Endothermic and exothermic reactions

Teacher Notes

CHEMISTRY
Thermo-chemistry

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

Applied Technology: Data-logging

Student Level: Middle School Level (11-14)

Duration: 1 lesson period

Recommended Settings: Student Investigations

Learning Objectives

- Observe endothermic and exothermic reactions.
- Observe other changes during chemical reactions (like production of gasses)
- Measure temperature changes during chemical reactions.

Didactical Approach

In this activity students measure the temperature change in four chemical reactions and classify the reactions as exothermic or endothermic. By investigating examples of exothermic and endothermic reactions, students develop an understanding of the changes in energy that occur during reactions. This experiment will also develop the students' skills in using a calorimeter and in performing software-based calculations on recorded data.

Concepts learnt in this activity:

– Energy, heat transfer, calorimeter, specific heat, insulation, enthalpy, heat of reaction, endothermic reaction, exothermic reaction, reaction speed

Common misconceptions

– Thinking that an exothermic reaction means that the temperature of the substances will increase
– Thinking that a solution (like hydrochloric acid) is a pure substance

Materials

In your investigations you will use:

- Data-logger e.g. CMA €Lab,
- Temperature sensor),
- Isolated calorimeter or a glass beaker (250 mL) and a Styrofoam cup,
- Measuring cylinder (10 mL),
- Spatula,
- Protection: goggles and lab coat.

For 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)

Procedure

- Connect the temperature sensor to input 1 of your data-logger.
- Open Coach Activity ‘Endothermic and exothermic reactions’.
- Let the student work in groups. Each group can choose their own chemical reaction
- Let the students perform the temperature measurements.
- Discuss the measurement results and categorize endothermic and exothermic reactions. Also address the other observations students could have done during the experiments (like the production of gasses)

There are four solutions and two solids involved. These chemicals should be treated with care. At the suggested concentrations, the solutions represent small hazards. As usual, acids and alkalis have to be considered irritant. Special care should be taken with the magnesium ribbon.

Questions and Assignments

- For every reaction: what other observations did you do?
- Determine the temperature change for each of the four reactions.
- Is the reaction endothermic or exothermic? How do you know?
- When is the change in temperature fastest for each reaction?
- Optional: For each reaction calculate the heat of reaction.

Data Analysis

Students perform four chemical reactions and measure the temperature changes during these reactions.

Reaction 1 (sodium hydroxide solution and hydrochloric acid solution, exothermic):

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

Reaction 2 (sodium hydrogen carbonate solution and citric acid, endothermic):

$$NaHCO_3(aq) + H_3Cz\ (s) \rightarrow Na^+(aq) + H_2O(l) + CO_2(g).$$

Reaction 3 (copper(II) sulfate solution and magnesium, exothermic, but hard to see):

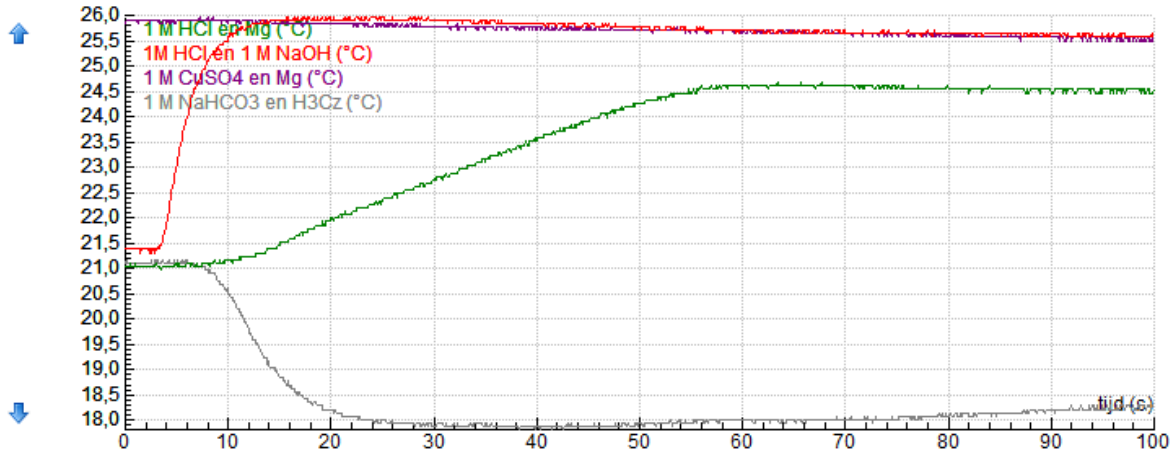
$$CuSO_4(aq) + Mg(s) \rightarrow MgSO_4(aq) + Cu(s).$$

Reaction 4 (hydrochloric acid and magnesium, exothermic):

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

The length of time required for carrying out the actual reactions is around 30 minutes, but this will depend on the nature of the class and how the activities are organized.

Typical Syrofoam cups will fit into 250 mL beakers. This provides a more stable reaction vessel. You could also do the experiment in a regular beaker combined with a Styrofoam cup or just a small beaker. An actual calorimeter is necessary if you want to do accurate measurements. To extend the activity students can calculate the heat change of each reaction (Q = c*m*ΔT), but this is most suited for high school level students.
The figure below gives an example of the data that can be acquired.



Resources

Coach 6 Activity: Endothermic or exothermic reaction.cma

Coach 6 Result: Endothermic or exothermic reaction.cmr

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Authors: CMA Team

Adapted from: Royal Society of Chemistry
(http://www.rsc.org/learn-chemistry/wiki/index.php?title=TeacherExpt:Exothermic_or_endothermic%3F&oldid=4691)