Experiment C-18
Endothermic and Exothermic reactions - part 1

Chemistry

Objectives

- To study enthalpy through a baking soda and vinegar reaction.
- To learn about endothermic and exothermic reactions.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-203 Temperature logger sensor

Equipment and Accessories

▪ 100 ml conical flask
▪ Sample container

- The items above are included in the NeuLog Utility accessories, UTL-KIT.

Materials

| |
|---|
| ▪ 20 ml of vinegar |
| ▪ 2.5 g of baking soda |

Introduction

In a chemical reaction, **reactant molecules** bonds break and new bonds are formed within the **product molecules**. In general, energy is required in order to break the reactant molecules bonds and energy is released by bond formation in the products.

An **exothermic reaction** occurs when the energy required in order to break the reactant molecules bonds is less than the energy released by bond formation in the products, therefore energy is released during the reaction.

Exothermic reaction

Energy required in order to break the reactant molecules bonds

energy released by bond formation in the products
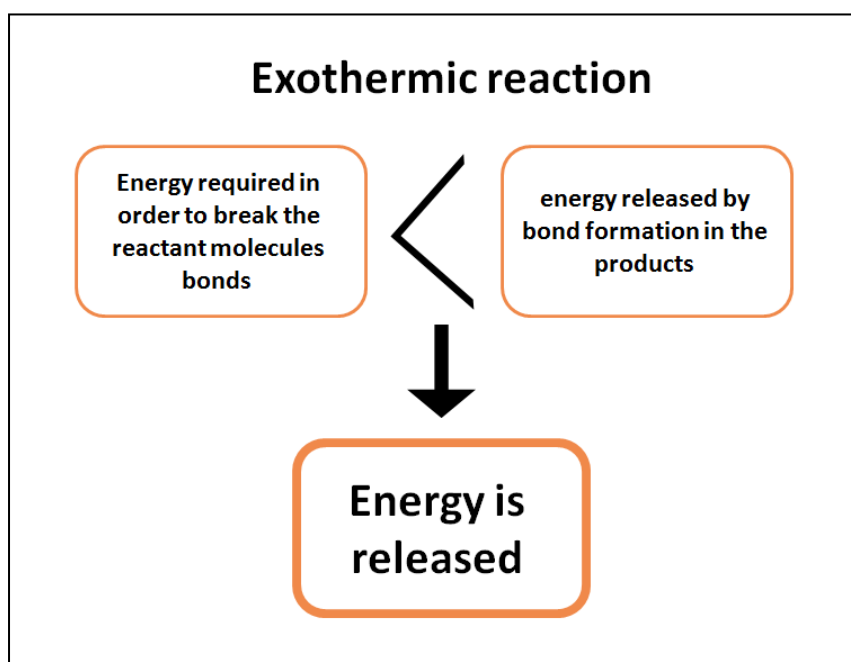
Energy is released

An **endothermic reaction** occurs when the energy required in order to break the reactant molecules bonds is higher than the energy released by bond formation in the products, therefore energy is absorbed during the reaction.

Endothermic reaction

Energy required in order to break the reactant molecules bonds

energy released by bond formation in the products

Energy is absorbed
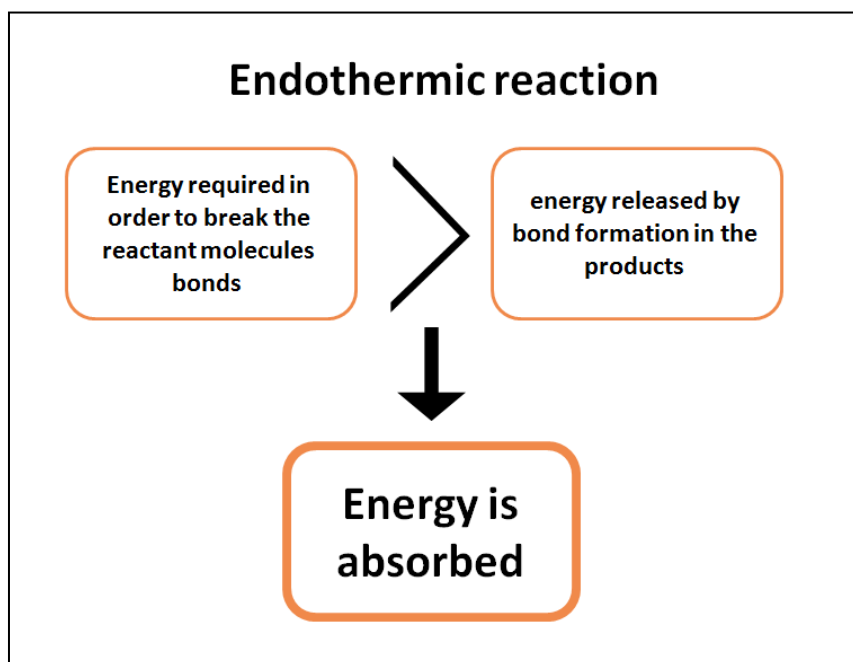
The difference in energy between the reactants and the products is known as the **enthalpy** change of the system (ΔH). The enthalpy change for a reaction can be calculated by this equation:

