Experiment C-16
Distillation – part 2

Chemistry

Objectives

- To learn about the three classical phases of matter, phase changes, and heating and cooling curves.
- To investigate the technique of distillation and to separate the components of a mixture by this means.
- To study the chemical differences between ethanol and water.

Modules and Sensors

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

Equipment and Accessories

▪ Utility stand	1
▪ Right angle clamp	1
▪ Extension clamp	1
▪ Still head	1
▪ Round bottom flask	1
▪ Condenser	1
▪ Receiver	1
▪ 50 ml beaker	2
▪ Alcohol lamp	1
▪ Safety goggles	-
▪ Boiling stone	4

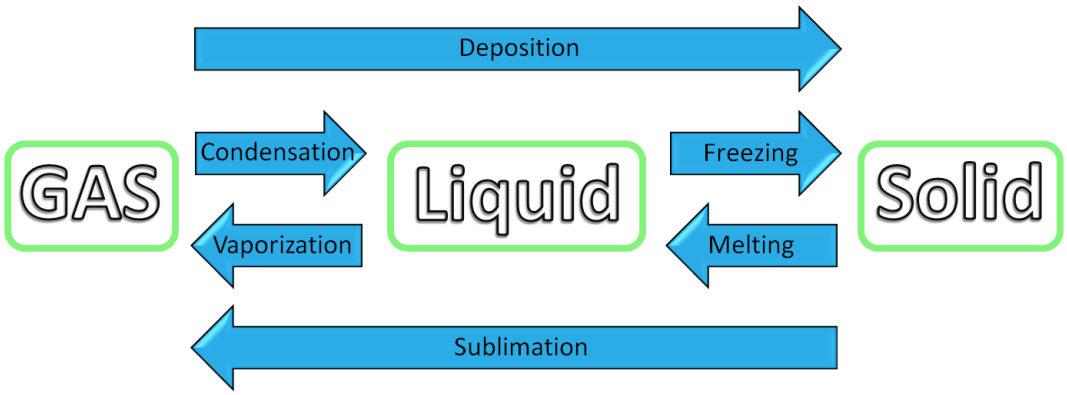
- The items above are included in the NeuLog Distillation kit, DST-KIT (four safety goggles are included in the NeuLog Utility accessories, UTL-KIT).

Materials

▪ 5 drops of food coloring
▪ 35 ml of 96 % Ethanol
▪ 5 ml of tap water
▪ Lighter

Introduction

The three classical phases of matter are solid, liquid and gas. Particles of a gas are well separated while particles of a liquid are closer together. Particles of a solid are tightly packed, and are structurally rigid. The following figure describes the different types of phase changes:



A heating or a cooling curve shows the change in temperature of a sample as it is heated or cooled. Sloped regions correspond to temperature changes in one of the different states. Flat regions (constant temperature) correspond to phase changes (this will be discussed further on).

Distillation is a method for purifying liquids and separating liquid mixtures. It is based on the fact that different substances have different boiling points (the temperature in which liquid changes into gas). It is commonly used in the lab, and it also has several commercial uses such as fractionation of crude oil into useful products and concentrating alcohol.

The general principle of distillation is starting with a mixture of liquids with different boiling points, heating the mixture to the first boiling point, cool down the vapor and collect the condensed liquid. This liquid is enriched with the lower boiling point component. The liquid that is left behind is enriched with the higher boiling point component.

In this experiment we will use a distillation kit with ethanol, water and food coloring in order to observe the distillation process.

