CHEMISTRY

Lab Manual and Worksheet

Vu Thi Ngoc minh

Hanoi, 2020

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This Chemistry Lab Manual and Worksheet was written for students of the HUST-TROY international program in March 2020, when online classes were activated due to the Covid-19 pandemic.

The experiments were designed based on the Virtual Lab software, a product of the Chemistry Collective project organized by a group of faculty and staff at Carnegie Mellon University and their colleagues overseas.

A student can use this lab manual to get familiar with the instrument and experimental procedure before going to the lab.

Vu Thi Ngoc Minh

March 31th, 2020

Name: ______________________

^{16}S AFETY RULES IN THE ^{12}C HEMISTRY LAB

The exercises done in this lab class pose little or no safety hazard. You must use common sense and always keep safety in mind while working. The precautions outlined below will make the lab safer for everyone.

General Safety Guidelines

1. Reading experiment write-ups in advance allows you to work more efficiently, manage your time wisely and be aware of safety precautions. Ask your instructor for clarifications before you begin the experiment.
2. Follow directions specified in the lab manual. Carefully listen to additional information from your instructor. Do not perform any unauthorized experiments and do not deviate from the procedure.
3. Come to class in the correct lab attire – long pants and closed-toed shoes. Do not wear loose sleeves (e.g. bell- or kimono-style) that can tip over glassware/equipment. Long hair must be tied back to avoid it falling into chemicals or flames.
4. Always wear eye protection inside the lab. Even when you are just taking notes after you finish the experiment, you are still exposed to safety hazards when people around you are working. Prescription eyeglasses and contact lenses can be worn in the lab, but safety goggles must still be used.
5. Do not eat, chew gum, drink, smoke or apply cosmetics in the lab. Food and drinks should never be on your work area and should be tucked away.
6. Horseplay, practical jokes and pranks are strictly prohibited in the lab.
7. Always be aware of safety as you perform lab techniques such as in manipulating glassware, handling chemicals, working in your limited bench space and in common areas.
8. Learn proper emergency procedures and what safety equipment are available. The lab is equipped with first aid kit, fire extinguisher, fire blanket, emergency drench hose, eyewash station and emergency shower. In case of emergency, call 911.
9. Keep in mind that you share the lab with students in your class and other classes. Keep your benches and the common areas clean. Take care of your own spills and messes. Properly dispose your wastes. Glassware taken from shelves must be returned to the shelves washed. Your work area and all equipment and materials on it must be clean and ready for the next student.

Lab Safety

1. Upon entering the lab, bags and books should be tucked under your desks, so that the aisles are clear. No food and drinks on the benches. Phones must be tucked away and may only be used in case of emergency.
2. Set-up your workspace so that it is safe, secure and efficient. It should be clear of any unneeded materials. Bunsen burner tubings and electrical cords should be placed so they cannot be snagged accidentally.
3. Inspect glassware before use. Glassware that is sharp-edged, broken, chipped or badly scratched should not be used and must be returned to your instructor or disposed of in the designated container for broken glassware. If you break glassware, do not pick up the pieces with your hands, use broom and dustpan. Dispose in the broken glassware box.

4. Wait for glassware or apparatus that has been heated to cool before handling. Use appropriate equipment like test tube holder and beaker and crucible tongs.
5. Be cautious around Bunsen burners as their flames can be nearly invisible.
6. Close the bench gas valve when the Bunsen burner is not in use.
7. Read chemical container labels carefully. Using the wrong reagent may ruin your experiment and may result to a dangerous reaction. Follow the amounts specified on the procedure.
8. Do not taste chemicals.
9. Avoid inhaling vapors from chemicals, unless you are asked to detect odor. Do not sniff on the chemical or container. Fan vapor gently toward your nose from the neck of the chemical container.
10. Some reactions need to be carried out in the lab fume hoods. Vapors must be released at least six inches inside the hood. Close the hood as far as you can while your arms and hands work inside the hood. Avoid rapid movements. Never put your face and head in the hood.
11. Dispose of chemical wastes in the appropriate containers provided in the front hood.
12. Wash your hands if you inadvertently touch chemicals. Wash your hands before you leave the lab.

