LAD C1 (pg 1 of 4) 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 4.186 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 an insulated thermos 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 watch metals dropped into water cool down while the water warms up. Utilizing the specific heat capacity value for water will allow us to calculate the specific heat capacity for various metals.

Formulas

When a substance is simply changing temperature (not reacting), we can calculate heat with a simple fomula to calculate heat, symbolized by *q*.

$$q = m \times c \times \Delta T$$

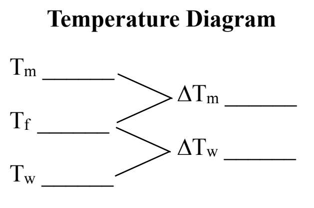
In all of our heat calculations, we will make the big assumption that heat lost will equal heat gained, which allows us to use the heat formula above for water and for metal and set them equal to each other as shown to the right.

$$\text{Heat Lost By Metal} = \text{Heat GainedBy Water}$$

$$-q_{Lost} = q_{gained}$$

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

Further is is sometimes helpful to organize the collected temperature data in what might be called a temperature diagram as shown to the right.



In the space below, solve the “Heat Lost = Heat Gained equation above for the specific heat capacity of the metal.

Pre Lab

Turn to the last page 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*. Make line items in your table for any calculations you will need to make. Include a line on which to write the theoretical value of the speciufic heat capacity so that we can compare and calculate percent error.

Processing the data

The theoretical specific heat capacity for various metals is shown in the table to the right, which can be used to calculate a percent error.

Specific Heat Capacity J/g ºC	
lead	0.138
tin	0.220
copper	0.385
zinc	0.386
aluminum	0.897

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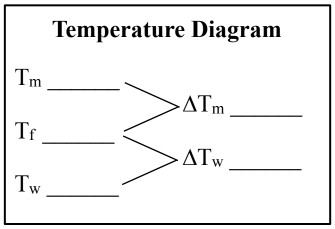
Post-Lab questions

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-Lab 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 the metal had actually not been boiled long enough?

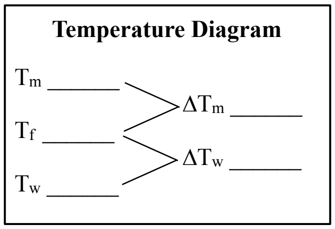
   What measurement(s) and subsequent calculation(s) would have been different if you had allowed this to happen? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower effects of this error source, and state the higher or lower effect on c_m in the space below.



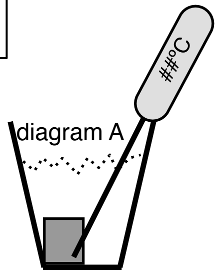
$$\frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)} = c_m$$

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 as in Diagram A?

   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.

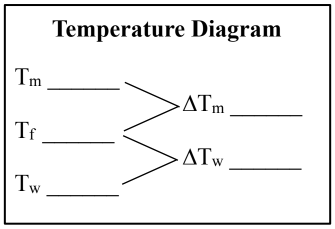


$$\frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)} = c_m$$

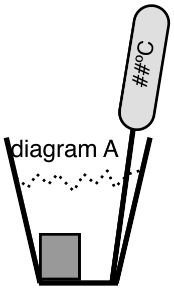


3. What if the water around the hot metal was not stirred, but the thermometer were rested in the cup away from the hot metal as in Diagram B?

   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.

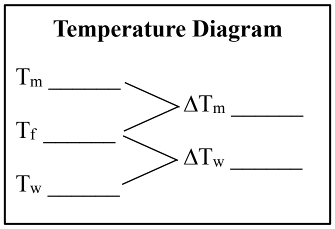


$$\frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)} = c_m$$



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..



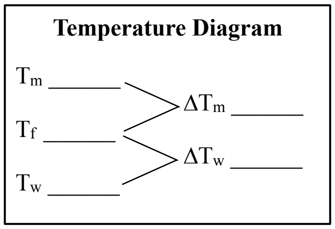
$$\frac{m_w c_w \Delta T_w}{-(m_m \Delta T_m)} = c_m$$

5. In order to calculate the specific heat for the various metals, what HUGE assumption must be made, rather than the smaller ancillary assumptions that are made?

6. This is NOT an error analysis question but rather a confirmation as to how in spite of varied measurements, specific heat capacity can remain constant and thus 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?

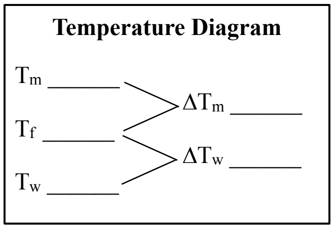
      What measurement(s) and subsequent calculation(s) would have been different than the original "ideal" trial? Show ↑ and ↓ arrows on the diagram and formula to the right to indicate higher or lower adjustments which would have compensated to allow the specific heat capacity of the metal to remain constant?



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

   b. You were never told exactly how much water should be in the foam calorimeter. Does it matter how much cool water was used?

      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 compensated to allow the specific heat capacity of the metal to remain constant?



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

This data table to be turned in with the lab. (pg 4 of 4)

	Al cube	Al cyliner	Cu cube	Cu cylinder	Zn cylinder	Sn cylinder	Pb cylinder
Experimental specific heat capacity, c_{metal}							
Theoretical specific heat capacity, c_{metal}							
Percent Error							

Clearly and carefully below, present the formulas used, show a literal solve, then demonstrate ONE set of data substituted and solved for result. In your table above, indicate by highlighting which set of data is shown below.

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