Endothermic and exothermic reactions

Driving Question:
How does the temperature change during chemical reactions?

Thinking about the question

A chemical reaction can result in spectacular temperature changes. In this activity you will study four chemical reactions and record the temperature changes during these reactions. You will also learn the difference between endothermic and exothermic chemical reactions.

Materials

In your investigations you will use:

- Data-logger e.g. CMA €Lab,
- Temperature sensor,
- Isolated calorimeter or a glass beaker (50 mL) and a Styrofoam cup,
- Measuring cylinder (10 mL),
- Spatula
- Protection: goggles and lab coat

For the chemical reactions your teacher will provide you with the following solutions:

- 1 M copper(II) sulphate ($CuSO_4$ (aq))
- 1,0 M waterstofchloride (HCl (aq))
- 1 M sodium hydrogen carbonate ($NaHCO_3$ (aq))
- 1,0 M sodium hydroxide (NaOH (aq))

And the following solids:

- Magnesium ribbon Mg(s), cut into 1 cm lengths
- Citric acid $HOOCCH_2C(OH)(COOH)CH_2COOH$ (s) (IRRITANT)

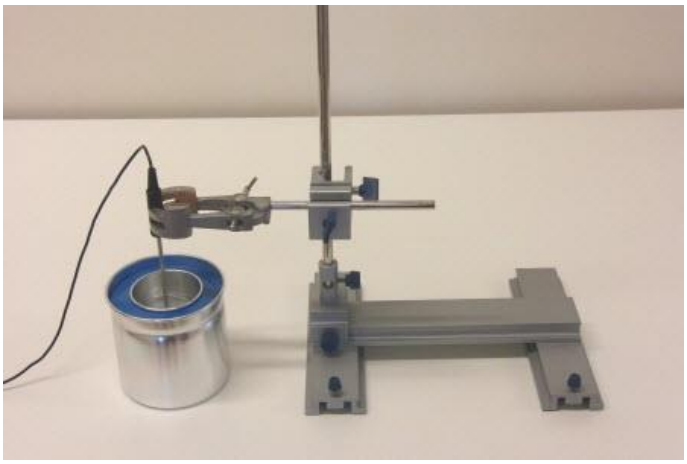
Safety

Warning:
Be careful. Wear goggles and a lab coat. You should only perform these experiments in a suitable (safe) laboratory environment with proper equipment.

Investigations

1. Connect the temperature sensor to the input 1 of your interface.
2. Open Coach 6 Activity 'Endothermic and exothermic reactions'.
3. Perform the first reaction of sodium hydroxide solution and dilute hydrochloric acid

$$NaOH\,(aq) + HCl\,(aq) \rightarrow NaCl\,(aq) + H_2O\,(l)$$



- Use an isolated calorimeter as shown on the photo. Alternatively, you can use a simple 50 mL beaker
- Measure out 10 mL of sodium hydroxide solution and pour it onto the calorimeter/beaker
- Place the temperature sensor in the calorimeter/beaker
- Measure out 10 mL of hydrochloric acid.
- Start the measurement and carefully add the acid to the sodium hydroxide solution in the container. Stir with the temperature sensor.
- Save the data of the first reaction by copying the column containing the data.
- Dispose of the product solution in the proper waste container (the sink) and clean the container and temperature sensor properly with demineralized water.

4. Perform the second reaction of sodium hydrogen carbonate solution and citric acid

$$NaHCO_3\,(aq) + H^+\,(aq) \rightarrow Na^+\,(aq) + H_2O\,(l) + CO_2\,(g)$$

- Use an isolated calorimeter or place a Styrofoam cup into a 250 mL beaker.
- Measure out 10 mL of sodium hydrogen carbonate and pour it into the calorimeter.
- Place the temperature sensor in the calorimeter.
- Start the measurement and add 4 small (not heaped) spatula measures of citric acid.
- Save the data of this reaction by copying the column containing the data.
- Dispose of the product solution in the proper waste container and clean the calorimeter and temperature sensor properly.

5. Perform the third reaction of copper(II)sulphate solution and magnesium

$$CuSO_4\,(aq) + Mg\,(s) \rightarrow MgSO_4\,(aq) + Cu\,(s)$$

- Use an isolated calorimeter or place a Styrofoam cup into a 250-mL beaker.
- Measure out 10 mL of copper(II) sulfate solution and pour it into the calorimeter.
- Place the temperature sensor in the Calorimeter.
- Start the measurement and add one 1 cm piece of magnesium. Stir with the temperature sensor.
- Save the data of this reaction by copying the column containing the data.
- Dispose of the product solution in the proper waste container and clean the calorimeter and temperature sensor properly.

6. Reaction 4: Reaction of diluted hydrochloric acid and magnesium

$$HCl\,(aq) + Mg\,(s) \rightarrow MgSO_4\,(aq) + H_2\,(g)$$

- Use an isolated calorimeter or place a Styrofoam cup into a 250-mL beaker.
- Measure out 10 mL of diluted hydrochloric acid and pour it into the calorimeter.
- Place the temperature sensor in the calorimeter.
- Start the measurement and add one 1 cm piece of magnesium ribbon. Stir with the temperature sensor.
- Save the data of this reaction by copying the column containing the data.
- Dispose of the product solution in the proper waste container and clean the calorimeter and temperature sensor properly.

7. What happened in each of the reaction? What could you observe?
8. For each reaction determine the temperature change.
9. An endothermic reaction is a chemical reaction in which energy is absorbed from the surrounding environment. An exothermic reaction is a chemical reaction in which energy is released to the surrounding environment.
    a. Based on your experimental results classify all four chemical reactions.
10. When is the change in temperature fastest for each reaction? At the beginning, in the middle or at the end of the reaction?
11. Can you think of more examples of endothermic and exothermic reactions?

Resources:

Coach 6 Activity: Endothermic or exothermic reactions.cma

Coach 6 Result: Endothermic or exothermic reactions.cmr