LAD C.1 (pg 1 of 2) Specific Heat Capacity and Error Analysis

Name_____________________Per____

Introduction

- Specific heat capacity, c, is the intrinsic capacity of a substance to absorb heat.
  and can be defined as **the amount of heat required to change 1 g of a substance 1ºC**.
- The specific heat capacity of liquid water is 4.18 J/gºC

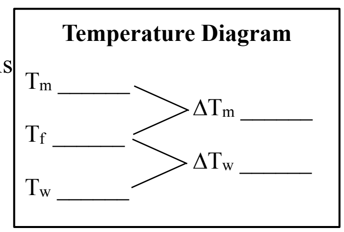
In your daily lives you unknowingly utilize the fact that different materials have different specific heat capacity values as well as different heat transfer rates. We put hot drinks in styrofoam cups and store hot or cold drinks in insulated thermoses to keep them hot or cold. Houses are insulated by special materials which are poor conductors of heat. Metal cooking utensils often have a wood or plastic handle, both of which conduct heat less readily than the metal itself. The specific heat capacity and the ability of a material to conduct heat directly affects how it will feel to your touch. Feel the table top and the table leg. Both of these materials are at the same temperature, having been in the room together all day, yet one of them feels distinctly colder. This is not because the desk top is at a colder temperature, but because the desk top has a different specific heat capacity and a different heat transfer rate causing the desk top to conduct heat better than the wood material which feels warmer.

In this experiment we will utilize the standard value for water (4.18 J/g°C) in order to determine the specific heat capacity of various metals.

Data Collection

A. Break out a lined piece of paper and make a list of what data we will need to measure in order to determine the specific heat capacity, "c" of a metal. The specific heat capacity of the metal will be determined by dropping hot pieces of metal into cool water, and recording the thermal equilibrium temperature. These data & calculation items will be put into your google spreadsheet data table. Use the same spreadsheet, just make a new sheet with the tab at the bottom.

Processing the data



B. Use the temperature diagram to the right, and the formula below to calculate the c of the metals

heat lost by metal = heat gained by water

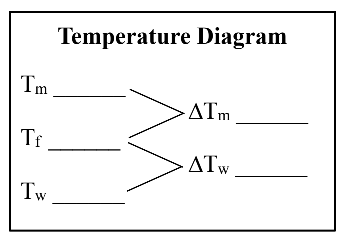
− q = q

$$-\left(m_m \times c_m \times \Delta T_m\right) = m_w \times c_w \times \Delta T_w$$

C. Look up and record the theoretical specific heat capacity in the data/results table, then calculate % error of the experimental specific heat capacity calculated for each trial and report it to your excel data table.

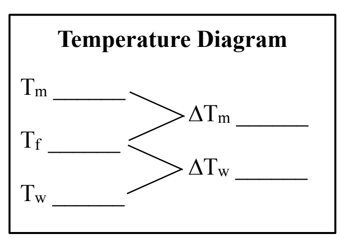
Post-LAD questions **Use the temperature diagrams and the formula for the calculations as a worksheet to sketch in higher or lower arrow indicators to show how the measurements and calculations would change due to the suggested the *error analysis* in each of the following Post-LAD questions.**

1. Why was it important that the metals were boiled for a long period of time? What if you assumed that the metal starting temperature was 100ºC, but in fact it had actually not been boiled long enough? What measurement(s) and subsequent calculation(s) would have been different if you had allowed this to happen? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower effects of this error source, and state the higher or lower effect on c_m in the space below.



$$c_m = \frac{m_w c_w \,\Delta T_w}{-(m_m \,\Delta T_m)}$$

2. Why is it important to stir the water around the metal in the foam cup? What if the water around the hot metal was not stirred, but the thermometer were rested against the hot metal? What measurement(s) and subsequent calculation(s) would have been different if you had allowed this to happen? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower effects of this error source, and state the higher or lower effect on c_m in the space below.



$$c_m = \frac{m_w c_w \,\Delta T_w}{-(m_m \,\Delta T_m)}$$

Post-LAD Questions

3. What if the water around the hot metal was not stirred, but the thermometer were rested in the cup away from the hot metal? What measurement(s) and subsequent calculation(s) would have been different if you had allowed this to happen? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower effects of this error source, and state the higher or lower effect on c_m in the space below.

Temperature Diagram

T_m ______ → ΔT_m ______

T_f ______

T_w ______ → ΔT_w ______

$$c_m = \frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)}$$

4. What if the metal was taken out of the hot water and not transferred quickly enough to the foam cup? What measurement(s) and subsequent calculation(s) would have been different if you had allowed this to happen? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower effects of this error source, and state the higher or lower effect on c_m in the space below.

Temperature Diagram

T_m ______ → ΔT_m ______

T_f ______

T_w ______ → ΔT_w ______

$$c_m = \frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)}$$

5. In order to calculate the specific heat for the various metals, what HUGE assumption must be made, and what smaller ancillary assumptions must be made? Are these valid assumptions?

6. Even though amount of energy (Joules), temperature changes (ΔT) and masses are extensive physical properties, remember that the specific heat capacity is an *intensive property*.

   a. Why is 100.0ºC a convenient starting temp for the lumps of metal? What if you had chosen to only heat the water bath that the metals were heating in, up to 75ºC and you measured it as 75ºC? What measurement(s) and subsequent calculation(s) would have been different than the original "ideal" trial? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower adjustments which would have allowed the specific heat capacity of the metal to remain constant?

Temperature Diagram

T_m ______ → ΔT_m ______

T_f ______

T_w ______ → ΔT_w ______

$$c_m = \frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)}$$

   b. You were never told exactly how much water should be in the foam calorimeter. What measurement(s) and subsequent calculation(s) would have been different if you had used much less water than our original "ideal" trial. Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower adjustments which would have allowed the specific heat capacity of the metal to remain constant?

Temperature Diagram

T_m ______ → ΔT_m ______

T_f ______

T_w ______ → ΔT_w ______

$$c_m = \frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)}$$