LAB 4 SPECIFIC HEAT CAPACITY by R.E. Tremblay

Purpose: To determine the specific heat capacity(c) of several metals.

Materials: Platform balance, calorimeter, thermometer, room temperature water and hot metal blocks (Al, lead, brass, steel).

Discussion: Heat is a measure of the amount of thermal energy that is transferred from an object of higher temperature to one of lower temperature. When you heat a pan of water on the stove, you may have noticed that the more water that you have in the pan, the longer it takes to raise its temperature to the boiling point. The amount of heat needed to raise the temperature of a substance depends on its mass, on the temperature change and a property known as its *specific heat capacity* of the substance.
Liquid water has a specific heat capacity of 1.00 cal/g°C. Most substances have a specific heat capacity of less than 1.00 cal/g°C . If you have two substances of the same mass, the one with the higher specific heat capacity will require more heat in order to change its temperature by the same amount.

The equation that shows the relationship between heat, mass, specific heat capacity and temperature change is: $Q = mc\Delta T$ eq. 1

We will measure the amount of heat 'Q', in calories, the mass 'm' in grams, the specific heat capacity 'c' in cal/g°C and the change in temperature Δt will be in °C.

If we have a perfectly insulated system, energy is conserved during warming, cooling or change of state, we can always write that HEAT GAINED by cooler objects = HEAT LOST by warmer objects.

Heat lost = Heat Gained ***Conservation of energy statement***

In this lab:
Heat lost by block = Heat gained by water + Heat gained by the inner cup and stirrer.

Therefore:

$$mc\Delta t_{block} = mc\Delta t_{water} + mc\Delta t_{cupandstirrer} \quad \text{eq.2}$$

Solving the above equation for the specific heat capacity of the metal block we get our working equation:

$$C_{block} = \frac{mc\Delta T_{water} + mc\Delta T_{cup+stirrer}}{m\Delta T_{block}} \quad \text{eq. 3}$$

Please view the Specific Heat Capacity before continuing in this lab.

LAB 4 Preparation. Name_____

1. Write equation 1.

2. In equation 1, what do the following letters represent?

   Q _____

   m _____

   c _____

   ΔT _____

3. Solve equation 2 for the specific heat capacity of the block

4. What units are used for the specific heat capacity of a substance?

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PART A-Determination of specific heat capacities of some common metals.
Procedure:

(1) Determine the mass of your calorimeter cup and stirrer and record it on the data sheet.

(2) Add water to the calorimeter cup until it is about 3/4 full. Determine and record the mass of the water in the calorimeter. Let it sit for one minute and then record its temperature. In order to minimize heat lost to the room, I recommend that you ***always start with new water*** for each trial.

(3) Take your calorimeter to the container of boiling water and hot metal blocks. The temperature of the boiling water is the initial temperature of your metal block. Your lab instructor will transfer a hot metal block to your calorimeter. Any heat lost by the hot object to the room during this transfer will increase the amount of error in your answer.
CAUTION !!! Be careful! There is a flame beneath the boiling water and you will hate it if your hair catches on fire.

(4) Stir the water in your container, until its temperature stops rising. Record the temperature of the water and the block(they are the same temperature) in your data sheet.

(5) Remove your block for the calorimeter cup, dry it off and determine its mass.

(6) On your calculations sheet write the conservation of energy statement, heat lost= heat gained. Write eq. 2 and solve for the specific heat capacity 'c' of the metal block, as in eq.3. Repeat this for each of your masses.

Note: the specific heat capacity of the aluminum cup = 0.215 cal/g°C and the specific heat capacity of water is $1\frac{\text{calorie}}{g^{\circ}C}$

Also: the water, cup and stirrer will all have the same change in temperature.

(7) Go back to step 2 until you have used 4 different metals.

(8) Determine the specific heat capacity of the metal blocks and calculate your percent error using the following values:

$c_{aluminum}$= 0.215 cal/g ˚C; c_{lead}= 0.0305 cal/g ˚C
c_{brass}= 0.0917 cal/g ˚C; c_{steel}= 0.113 cal/g ˚C

Part B-Heat of fusion of water-**optional(2pts)-I will not help, but I have posted a Latent Heat lesson, that may help you.**

$Q = H_f \bullet m$ where H_f is the heat of fusion, 'm' is mass and 'Q' of course is heat.

