MiSP Thermal Conduction Worksheet #1 L3

Name ______________________________ Date _____________

HEAT TRANSFER

Introduction

Areas that have heat energy are called *heat sources*. Areas that have little or less heat energy are called *heat sinks*.

In this lab activity you will determine the direction in which heat energy flows between a heat source and a heat sink, and you will determine how the temperature changes.

Problems

- In which direction does heat energy flow: *from source to sink* or *from sink to source*?
- What happens to the temperature of hot and cold water connected with an aluminum bar?

Hypothesis

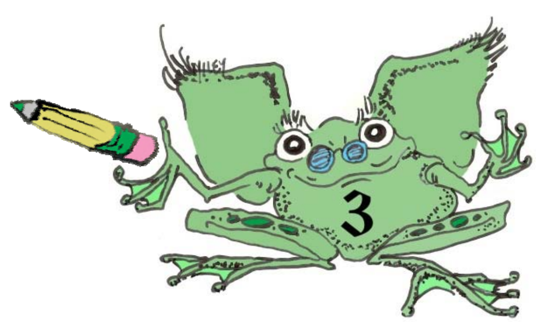
If a container of hot water (the heat source) is connected to a container of cold water (the heat sink) with an aluminum bar, the heat will transfer from the **heat source** / **heat sink** (*circle one*) to the **heat source** / **heat sink** (*circle one*).

Materials:

- goggles
- 2 insulated containers with lids and an aluminum connecting bar
- warm water (approximately $100^{\circ}C$)
- cold water
- 2 thermometers
- color pencils
- timer

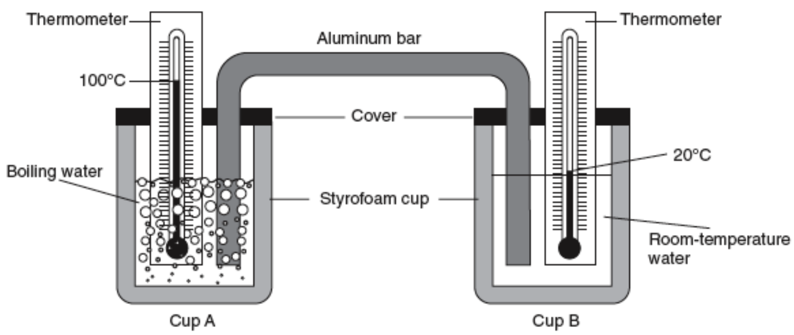
Safety:

- Wear goggles.
- Use caution when handling the hot water.



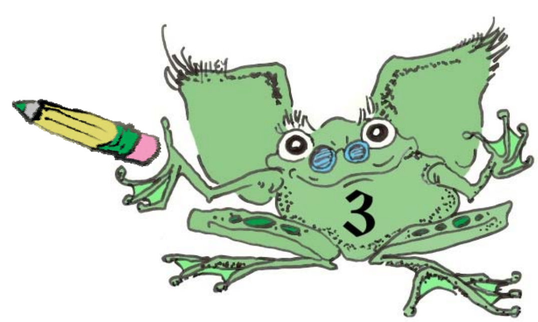
Procedure:

(Note: Your teacher may supply water with temperatures different than those in this diagram.)



Check off each step as you complete it.

- ☐ Set up the heat transfer kit as in the diagram above. The thermometer bulbs and the bottoms of the aluminum bar should be near the bottom but NOT touching the bottom of each Styrofoam insulated container.
- ☐ Measure 150 ml of hot water and the same amount of cold water, and add the hot water to one insulated cup and the cold water to the other.
- ☐ Gently place the lids with aluminum bar and thermometers on the cups at the same time. (Be careful not to submerge the lids.)
- ☐ Wait 15 seconds for the thermometer to get a reading. Then record the initial temperature (time 0) of the water in each cup on the data table.
- ☐ Continue to record in the data table temperatures for both cups each minute for 15 minutes (or longer if your teacher indicates a different time).



Record your data:

Record in the data table the temperatures for both cups each minute.

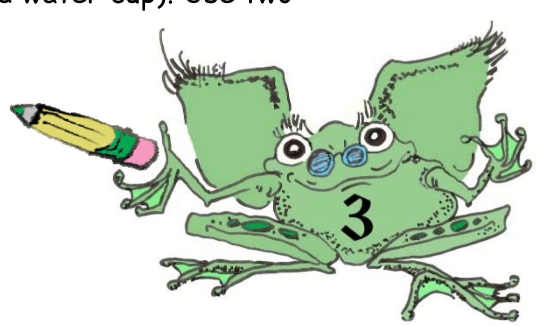
Data Table Temperatures

Time (minutes)	Temperature °C Hot water cup	Temperature °C Cold water cup
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

Graph your data:

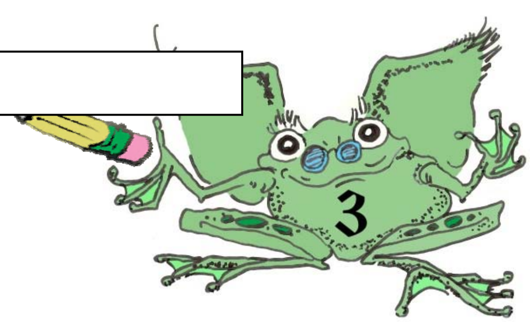
Graph the above data on the next page to show the relationship between time (minutes) and the temperature (°C) in each cup.