ΔH = H(products) - H(reactants)

In exothermic reactions, the enthalpy of the products is less that the enthalpy of the reactants due to energy release, therefore ΔH is negative. In endothermic reactions, the enthalpy of the products is higher than the enthalpy of the reactants due to energy absorption, therefore ΔH is positive.

In this experiment, you will study the reaction of baking soda and vinegar and decide whether it is an exothermic or endothermic reaction. Baking soda is sodium bicarbonate ($NaHCO_3$) and the key ingredient of vinegar is acetic acid (CH_3COOH). When they react together they produce carbon dioxide, water and sodium acetate.

$$CH_3COOH(aq) + NaHCO_3(s) \Rightarrow CO_2(g) + H_2O(l) + CH_3COONa(aq)$$

Procedure

Experiment setup

Caution:

It is recommended to wear personal protective equipment. Material Safety Data Sheets (MSDS) are available online.

1.   Set up the experiment as shown in the picture below.

2.   Make sure you have a conical flask with 20 ml of vinegar, and a sample container with 2.5 g of baking soda (approximately half a teaspoon).

3.   Insert the temperature sensor's probe in the conical flask.

4.   Open the sample container.

Sensor setup

5.   Connect the USB-200 module [icon] to the PC.

6.   Check that the temperature sensor [icon] is connected to the USB-200 module.

> Note:
>
> The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

7.   Run the NeuLog application and check that the temperature sensor is identified.

Settings

8.   Click on the **On-line Experiment** icon [icon] in the NeuLog main icon bar.

9.

10.   Click on the **Experiment Setup** icon [icon] and set the:

Experiment duration to 2 minutes
Sampling rate to 60 per minute

Testing and measurements

11.   Wait until the temperature stabilizes.

12.   Click on the **Run Experiment** icon ▶ to start the measurement.

13.   Wait for about 10 seconds and then slowly add the 2.5 g of baking soda to the vinegar. Shake the flask from time to time.

14.   Observe the changes in the temperature (stop the measurement if the value has stabilized).

15.   When the measurement is over, touch the flask, can you feel the temperature difference?

17.   Click on the **Zoom fit** icon (or click on the icon and locate the mouse cursor at a point above the graph and press its left button; keep it pressed and create a rectangle that includes the whole graph).

