Lab - Heat Transfer

Background

Often it is necessary in science to predict energy flow and even to measure this flow. Since energy is invisible, this often requires special equipment. Heat, a form of energy, is not measured directly. Instead, scientists must study heat by how it affects matter. Heat causes the molecules of matter to vibrate faster, which is recorded as temperature. With the Heat Transfer Kit, two insulated containers (called calorimeters), thermometers, and an aluminum transfer bar make it possible to study the transfer of heat from a substance in one calorimeter to a substance in the other. This investigation measures the flow of heat as it is affected by different variables.

SPECIFICATIONS OF MATERIALS:

-wood alcohol
-graduated cylinder
-aluminum transfer bar
-boiling water
-thermometers (2)
-calorimeters (insulated containers)
-lids with slots

INVESTIGATIONS:

Part 1 - Measuring heat flow between equal amounts of the same substance.

Procedure

Before beginning the investigation, discuss the idea of insulated plastic containers (calorimeters) being able to hold heat in or keep heat out as it does, for example, in a thermos bottle. Prepare boiling water for use in the investigation. The heat transfer bar and the thermometer are inserted into the lids of the containers before filling the calorimeters, so that they can he quickly assembled after the water has been added. Fill one calorimeter with water at room temperature to a level about one inch from the top. One of the lids with the bar and thermometer should he inserted into the container and its temperature recorded. Then, place an equal amount of boiling water into the other calorimeter and quickly place the lid on the container.

Since the temperature of boiling water is 100°C, this reading should be recorded as the initial reading for the container with the boiling water. Temperature readings for both calorimeters should he taken every two minutes in the table below for a period of 20 minutes. A *line graph will need to be constructed* showing the temperature change of the water in both calorimeters on the same graph.

TIME (MINUTES)	HOT WATER TEMPERATURE (°C)	ROOM WATER TEMPERATURE (°C)
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		

Evaluation Questions (answer on separate paper)

1. How does the energy get from one calorimeter to the other?

2. What kind of heat transfer does this illustrate?

3. What happens to the temperature of the liquids in the two containers?

4. How can you determine the direction in which the energy flows?

5. Why don't (won't) the graphed lines cross?

6. Where is the slope of the graph the greatest (during the beginning or end readings)?

7. What does this illustrate about the speed of heat flow as compared to the amount of temperature difference?

8. The amount of heat loss should equal the amount of heat gain. Since the materials were both water and in the same quantity, this means that the temperature of one should have risen the identical number of degrees that the temperature of the other fell. Did this occur in the experiment after the required 20-minute period? Why or why not?

Part 2 - Measuring heat flow through unequal amounts of the same substance.

Procedure

In this experiment, unequal volumes of water are used to ascertain if the temperature adjusts itself to the midpoint between the two original temperature readings. If the materials are the same, as they are in this investigation, the results can he predicted. We can help ourselves predict this equilibrium temperature by calculating the amount of heat energy that is transferred from one container to another by use of the following formula:

$$Q = mC\Delta T$$

Where Q is heat energy in calories, m is the mass of the water in grams (remember 1 milliliter = 1 gram), C is the specific heat of the water (see reference tables), and ΔT is the temperature change of the water (remember $\Delta T = T_{final} - T_{initial}$).

Insert the heat transfer bar and thermometers into the lids. Measure 100 milliliters of room temperature water and pour it in one of the calorimeters. Insert one of the lids and record its temperature. Place 200 milliliters of boiling water (100°C) into the other calorimeter and quickly put its lid in place. Use the 100°C temperature of the boiling water and the temperature of the room temperature water as the original readings. Record the temperature every two minutes in the table below for a period of 20 minutes, and *construct a line graph* of the results.

TIME (MINUTES)	HOT WATER TEMPERATURE (°C)	ROOM WATER TEMPERATURE (°C)
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		

Evaluation Questions (answer on separate paper)

1. Does the temperature of the room temperature water increase at a higher rate than the temperature of the boiling water decreases?

2. If yes in the above question, why would this occur?

3. Determine both the heat energy gained by the room temperature water and the energy lost by the boiling water by the formula previously defined above after the required 20-minute period. Be sure to show all work and substitutions. Are they the same?

4. If the heat energy gained is not equal to the energy lost, what *2 reasons* could cause the difference?

5. Estimate the temperature at which both containers should stabilize (with help from your answers to question 3). Be sure to show all work and substitutions. Will this temperature be exactly the midpoint between their initial temperatures?

Part 3 - Measuring heat flow through equal amounts of different materials

Procedure

Place 200 milliliters of wood alcohol into one calorimeter at room temperature and record the temperature. Pour 200 milliliters of 100°C water in the other calorimeter. Cover the containers, using the original temperature of the alcohol and 100°C for the water as the original readings. Record the changes in temperature every two minutes in the table below for a period of 20 minutes and *construct a line graph of the changes*.

TIME (MINUTES)	HOT WATER TEMPERATURE (°C)	ALCOHOL TEMPERATURE (°C)
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		

Evaluation Questions (answer on separate paper)

1. Does the alcohol show the same amount of temperature increase as the water shows a decrease?

2. If no in the above question, could the difference be attributed to volumes?

3. If no in question 1 above, what could cause the difference?

4. What would be a problem of predicting a stabilizing temperature when three different volumes of three different kinds of liquids are mixed in a calorimeter?

***Working Further:** If time permits, you can also do this experiment with *unequal* amounts of *different* materials.

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