LABORATORY EXPERIMENT:

THERMALIZATION AND ZEROTH PRINCIPLE OF THERMODYNAMICS

INTRODUCTION:

We all know that when we mix 2 quantities of water at different temperatures, the final mixture will have a temperature between the 2 starting temperature. This process is called **thermalization**, and today we are going to find out how it works, starting with equal quantities of water to simplify the calculations and ending with different quantities of water to find the general rule.

You should prove that for equal quantities of water at different temperature the final temperature will be the mean value between the two starting temperatures, while for different quantities of water you can predict the final temperature by calculating a weighted mean value, using the starting masses of water as weights.

MATERIALS:

- 1 bowl (to mix the water);
- 1 heating stirrer;
- 1 fridge;
- 2 beakers;
- 2 thermometers;
- 1 clamp stand.

PROCEDURE, PART 1 - SAME AMOUNTS OF WATER:

1. Fill the 2 beakers with 500 mL of tap water each;
2. Place one of them on the heating stirrer and immerse the thermometer using the clamp-stand;
3. Start heating up the water, make sure it reaches maximum 60°C to avoid accidents;
4. When the water in the beaker reaches the desired temperature, take note of the temperature;
5. Measure and take note of the temperature of the water in the other beaker (it should be at room temperature);
6. Mix the water of the 2 beakers in the bowl, stir to help it mix homogeneously (be as fast as possible during this step);
7. Measure and take note of the final temperature of the water in the bowl;
8. Repeat the procedure always using the same amounts of water, but at different temperatures, you can put one of the beaker in the fridge, in order to have a lower temperature that is below room temperature;
9. You can use a table like the following one to record the data.

TRIAL	HIGHER TEMPERATURE [°C]	LOWER TEMPERATURE [°C]	FINAL TEMPERATURE OF THE MIXTURE [°C]
1			
2			
3			
4			

PROCEDURE, PART 2 – DIFFERENT AMOUNTS OF WATER:

1. Fill the 2 beakers with different amounts of water (take notes of the volume, you'll convert it into mass using the density of water: 1000 Kg/m^3);
2. Repeat all the procedures of points 2-8 of PROCEDURE, PART 1 using the different amounts of water and report your data in a table like the following one.

TRIAL	HIGHER TEMPERATURE [°C]	MASS OF WARMER WATER [Kg]	LOWER TEMPERATURE [°C]	MASS OF COLDER WATER [Kg]	FINAL TEMPERATURE OF THE MIXTURE [°C]
1					
2					
3					
4					

RESULTS ANALYSIS – PART 1:

Use the temperatures you measured in part 1, of the warm and cold water, for each trial, and confirm that you can find the final temperature of the water mixture by simply calculating the mean value of the higher and lower temperature. You will notice that the final temperature you measured is slightly lower than the calculated theoretical temperature, this means that some heat "disappeared", where did it go? How has it been used?

RESULT ANALYSIS – PART 2:

Use the temperatures you measured in part 2 of the experiment, of the warm and cold water, for each trial, and calculate the weighted mean value by using the masses of water as weights, use the following formula

$$T_f = \frac{m_1 T_1 + m_2 T_2}{m_1 m_2}$$

Also in this case you'll notice that the measured final temperature is slightly lower than the calculated theoretical temperature, like in part 1, for the same reason.

Do you think the formula to calculate the thermalization of 2 different masses of the same substance can be generalized to more than 2 masses? Will the weighted mean value work as well?

CONCLUSIONS:

With this experiment we've just found one of the fundamental principle of thermodynamics. This principle is called **Zeroth Law of Thermodynamics** and states that "If a body A is in thermal equilibrium with a body B and if B is in thermal equilibrium with body C, then A is in thermal equilibrium with C", or, more formally, "If two systems are in thermal equilibrium with a third system, then they are in thermal equilibrium with each other".

This law tells us that when two objects at different temperatures are placed in contact one with the other they will eventually reach the same temperature (thermalization). The temperature of the warmer object will decrease, while the temperature of the colder object will increase, meaning that there is a heat transfer from the warmer to the colder object.