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 which direction heat energy flows between a heat source and heat sink and how the temperature changes.

Problems: In which direction does heat energy flow: source to sink, or 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 (heat source) is connected to a container of cold water (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 with aluminum connecting bar
Warm water (approximately 100 degrees)
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 bottom of the aluminum bar should be near but NOT touch the bottom of the Styrofoam insulated container.
- Measure 150 mL of hot and cold water and add hot to one insulated cup and cold 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 on the data table temperatures for both cups each minute for 15 minutes (or longer if your teacher indicates a different time)
Data:

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature °C Hot water cup</th>
<th>Temperature °C Cold water cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph the 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.
Discussion L1-3
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?
_________________________________________________________________
_________________________________________________________________
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)?
   \begin{tabular}{ccc}
   Conduction & Convection & Radiation \\
   \end{tabular}
6. How did the graph of the cold water cup temperatures compare to the graph of the hot
   water cup temperatures.
_________________________________________________________________
_________________________________________________________________
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.
_________________________________________________________________
_________________________________________________________________
Discussion L2-3

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 (5-10) minutes of the experiment in the hot water cup and 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 and 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 unit rates of change (slopes) must be from the best fit line, not from your data chart.)

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

<table>
<thead>
<tr>
<th>Graphed Data</th>
<th>Best Fit Line</th>
<th>Ordered Pair used for calculation</th>
<th>( \Delta \text{Temperature} \ (°C) )</th>
<th>( \Delta \text{Time} \ (\text{minutes}) )</th>
<th>Unit Rate of Change (slope)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold water data from 5-10 minutes</td>
<td></td>
<td></td>
<td>( \Delta y )</td>
<td>( \Delta x )</td>
<td>( \Delta y/\Delta x )</td>
</tr>
<tr>
<td>Hot water data from 5-10 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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/-)?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
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?

__________________________________________________________________

__________________________________________________________________

**Discussion L3**

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

\[ y = mx + b \]

where \( m \) is the unit rate of change (slope) and \( b \) is the y-intercept

<table>
<thead>
<tr>
<th>y Intercept - Cold Water line</th>
<th>y Intercept - Hot Water line</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ m = ]</td>
<td>[ m = ]</td>
</tr>
<tr>
<td>[ Ordered pair (x, y) = (_,___) ]</td>
<td>[ Ordered pair (x, y) = (_,___) ]</td>
</tr>
<tr>
<td>[ y = mx + b ]</td>
<td>[ y = mx + b ]</td>
</tr>
<tr>
<td>Solve for b:</td>
<td>Solve for b:</td>
</tr>
</tbody>
</table>
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 \( y = mx + b \) and \( m \) is the unit rate of change (slope) and \( b \) is the y intercept.

<table>
<thead>
<tr>
<th>Equation – Cold Water line</th>
<th>Equation – Hot Water line</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Cold Water line</th>
<th>Hot Water line</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x = 40 \text{ minutes} )</td>
<td>( x = 40 \text{ minutes} )</td>
</tr>
<tr>
<td>( y = __________________________________________________________°C )</td>
<td>( y = ___________________________________________________________°C )</td>
</tr>
</tbody>
</table>

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.

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________