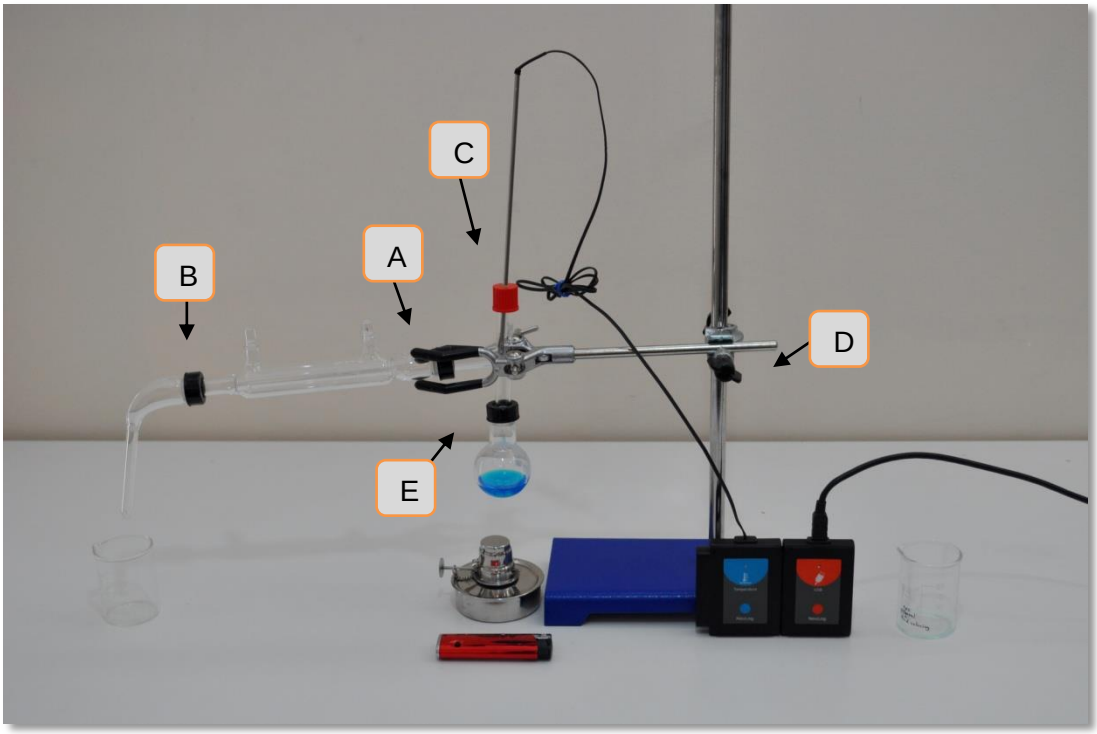
Procedure

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 very careful when working with high temperatures. 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 beaker with 5 ml of 96% ethanol, 5 ml of tap water, 5 drops of food coloring and 4 boiling stones.

3. Insert the side tube of the still head into the condenser adaptor and screw the black cap (the caps should be screwed tightly but carefully) (A).

4. Insert the other side of the condenser into the receiver and screw the black cap (B).

5. Insert the temperature sensor's probe in the still head through the hole in the top cap up to where the still head and the condenser meet. Screw this cap to hold the probe in place (C).

6. Install the assembled system on the utility stand, using the extension clamp (D).

7. Pour the solution into the round bottom flask and put the boiling stones inside as well. Insert the still head into it and screw the black cap (E).

8. Wash the beaker that contained the solution and place it under the receiver.

9. Place a closed alcohol lamp filled with 30 ml of 96 % ethanol around 4 cm under the round bottom flask.

10. Make sure you also have a lighter.

Sensor setup

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

12. Check that the temperature sensor  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.

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

Settings

14. Click on the **On-line Experiment** icon  in the NeuLog main icon bar.

15. Click on the **Experiment Setup** icon  and set the:

    Experiment duration to 15 minutes
    Sampling rate to 60 per minute

Testing and measurements

16. Open the alcohol lamp and pull out (using the handle) a little bit of wick.

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

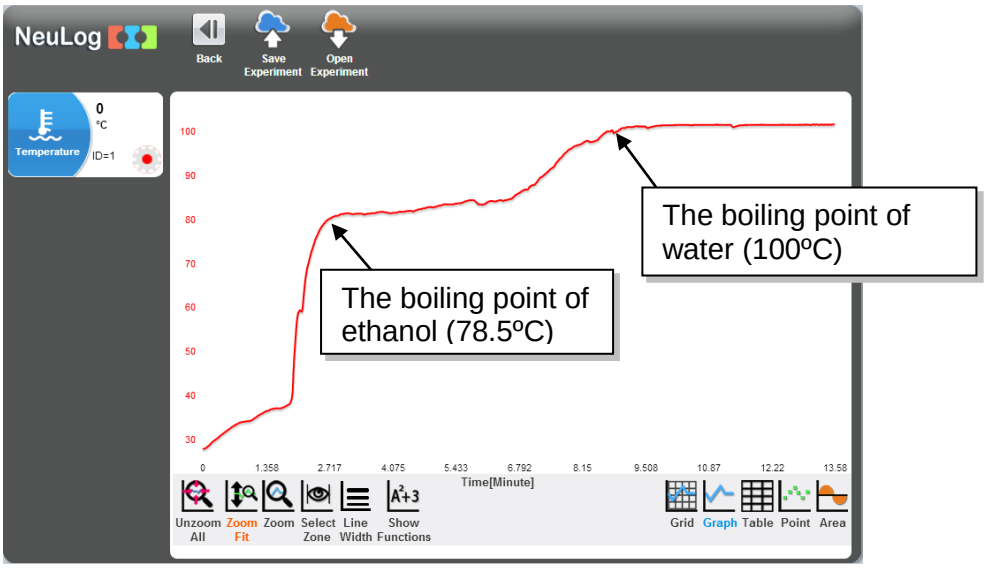
18. Make sure that there isn't any exposed ethanol near the working space. Very carefully light the alcohol lamp and adjust the flame so that it will be around 1 cm bellow the flask.

19. The graph should include two flat regions (one for the boiling of ethanol and one for the boiling of water). Replace the first beaker when the second flat region begins.

20. Stop the measurement when only a little bit of food coloring with water remains in the round bottom flask and turn off the alcohol lamp.

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

22. Your graph should be similar to the following.



23. Save your graph.

24. After finishing the experiment loosen the cap before separating each part.

25. The measurement starts at room temperature, after lighting the alcohol lamp, the probe is heated by the flame.

    After reaching 38 ºC there is a sharper rise in temperature, the solution heats up until the temperature is around 78.5 ºC– the boiling point of ethanol, and remains constant throughout the boiling process. Mostly ethanol comes out at the first flat region.

    The temperature continues to rise slowly until it is around 100 ºC – the boiling point of water, and again stays constant throughout the boiling process. Mostly water comes out at the second flat region.

    The reason that the temperature stays constant throughout the boiling processes is latent heat. Latent heat is the amount of energy absorbed or released by a substance during a change in its physical state without a change in temperature. The temperature was constant because heat was absorbed as latent heat of vaporization.

Summary questions

1. Why does ethanol has a lower boiling point than water?

2. Can we separate ethanol and water completely by using this method?

3. Give another example of a mixture that can be separated by distillation.