Calorimetry Review Worksheets

Additional Review: These concepts and the attached lab were covered in the Gr 10 Chemistry Class. Review the procedure and answer all of the worksheet, pre-lab and post lab questions. These concepts are essential for the Heating Project. Use additional after-school tutoring periods if needed.

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$$q = mCp\Delta T$$

Where: q = total heat flow, m = mass, Cp = specific heat, & ΔT = change in temp.

Example:

Calculate the number of joules required to warm 1.00×10^2 grams of water from 25.0^oC to 80.0^oC.

Heat energy = mass x specific heat x change in temperature

= $(1.00 \times 10^2 g)$ (4.184J/g ^oC) (80.0 - 25.0) ^oC = 23,012 J = $2.30 \times 10^4 J$

Example:

Calculate the number of joules released when 72.5 grams of water at 95.0^oC cools to 28.0^oC.

Heat energy = mass x specific heat x change in temperature

= (72.5g) (4.184J/g ^oC) (95.0 - 28.0) ^oC = 20323.78J = 2.03×10^4

Problems:

Solve the following problems on a separate sheet of paper. You must use the set-up illustrated above. Be sure to include units and show how the units cancel out. All final answers should be boxed.

1. How many joules are needed to warm 25.5 grams of water from 14.0^oC to 22.5^oC?

2. Calculate the number of joules released when 75.0 grams of water are cooled from 100.0^oC to 27.5^oC.

3. Calculate the heat, in joules, needed to warm 225 grams of water from 88.0^oC to its boiling point, 100.0^oC.

4. The specific heat of gold is 0.128 J/gC^o. How much heat would be needed to warm 250.0 grams of gold from 25.0^oC to 100.0^oC?

5. The specific heat of zinc is 0.386 J/gC^o. How many joules would be released when 454 grams of zinc at 96.0^oC were cooled to 28.0^oC?

Specific Heat

Many times Calorimetry problems involve solving for one of the other quantities such as specific heat of temperature change. This is done by simply using algebra to rearrange the formula $q = mC\Delta T$.

Example:

Calculate the specific heat of gold if it required 48.0 joules of heat to warm 25.0 grams of gold from 40.0ºC to 55.0ºC.

$C = q / m\Delta T$ = 48.0 J / (25.0 g (55.0 - 40.0)ºC) = 48.0 J / (25.0 g)(15.0 ºC) = 0.128 J/g ºC

Example:

What would be the final temperature if 8.94×10^3 joules of heat were added to 454 grams of copper, specific heat 0.386 J/gºC, at 23.0ºC?

ΔT = q/mºC = 8.94×10^3 J/[454 g (0.386 J/gº C)]

= 5.101×10^1 ºC = 51.0ºC

$T_f = T_i + \Delta T$ = 23.0º + 51.0º = 74.0ºC

Problems:

Solve the following problems on a separate sheet of paper. You must use the set-up illustrated above. Be sure to include units and show how the units cancel out. All final answers should be boxed.

1. What would be the final temperature if 3.31×10^3 joules were added to 18.5 grams of water at 22.0ºC?

2. A sample of lead, specific heat 0.138J/gCº, released 1.20×10^3J when it cooled from 93.0ºC to 29.5ºC. What was the mass of this sample of lead?

3. Calculate the specific heat of platinum if 1092 joules of heat were released when 125 grams of platinum cooled 65.2 Celsius degrees.

I. Heating Curve Lab

This lab was done in the Gr 10 Chemistry Class. As a review answer all of the pre-lab and post lab questions that do not require experimental data. The review will provide a solid foundation for the project calculations.

Note to Engineering Class: Use 150 g of water in the calorimeter for the review calculations

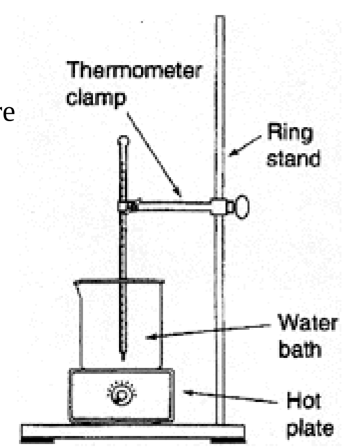
Purpose: Analyze the heating and cooling patterns of water.

Caution: The beaker, water and hot plate will be hot for an extended time after the experiment is done. Do not touch with your hands. The instructor must give permission before you remove the beaker from the hot plate.

Materials: Thermometer, clamp, ring stand, hot plate, 250 mL beaker, ice, boiling chip, stirring rod or magnetic stirring bar.

Procedure:

1. Weigh a dry 250 mL beaker. Fill the beaker approximately ¾ full of ice. Add approximately ½ inch of water.
2. Determine the mass of the ice/water mixture by difference.
3. Place the beaker on the hot plate and turn it to high. Record the temperature every 30 seconds.
4. Stir the ice water system
5. Continue recording data until the water has been boiling for 3 minutes
6. Record your observations every time that you make a reading.
7. When your instructor gives permission, clean your equipment.



Data Analysis:

Make a line graph of the time/temperature data. Time should be on the x axis and temperature on the y axis. Label all axes and show the units. Include a title for the graph.

Label the melting point, boiling point, and indicate the phases of water in each of the transition regions.

Calculations: Show all calculations with units and correct significant figures.

