Experiment C-5
Combustion

Objectives

- To study the chemical process of combustion.
- To measure the oxygen levels during the combustion of a candle.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-205 Oxygen logger sensor

Equipment and Accessories

▪ Cover
▪ Candle base
▪ Candle

- The items above are included in the NeuLog Oxygen and Carbon Dioxide kit, CGG-KIT.

Materials

▪ Lighter
▪ DO filling solution (included with the oxygen sensor)

Introduction

Combustion is an exothermic reaction between a fuel and an oxidizing agent, usually accompanied by the production of heat and light in the form of flames.

Many organic compounds burn in the presence of oxygen (air contains approximately 21% oxygen) to produce water and carbon dioxide. For example: methane (a natural gas), which burns in the air to produce water, carbon dioxide and maybe the most important additional product, heat. This energy in the form of heat is used to warm houses:

$$\mathbf{CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + energy\ (heat)}$$

A similar reaction to combustion of organic compounds is cellular respiration.

$$\mathbf{C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + energy\ (ATPs,\ heat)}$$

In this reaction, like in the combustion reaction, an organic compound reacts with oxygen to produce water, carbon dioxide and energy.

It is common to think that combustion ends when all the oxygen is consumed. In this experiment, we will investigate it by burning a candle in a closed container while monitoring the oxygen content.

Procedure

Experiment setup

Caution:

You will be working with an open flame. Make sure not to have any flammable material in the proximity of the experiment. Be careful when working with high temperatures. It is recommended to wear personal protective equipment.

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

2. Remove the rubber protection from the oxygen sensor's probe cap. Unscrew the cap, fill half of it with the included liquid and screw it back.

3. Place the probe in the side hole of the candle base.

4. Place the candle in the candle base.

Sensor setup

5. Connect the USB-200 module  to the PC.

6. Check that the oxygen sensor  is connected to the USB-200 module.

Important:

You must wait about 5 minutes after connecting the sensor to the USB-200 module before beginning calibration and measurements. For a more accurate measurement you can look at the module window and wait for the reading to stabilize (it could take longer than 5 minutes).

Note:

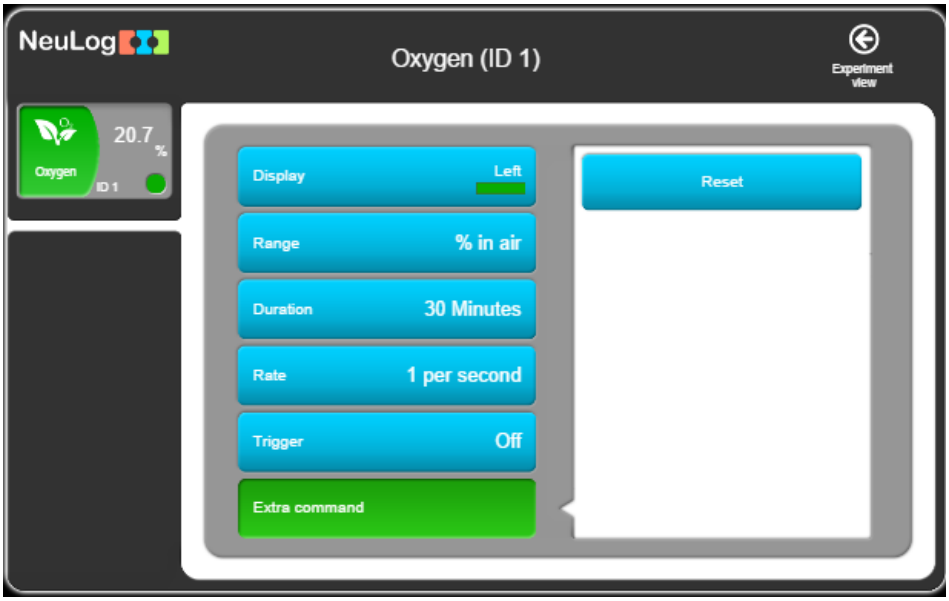
The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

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

Settings

8. Click on the pressure **sensor's module** box.

9. Select the “% in air” button to set the sensor's mode.



10. Click on the  icon to go back to the graph.

11. Click on the **Run Experiment** icon  and set the:

    Experiment duration to 2 minutes
    Sampling rate to 5 per second

Testing and measurements

12. Press on the sensor's offset button continuously (3 seconds), or alternatively, click on the **Extra command** button in the **Module setup** menu and then on the **Reset** button. This will offset the sensor to a value of 20.9%.