16.   Your graph should be similar to the following:
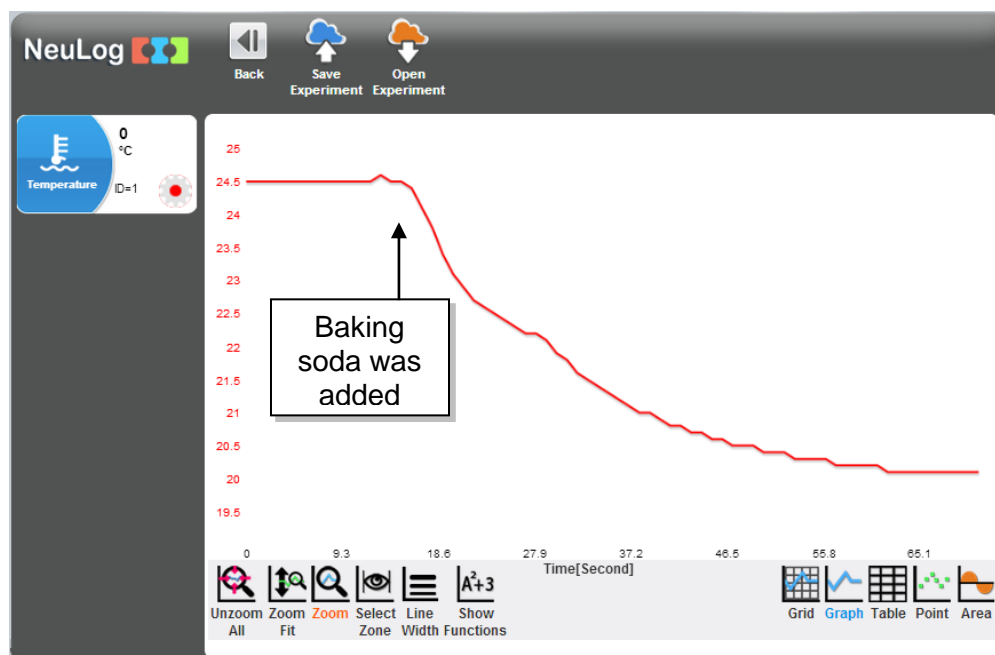
18.   Save your graph.

19. In order to calculate the temperature change, click on the **Select Zone** icon and select the part between the beginning and ending of the measurement.

X1= 00:10 m	X2= 01:07 m	ΔX= 00:57 m
Y1= 24.5 [°C]	Y2= 20.1 [°C]	ΔY= -4.400
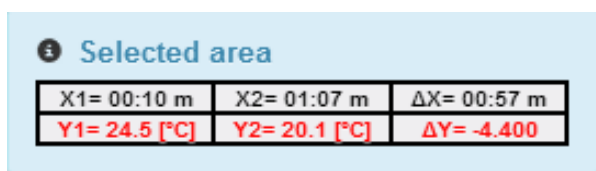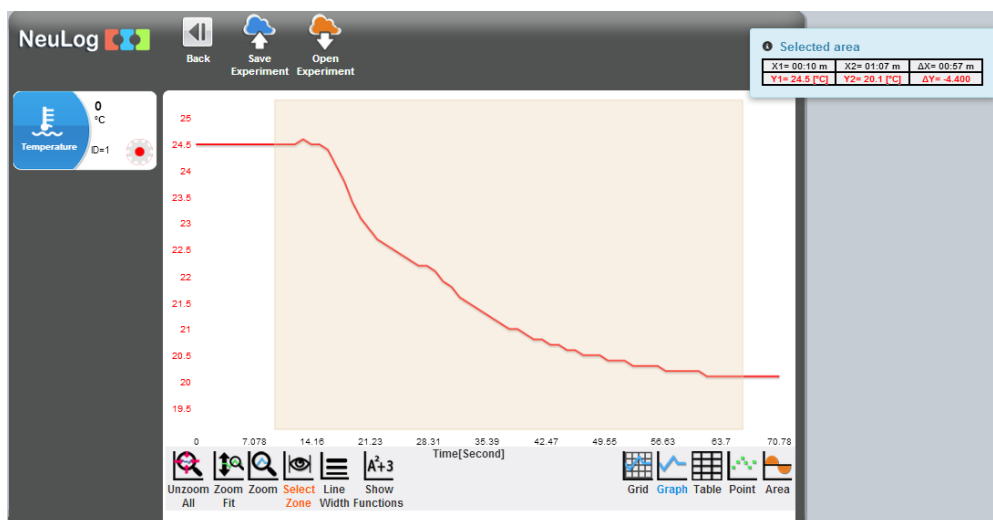
17. Look at the data at the bottom of the graph, we can see that the temperature dropped from 24.5 °C to 20.1 °C in the sample measurement.

The temperature change was 4.4 °C. Is the reaction exothermic or endothermic? Is the energy released or absorbed from the surrounding?

Summary questions

1. Is the ΔH positive or negative for this reaction? Explain.

2. Name three uses of endothermic and/or exothermic reactions.

3. Did you see bubbles after adding the baking soda? Why do you think they formed?