

Experiment C-32 Temperature of a Flame



Objectives

- To learn about different parts of a flame and how different candles produce flames with different temperature.
- To recognize different regions in the flame of a candle and measure each region's temperature with a wide range temperature sensor.
- To compare the temperature of different types of candles.

Modules and Sensors

- PC + NeuLog application
- USB-200 module 
- NUL-234 Wide range temperature logger sensor 

Equipment and Accessories

- | |
|----------------------------|
| ▪ Various types of candles |
| ▪ Lighter |

Introduction

A candle is made of two parts, the fuel, which is some type of wax, and the wick, which is made of twine. The wick has to be absorbent or with a strong capillary action (the tendency of a liquid to move up in a thin tube). The absorbance of the wick allows it to carry the liquid wax to the flame. When the wick is lit, the wax that is on or near it melts. The wax is then vaporized by the flame and burns.

A candle's flame can be divided into several zones:

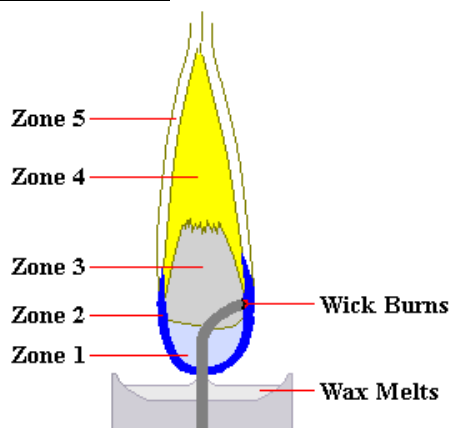
Zone 1: **Non-Luminous zone** - There is not enough oxygen for the fuel to burn. The temperature is around 600 °C (The temperature in each zone changes among different candles and environments).

Zone 2: **Blue zone** – There is plenty of oxygen and the flame burns with blue light. The temperature is around 800 °C.

Zone 3: **Dark zone** – Pyrolysis (cracking) of the fuel begins due to a shortage of oxygen. This creates minute carbon particles. The temperature is around 1000 °C.

Zone 4: **Luminous zone** – Pyrolysis continues due to a shortage of oxygen, carbon particles continue to heat as they rise until they ignite and emit the full spectrum of visible light (we see it as yellow). The temperature is around 1200 °C.

Zone 5: **Veil** – There is plenty of oxygen so carbon particles burn more completely. The temperature is around 1400 °C.



http://www.pysanky.info/Chemistry/Candle_Flame.html

Some candles work better than others; here are a few examples: A harder wax will produce a hotter flame. A larger wick will produce a larger and hotter flame. Darker candles (with coloring agents) and scented candles produce lower temperature flames.

In this experiment we will measure the temperature in different regions inside a flame and the temperature of different candles' flames.

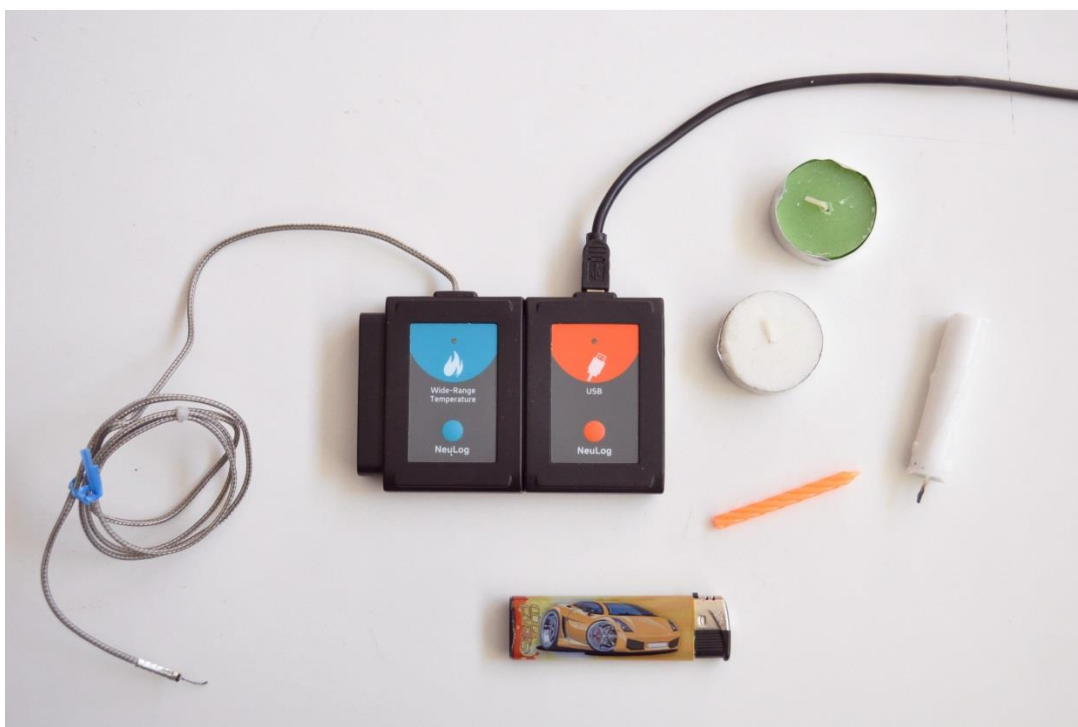
Procedure

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. Prepare different kinds of candles (different size of wick, different waxes, etc.). One of the candles should be able to produce a relatively large flame so that different regions will be recognized (see the pictures in the "testing and measurement" section).
3. Make sure you also have a lighter (or matches).