13. Light the candle and check that the oxygen levels are stable in the module window.

14. Click on the **Record** icon  to start the measurement.

15. Click on the **Arrows** icon  in order to see the sensor's values during the measurement.

16. Wait about 10 seconds and cover the candle with the glass cover.

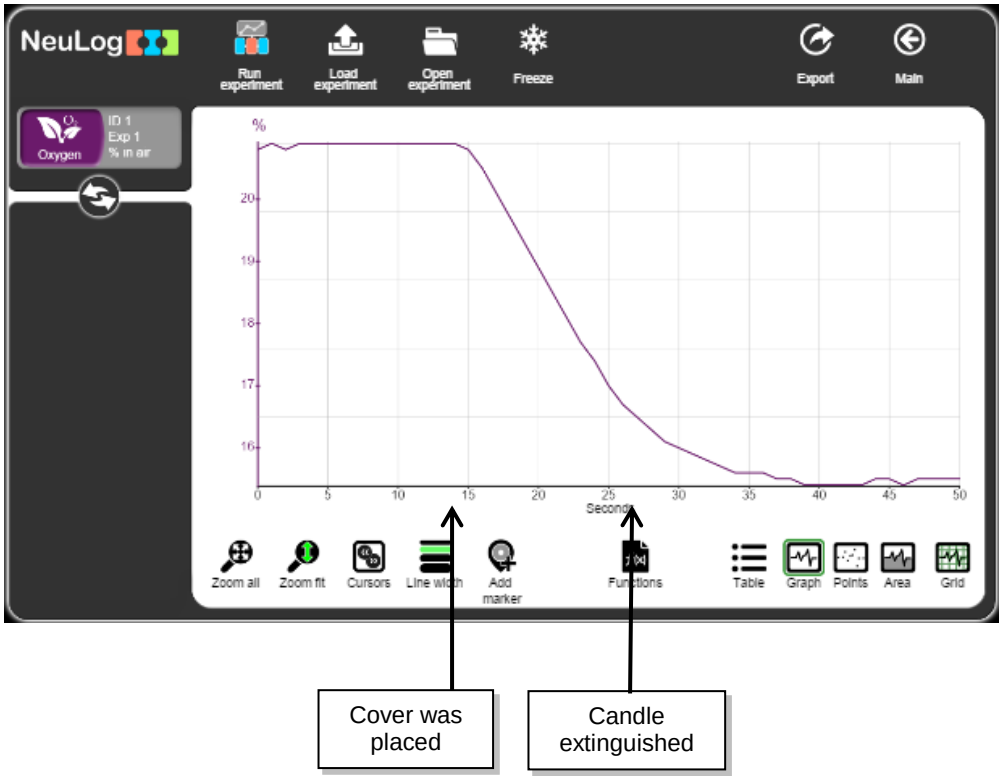
17. Note how long it took for the candle to get extinguished.

18. To see the entire graph after one minute, use the mouse's scroll wheel.

19. Observe the changes in the oxygen percentage (stop the measurement if the value has stabilized).

20. Click on the **Zoom fit** icon  .

21. Your graph should be similar to the following:



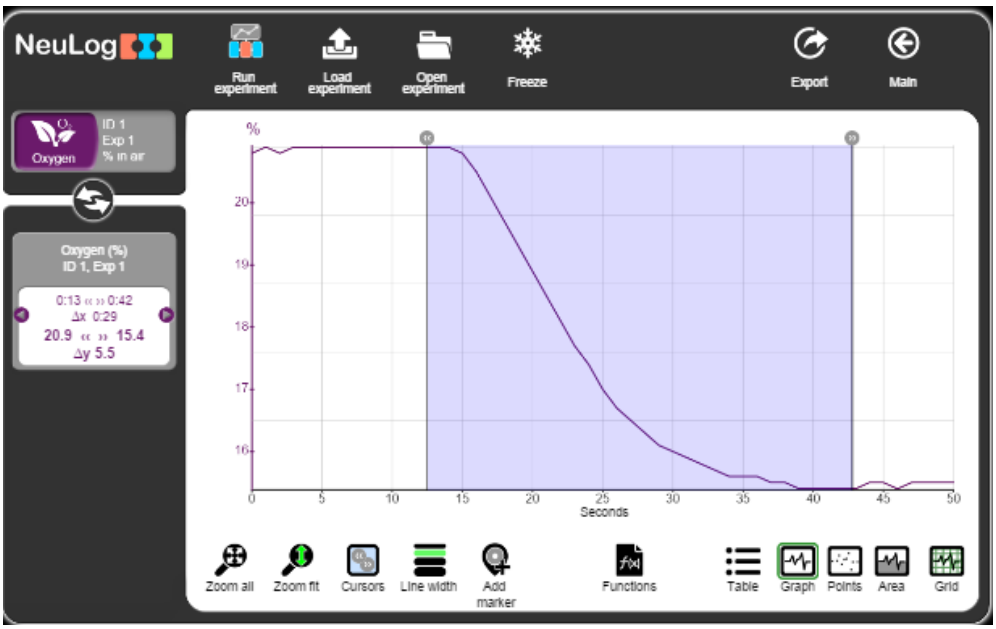
22. Click on the **Export** Icon  and then on the **Save value table (.CSV)** button to save your graph.

23. Click on the  icon to go back to the graph.

24. After placing the cover, oxygen molecules cannot get in the container and the oxygen level decreases as the candle is burning.

    We can see in the previous graph that a few seconds after the candle was extinguished, the measured oxygen levels were minimal (diffusion rates of oxygen in the container might cause this small delay).

25. Click on the **Cursors** icon  and select the part between the beginning and ending of the measurement.



26. Look at the data at the bottom of the graph, we can see that the oxygen level had changed in our example from 20.9% to 15.4%.

The measured minimum oxygen level matches the measured value in caves with low concentrations of oxygen. The study showed that bellow 15% oxygen, candles extinguish.

Usually the oxygen concentration measured is the Minimum Oxygen Concentration (MOC) required for combustion. This value is different between fuels and depends on the stoichiometric relations (quantitative relations) between the oxygen and fuel.

Summary questions

1. What was the minimum oxygen percentage in your measurement? Does this value match the documented data from caves?

2. What was the fuel in the experiment? Was it solid, liquid or gas?

3. If we would have used a larger container, how do you think this would affect the results?

4. Which chemical product that was not mentioned could also be a result of combustion? What is the effect of this product on our health?