Procedure:

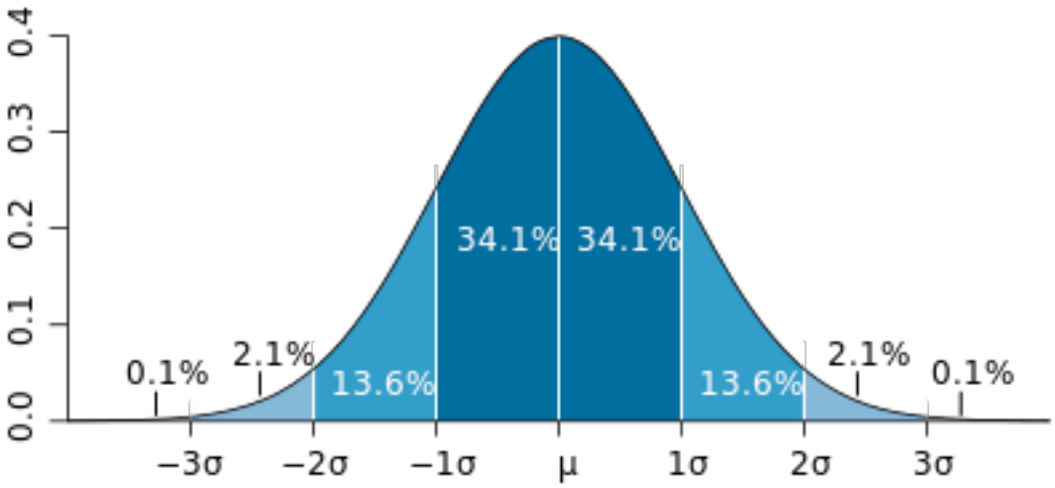
(1) Determine the temperature and mass of the water in your calorimeter.

(2) Add some ice, stir until melted and record the temperature and mass of the final mixture.

(3) Using the concept of heat lost by the water equals heat gained by the melting ice, and heat gained by the warming of the ice water, calculate the heat of fusion of the ice. The lab instructor will not help you on this part.

Standard Deviation: Standard deviation tells us how closely collected or measured data agrees with the average value. The Greek letter sigma, σ is often used to represent standard deviation. An inspection of the fig. below reveals that 68.2% of the sampled data are contained within one standard deviation of the mean.

Fig. from Wikipedia



Standard deviation is the square root of the variance. $\sigma \equiv \sqrt{Varience}$

To calculate the variance:

a. Calculate the mean by getting the average of all values.
b. Subtract the mean from each of the other valuses and square the result.
c. Calculate the average of the results from step b.

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Phy 111 Lab 4 **Name_____/section_____**
DATA SHEET **PART A**

Mass of cup and stirrer _____

Metal	water mass	initial water temp.	initial metal temp.	final water and metal temp.	ΔT water	ΔT metal	metal mass	Specific Heat Capacity (C)	% error
Brass									
Alum.									
Steel									
Lead									

Summary of class data:(Optional)

Group name												mean	SD
Brass													
Al.													
Steel													
Lead													

PART B-HEAT OF FUSION OF WATER-(Optional -2pts. EC possible)

Mass of water	Initial water temp.	Initial ice temp.	Final temp. of water and ice	Final mass of water and ice	Mass of ice	Heat of fusion

Diagrams and calculations: Add more pages as needed.

Sample data. Unless the lab is cancelled, we will not use this information.

Metal	water mass (grams)	initial water temp. (˚C˚)	initial metal temp. (˚C˚)	final water and metal temp. (˚C˚)	ΔT wate (˚C˚)	ΔT metal (˚C˚)	metal mass (grams)	Specific Heat Capacity (Cal/g˚C)	% error
Brass	208.2	22	100	30	8	70	274.6		
Alum.	215.2	22	100	28	6	72	87.2		
Steel	214.2	22	100	31	9	69	251.8		
Lead	215.5	22	100	26	4	74	349		

Summary of class data:(Optional)

Specific Heat Capacity (Cal/g˚C)

Group name						mean	SD
Brass	0.091	0.097	0.087	0.101	0.108		
Al.	0.125	0.201	0.255	0.194	0.239		
Steel	0.116	0.120	0.110	0.113	0.121		
Lead	0.035	0.040	0.028	0.0308	0.101		