Sensor setup



4. Connect the USB-200 module  to the PC.
5. Check that the wide range temperature sensor  is connected to the USB-200 module.

Note:

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

6. Run the NeuLog application and check that the wide range temperature sensor is identified.

Settings

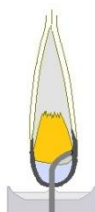
7. Click on the **On-line Experiment** icon  in the NeuLog main icon bar.
8. Click on the **Experiment Setup** icon  and set the:
Experiment duration to 2 minutes
Sampling rate to 5 per second

Testing and measurements

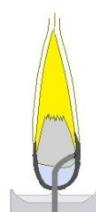
9. Carefully, light the candle with the biggest wick (and biggest flame).
10. Try to recognize these three zones:



Non-Luminous
zone



Dark zone



Luminous zone

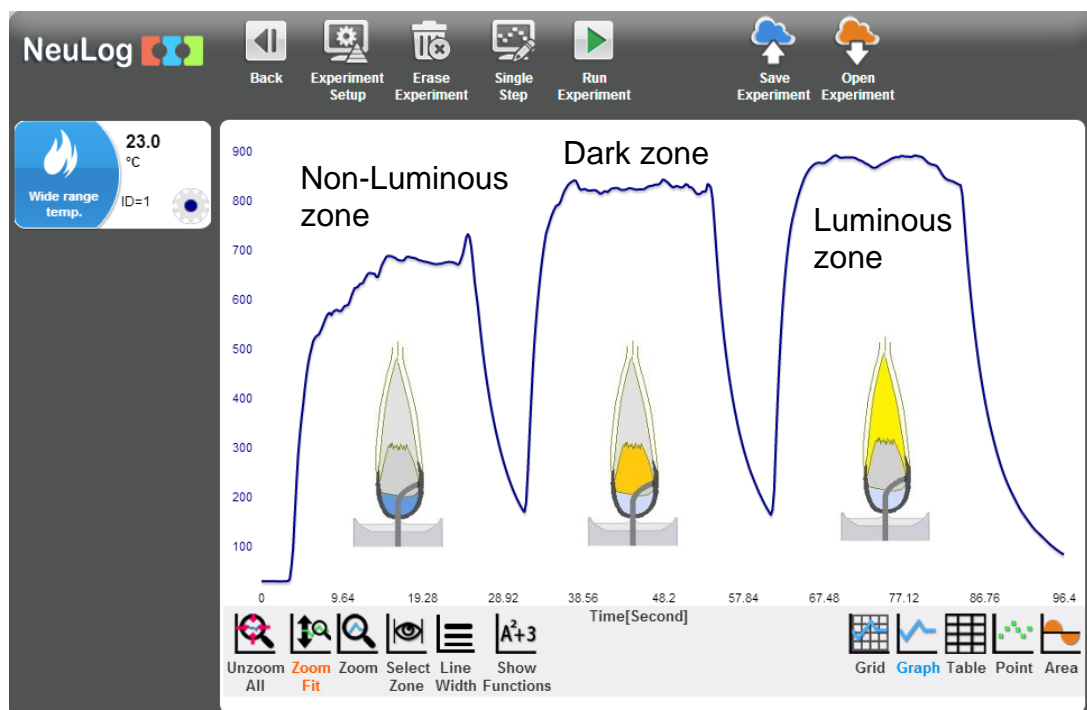
11. Click on the **Run Experiment** icon  to start the measurement.


12. Carefully, insert the wide range temperature sensor's probe into the Non-Luminous zone for about 20 seconds and then take it out.
13. Without stopping the experiment, repeat this process with the Dark zone and the Luminous zone.



14. Click on the **Stop Experiment** icon  to stop recording data.

15. Your graph should be similar to the one below.



16. Save your data.
17. We can see that in the sample experiment, the Non-Luminous zone has the lowest temperature (around 700 °C), the dark zone's temperature is higher (around 850 °C) and the Luminous zone has the highest temperature (around 900 °C).
18. Change the duration of the experiment to 10 seconds and 10 samples per second.
19. Light one of the candles you have prepared.
20. Carefully put the wide range temperature sensor probe in its Luminous zone and click on the **Run Experiment** icon  to start the measurement.
21. Repeat this measurement for each candle (do not erase the previous measurements so that you can see all the graphs together).

22. In this experiment, four different candles were tested:



23. Save your data.

Summary questions

1. Did you get different results for different candles? Explain the differences.
2. Specify two more types of flames (except for candle flame) and explain how they work.
3. What are the reactants and the products of the wax combustion reaction? What is the part of each reactant?