Use the following data

Specific heat capacity (C_p) of water	4.18J/g^{0}C
Heat of fusion of water (ΔH_{fus})	334 J/g
Heat of vaporization for water (ΔH_{vap})	2250 J/g
Heat change during temperature rise	$Q = mC_p\Delta t$ m = mass, $\Delta T = T_2 - T_1$
Heat change for phase change—melting	$Q = m\Delta H_{fus}$ ΔH_{fus} = heat of fusion

Heat change for phase change—boiling	$Q = mH_{vap}$ ΔH_{vap} = heat of fusion

1. Assuming that you started with ice/water at 0ºC, calculate the amount of heat needed to melt the ice completely to water?

2. After all of the ice melted, how much heat was needed to heat the water from 0ºC to 100 ºC?

3. How much heat would be needed to heat the water into steam?

4. Calculate the % error for your boiling point and melting point experimental measurements.

Post Lab Questions:

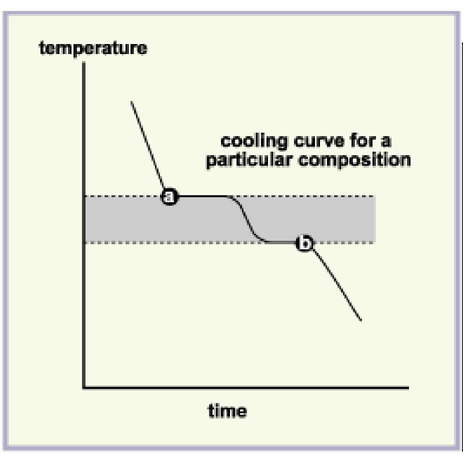
1. Why is heat required for a phase change calculated differently from heat required to raise the temperature of a substance?

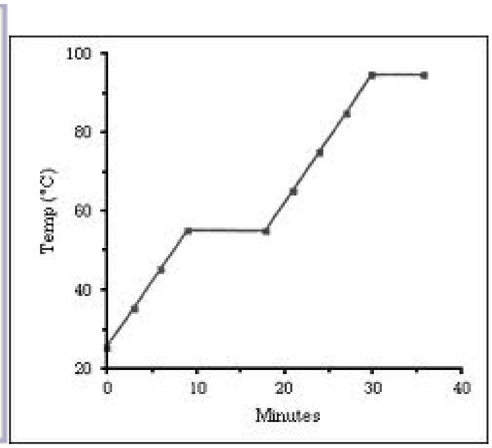
2. What did you observe about the temperature during the phase changes. How can you explain this? What is happening on a molecular level.

3. Where is the energy from the hot plate going during the boiling phase?

4. What are the differences and similarities between the two curves below? Be as specific as possible

5. Label the phases for the cooling curve shown below. Clearly mark in your report, the physical significance of points a and b as well as the phases (gas only, gas/liquid, liquid only , solid/liquid or solid only) in the each of the 5 regions of transition.





II Heat of Solution of a Solid

Background: When a solid dissolves in water to form a solution, energy changes occur. In this experiment, you will determine the heat absorbed or released for two substances.

Prelab:
Prepare a data table for the two experiments: Be sure to include units.

Data: mass of cup with water, mass of empty cup, mass of water, mass of solid used, initial water temperature, final water temperature

Materials:

Styrofoam cup
Thermometer
Balance
Stirring rod
Graduated cylinder
Ammonium nitrate
LiCl

Procedure:

1. Accurately find the mass of about 60 mL of tap water. It is best to use water that is near room temperature. Record this value in your data table.
2. Determine the mass of 15 g of solid ammonium sulfate.
3. Record the initial temperature of the water.
4. Dissolve the solid ammonium nitrate in the water stirring or gently agitating. Record the temperature change at 30 second intervals. Continue until the temperature does not increase. Record the maximum temperature difference from the initial reading.
5. Rinse the cup, and repeat the experiment using a sample of 15 g of LiCl.

Calculations:

The total heat of solution can be calculated by determining the amount of heat absorbed or lost by the water during the experiment. The is calculated by the formula:

(1) Q	=	m	x	C_p	x	ΔT
Total heat gained or lost) (joules)		mass of water (g)		specific heat of water J/g^{o}C		temperature change ^{o}C

The Cp of water is 4.18 (J/g^{o}C)

The Total heat of solution tells how much heat was gained or lost in the actual experiment with the mass of water and salt actually used.

Molar heat of solution expresses how much energy would be gained or lost for one mole of the substance. The molar heat of solution, expressed in kJ/mole is determined by converting the mass of the solute used to moles.

(2) Molar heat of solution = total heat solution in the experiment / moles of solute used in the experiment.

Complete the calculations using the table below:

Salt Dissolved		
Total Mass of water used		
Maximum change in temperature		
Specific heat of water	4.18 J/g°C	4.18 J/g°C
Energy (J) absorbed or lost by water $Q = mCp\Delta T$ (eqn 1)		
Energy absorbed/lost by solute(J) (same value, but opposite sign as in the above calculation)		
Convert energy from J to kJ (Divide by 1000)		
Molar mass of solute		
Moles of solute actually used		
Molar heat of solution (eqn 2)		

Post Lab Questions

1. Write balanced equations for the dissociation of each ionic compound. Include the physical states (s,l,g, aq) and indicate whether energy was absorbed or released during the dissolution.

2. Calculate the % error to measure the accuracy of the experimental work.
% Error = (observed- accepted)/accepted x 100%
The accepted values for ammonium nitrate + 25.8 kJ/mole

3. What are the most likely sources of error in your experimental work? Be specific.