

Nearly all chemical reactions involve a change in energy. Some reactions involve electrical or light energy, but most involve heat energy. The study of heat energy in chemical reactions is called *thermochemistry*.

When a chemical reaction occurs, bonds between atoms in molecules and bonds between molecules are broken. This requires energy to be put into the system. When the products form, new bonds are made, and energy is given out by the system. The overall energy change in a reaction depends on the relative amounts of energy involved in the breaking and formation of chemical bonds.

Question

How can you tell whether a reaction is exothermic or endothermic?

Prediction

You will carry out a reaction between barium hydroxide and ammonium thiocyanate, and a reaction between sodium sulfite and bleach. Predict which reaction will be endothermic, and which reaction will be exothermic.

Materials

computer system and interface
temperature probe
32 g barium hydroxide octahydrate,
 $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$
16 g ammonium thiocyanate, NH_4SCN
250 mL beakers (2)
50 mL bleach (sodium hypochlorite, NaOCl)
50 mL 0.05 mol/L sodium sulfite, Na_2SO_3

Safety Precautions



- Wear safety goggles, gloves, and a lab coat while carrying out the experiment.
- Carry out this investigation carefully to avoid broken glass.
- The endothermic reaction can be cold enough to cause frostbite. Use insulated gloves throughout this investigation.
- The chemicals used in this investigation can cause harm if handled inappropriately. Always handle chemicals with due care. Do not smell any gas evolved.
- Dispose of the chemicals safely and appropriately, as directed by your teacher.

Procedure

Part 1

1. Set up the computer system with the temperature probe set to record at a rate of once per second.
2. Display the temperature probe with a graph (temperature vs. time) and digits display.
3. Place 32 g of barium hydroxide octahydrate into the 250 mL beaker.
4. Add 16 g of ammonium thiocyanate to the 250 mL beaker.
5. Start the temperature probe to monitor the temperature.
6. Place the thermometer probe into the mixture and begin stirring the two compounds gently. *Be careful not to touch the thermometer probe to the glass of the beaker.*

7. After the temperature has reached its maximum point and begins to decrease, stop recording the data.

8. Carefully clean the thermometer probe, and dispose of the materials as directed by your teacher. Do not pour anything down the drain.

Part 2

9. Set up the computer system once again with the temperature probe set to record at a rate of once per second.

10. Display the temperature probe with a graph (temperature vs. time) and digits display.

11. Put 50 mL of liquid bleach into a 250 mL beaker.

12. Place the thermometer probe into the beaker.

13. Start the temperature probe to monitor the temperature.

14. Add 50 mL of the sodium sulfite to the 250 mL beaker.

15. Begin stirring the mixture gently. *Be careful not to touch the thermometer probe to the glass of the beaker.*

16. After the temperature has reached its maximum point and begins to decrease, stop recording the data.

17. Carefully clean the thermometer probe, and dispose of the materials as directed by your teacher. Do not pour anything down the drain.

Analyze and Conclude

1. Though no water was added to the first reaction, how did the mixture become “wet?”

2. What maximum/minimum temperature was reached in the first reaction (Part 1)?

3. What maximum/minimum temperature was reached in the second reaction (Part 2)?

4. Is the first reaction (Part 1) endothermic or exothermic? Explain your answer.

5. Is the second reaction (Part 2) endothermic or exothermic? Explain your answer.

6. What observations can be made to determine if a chemical reaction is endothermic or exothermic?

Applications

7. Write a balanced equation for the reaction between $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ and NH_4SCN . What are the products of this reaction?

8. What observable evidence indicates that a chemical reaction has taken place during the first reaction (Part 1)?

9. Repeat the first reaction (Part 1) while holding a piece of wide-range litmus paper over the surface of the mixture. Is the gas produced by the reaction acidic, or basic?

10. What is the gas produced by this reaction?

11. Name a familiar use of a chemical reaction that involves the absorption of energy.

Teacher Information

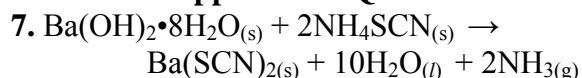
Notes

- When barium hydroxide octahydrate and ammonium thiocyanate react, so much energy is absorbed that the temperature drops well below the freezing point of water.

Answers to Analyze and Conclude Questions

1. The mixture became wet and slush was formed because water is one of the products of the reaction.
2. The minimum temperature for the first reaction was between -20°C and -30°C .
3. The maximum temperature for the second reaction was between 20°C and 25°C .
4. The first reaction is endothermic; it takes in heat.
5. The second reaction is exothermic; it releases heat.
6. Some chemical reactions absorb heat from the surroundings, resulting in a cooling of the surroundings (endothermic reactions). Some chemical reactions produce heat, resulting in a warming of the surroundings (exothermic reactions).

Answers to Applications Questions



The equation for the reaction shows that barium thiocyanate, ammonia gas, and liquid water are formed by the reaction of solid barium hydroxide and solid ammonium thiocyanate.

8. The change in temperature, the production of a gas, and the change in appearance indicate that a chemical reaction has occurred.
9. The gas is basic.
10. As seen in the chemical equation above, this gas is $\text{NH}_{3(g)}$.
11. Endothermic reactions are the basis of chemical ice packs used by athletic trainers that cool after being activated.