- Label the *x*-axis.
- Label the *y*-axis.
- Connect the dots for each cup's data set (hot water cup, cold water cup). Use two different colors and write a key for the graph.



Title:________________________

Key
Warm water line:
Cold water line:



Discussion Questions:

Answer each of the following questions.

1. Which container is the heat source? ______________________________________

2. Which container is the heat sink? ____

3a. Which container "lost" heat energy? ______________________________________

3b. Since energy is never lost or created, where did the heat energy go?

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4. In this experiment, the heat energy moved from the ____________________ container to the________________ container or from the **heat source** / **heat sink** (*circle one*) to the **heat source** / **heat sink** (*circle one*).

5. What method of energy transfer occurred in this experiment? (*Circle one.*)

Conduction **Convection** **Radiation**

6. How did the graph of the cold water cup temperatures compare to the graph of the hot water cup temperatures?

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7. Predict how the temperature in the cold water cup would compare to the temperature in the hot water cup if the experiment was allowed to continue for a longer time.

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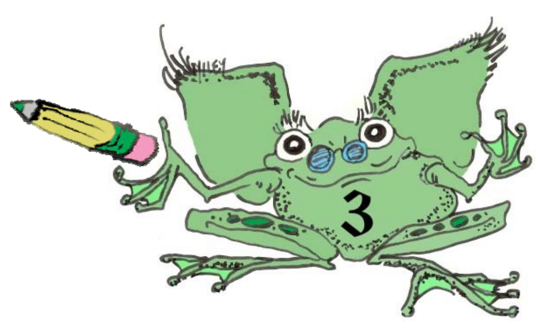

8. Look at the graph you drew. Notice that as time passed, the temperature in each cup changed. You will compare the temperature changes in the second five minutes (from 5 to 10 minutes) of the experiment in the hot water cup and the cold water cup by calculating the unit rate of change (slope) of each line. Use the information from the graph to calculate the unit rates of change (slopes) for the cold water data and the hot water data on the heat transfer graph. If your data points from 5 to 10 minutes all lie on a line, determine the unit rates of change (slopes) of the lines. If your data points do not produce lines, determine the unit rates of change (slopes) of best-fit lines from 5 to 10 minutes. *(If you use best-fit lines, the ordered pairs to determine the unit rates of change [slopes] must be from the best-fit line, not from your data chart.)*

$$\text{Unit Rate of Change} = \frac{\Delta \text{ Temperature } (^{o}\text{C})}{\Delta \text{ Time (minutes)}} = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

Graphed Data Best-Fit Line	**Ordered Pair used for calculation (x_1, y_1) (x_2, y_2)**	**Δ Temperature °C Δy**	**Δ Time (minutes) Δx**	**Unit Rate of Change (slope) $\Delta y/\Delta x$**
Cold water data from 5 to 10 minutes				
Hot water data from 5 to 10 minutes				

9a. How do the unit rates of change (slopes) for the two sets of data on the graph compare? Discuss numerical value and sign (positive/+ or negative/-).

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9b. Which set of data had a negative/- unit rate of change (slope)? What does that tell you about the changes in temperature as time passes?

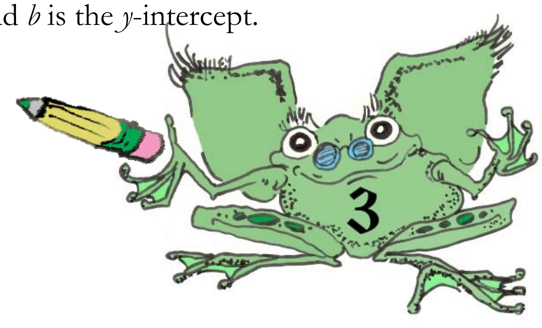
9c. Which set of data had a positive/+ unit rate of change (slope)? What does that tell you about the changes in temperature as time passes?

10. Both lines made from the data on the graph from 5 to 10 minutes intersect the y-axis. Determine the y-intercept for the 5–10 minute cold cup and hot cup lines or best-fit lines. Use the equation for a line to calculate the y-intercept. Use the lines or best-fit lines you used in #8. The equation for a line is

$y = \text{mx} + b$
where m is the unit rate of change (slope) and
b is the y-intercept

***Y*-Intercept — Cold Water line**	***Y*-Intercept — Hot Water line**
$m =$ Ordered pair $(x, y) = (\_\_\_ , \_\_\_)$ $y = mx + b$ Solve for b:	$m =$ Ordered pair $(x, y) = (\_\_\_ , \_\_\_)$ $y = mx + b$ Solve for b:

11. Based on the unit rates of change (slopes) that you calculated above and the y- intercepts, write equations for the lines or best-fit lines on the heat transfer graph. Remember that the equation for a line is $\boldsymbol{y = mx + b}$ and m is the unit rate of change (slope) and b is the y-intercept.



Equation — Cold Water line	Equation — Hot Water line

12. Using each equation above, calculate the predicted temperature of the water at 40 minutes. Show your work.

Cold Water line	Hot Water line
x = 40 minutes y =_______________ºC	x = 40 minutes y =_______________ºC

13. The temperatures you calculated for 40 minutes likely would not be reached if the experiment was allowed to continue for 40 minutes. Why not? Refer to your graph in your answer.

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