the 50-milliliter beaker.
   e. Place the beaker in the water on the Petri dish.
   i. Wait several minutes. Carefully lift the beaker. Note the result.
2. Divide students into groups. Distribute a commercially-produced handwarmer to each group. Instruct groups to activate the hand warmer and observe the color and temperature of the hand warmer for several minutes by sight and touch.
3. Ask students to explain what happened in each reaction. Review chemical bonding and chemical reactions with students. Ask students what they know about different types of energy and energy transformations. If necessary, point out that heat was absorbed in one reaction and given off in another. Explain that heat is a type of electromagnetic energy and that energy is stored in chemical bonds.

Explore

Process Skills: making quantitative and qualitative observations and measuring

4. Explain in the next activity each group will perform a distinct set of chemical reactions.
   a. Assign half of the groups to perform endothermic reactions. Instruct them to add 250 milliliters of tap water to a beaker and measure and record the temperature. Next, ask students to add 25 grams of ammonium nitrate to the water and measure and record the temperature of the mixture, *immediately* after the ammonium nitrate has dissolved and again at the point where the solution has reached its maximum or minimum.
   b. Assign the other groups to pour 250 milliliters of bleach (NaOCl) into a beaker and measure and record the temperature. Ask them to add 25 grams of sodium sulfite and measure and record the temperature of the mixture after it has reached its maximum or minimum.
5. Instruct students to record other observations while the reactions proceed.

Generalize

Process Skills: analyzing, inferring, communicating, and interpreting

6. Record students' data on a single class data table.
7. Write the following reactions on the board:

Reaction 1:

$Na_2SO_3(aq) + 2NaOCl(aq) \rightarrow$
$4Na+(aq) + SO_3^{2-}(aq) + 2OCl^-(aq) + heat$

Reaction 2:

$heat + NH_4NO_3(s) + H_2O(l) \rightarrow$
$NH_4^+(aq) + NO_3^-(aq)$

8. Ask students where they think the energy in the two reactions came from. Introduce and explain the terms endothermic and exothermic (See Vocabulary). Ask students if they have any questions and list their questions on the board.

Apply/Assess

Process Skills: communicating, predicting, and interpreting

9. Write the following examples of endothermic and exothermic reactions on the board, but do not label them as endothermic or exothermic.

Examples of Endothermic Reactions:

$H_3C_6H_5O_7(aq) + 3\ NaHCO_3(s) + energy \rightarrow 3\ CO_2(g) + 3\ H_2O(l) + NaC_6H_5O_7(aq)$

$Ba(OH)_2\ 8H_2O_{(s)} + 2NH_4NO_{3(s)} + energy \rightarrow Ba(NO_3)_{2(s)} + 2NH_{3(aq)} + 10\ H_2O_{(l)}$

$6CO_2 + 6H_2O + energy \rightarrow C_6H_{12}O_6 + 6O_2$ (photosynthesis)

Examples of Exothermic Reactions:

$HCl(dilute) + NaOH(dilute) \rightarrow H_2O + NaCl + energy$

$CH_4 + O_2 \rightarrow CO_2 + H_2O + energy$

$H_2SO_4(conc) + H_2O \rightarrow H^+(aq) + SO4^-(aq) + energy$

10. Ask students to predict which reactions are endothermic and which are exothermic. Ask students to describe the transfer of energy in these reactions in their journals or on a blank sheet of paper.

Extension Ideas:

Process Skills: hypothesizing, designing an experiment, and making graphs

Instruct students to write a hypothesis and devise an experiment to test one of the questions that were written down in the "Generalize" section.

EXOTHERMIC AND ENDOTHERMIC CHEMICAL REACTIONS

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Objective	GLE	Emergent	Developing	Proficient	Advanced
The student makes quantitative observations.	SA1.1	The student does not measure temperatures or temperatures are measured in Fahrenheit.	The student uses metric units. Temperature measurements are +/- 5 degrees.	The student uses metric units. Temperatures are measured to the nearest degree. Temperatures are accurate to +/- 2 degrees.	The student uses metric units. Temperatures are measured to the nearest tenth of degree. Temperature measurements are accurate to +/- 1 degree.
The student safely and appropriately performs lab procedure.	SA1.2	The student is reminded more than once to wear safety goggles; beakers not labeled. The student's measurements are inadequate or sloppy.	The student is reminded once to wear safety goggles and only some beakers are labeled. The student's measurements are inadequate or sloppy.	The student wears safety goggles throughout the lab and most beakers are labeled. The student's measurements are adequate.	The student wears safety goggles throughout the lab and all beakers are labeled. The student's measurements are precise.
The student explains the transfer of energy in endothermic and exothermic reactions.	SB3.2	The student does not complete the assignment.	The student does not predict or explain whether a chemical reaction will transfer energy into or out of a system.	The student predicts and explains whether a chemical reaction will transfer energy into or out of a system, but the explanation does not use the appropriate vocabulary.	The student predicts and explains whether a chemical reaction will transfer energy into or out of a system. A concise and correct explanation is given, using appropriate vocabulary.

Subhead

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