Chemical and Fire Emergency Procedures

1. Report accidents, injuries and contact with chemicals to your instructor.
2. In case of burns, cool the affected area with cold running water for several minutes. Repeat if necessary. Notify your instructor.
3. If chemicals splash in your eyes, flush your eyes thoroughly for at least 15 minutes in the eyewash station; keep your eyes open while flushing or ask someone to pull your eyelids back. For contact lens users, begin eye irrigation immediately and remove contact lens as soon as practical.
4. If chemical splashes on your skin, wash off with cold water for at least 15 minutes. Use an appropriate water source, such as faucet, drench hose or safety shower.
5. If chemicals are splashed onto clothing, remove clothing.
6. If chemicals spill on the bench or floor, notify your instructor and everyone nearby. Neutralize acid with sodium bicarbonate and base with dilute acetic acid, then remove residue and wipe dry.
7. In case of fire, evacuate the area. If it will not pose danger to yourself, try to confine the fire. Close the sash if the fire is in the hood. Close the doors to the lab. Call 911 even if the fire is extinguished.
8. If your clothing catches fire, do not run. Stop, drop and roll. If someone else's clothing catches fire, stop him/her from running and help him/her drop and roll. Call for medical help ASAP. Cool burns with cold running water.

Please sign and submit to your instructor.

Student's name: ______________________________

I have read, understand, and agree to comply with the Chemistry lab safety rules.

Signed: ______________________________ Date: ________________

Measurement: Identification of Unknown Liquids by Measuring Their Densities

INTRODUCTION

Measurement is the assignment of a number to a characteristic of an object or event which can be compared with other objects or events. In this experiment, you will work with two liquids and measure their densities. Liquid density is calculated by the following equation:

$$D = \frac{m}{V}$$

Where D is the density, m is the weight of the liquid, and V is the volume of the liquid.

OBJECTIVES

This experiment aims to identify two liquids by their density.

CONCEPTS

This experiment uses the concepts of weight, volume, and density.

TECHNIQUES

Correct use of scales and volumetric flasks are some of the techniques encountered in the experiment.

PROBLEM DESCRIPTION

Two research groups worked independently on two new compounds, a food preservative, and a neurotoxin. They all named their products "Compound A." An intern reorganized the chemical storage stockroom and placed all the bottles labeled "Compound A" on the same shelf.

You would like to begin testing the new food preservative but do not know which bottle contains the food preservative and which bottle contains the neurotoxin. It would clearly not be a good idea to put neurotoxin into your food products. You have asked a theoretical chemist what to do, and he said that the preservative would have a higher density.[1]

You will need to perform an experiment to determine which bottle of Compound A contains the food preservative.

[1] The problem description was copied from the Virtual Lab module written by Prof. Sophia Nussbaum, University of British Columbia, 2003. All else was written by the author of this book..

PROCEDURE

1. Bring three flasks containing Compound A-1 from the stockroom to the workbench.
2. Bring three 100-mL volumetric flasks that are labeled as A-1-1, A-1-2, and A-1-3 to the scale (balance) place
3. Press the zero button
4. Put a volumetric flask A-1-1 on the scale, record the weight g_d (g) =
5. Remove the weighed flask.
6. Pour the liquid in the flask containing Compound A-1 to the weighed flask until the bottom of the meniscus touches the calibration mark.
7. Put the volumetric flask on the scale (balance) and record the obtained value (in grams), record the weight as g_c (g) =
8. Repeat steps 2 to 6 with the remaining flasks.
9. Do the same experiment to Compound A-2 with three volumetric flasks labeled A-2-1, A-2- 2, and A-2-3.
10. Calculate liquid density for each trial.
11. Take the average of the data obtained from three trials.
12. Ask the tutor for approve the data
13. Clean the workbench before leaving

Pre-lab Discussion

1. Why are measurements important in every aspect of life?

2. What is the difference between accuracy and precision? Please give two examples to clarify your point.

3. Why is the last digit in a measurement called the uncertain digit?

Name (PRINT) ________________ Date (of Lab Meeting) ________________ Instructor ________________

Course/Section ________________ Partners' name (if appropriate) ________________

Report Form

TITLE OF EXPERIMENT:____

____

RESULTS

Table 1. Data obtained for Compound A-1

Trial	Label of the flask	Volume (mL)	Weight (g)	Density (g/mL)
1				
2				
3				
			Average	

Table 2. Data obtained for Compound A-2

Trial	Label of the flask	Volume (mL)	Weight (g)	Density (g/mL)
1				
2				
3				
			Average	

ANALYSIS

1. Which compound might be the new food preservative? Why?

2. Why might you obtain different data in three trials?

CONCLUSION

Date:________________ **Student's Signature:**________________

Thermochemistry: Preparation of a Milk Coffee Solution with the Required Temperature

INTRODUCTION

Thermochemistry is the study of the thermal energy associated with chemical and physical changes of substances. It discusses heat, heat capacity, specific heat capacity, and the heat of chemical and physical changes.

The amount of heat that a substance gains or releases to the surrounding is calculated by the following equation, where m is the mass of the substance, ΔT is the temperature change, and C is the specific heat capacity of the substance:

$$\text{Heat} = m \times \Delta T \times C$$

In this experiment, you will work with two liquids of different temperatures. You will calculate the amount of one liquid needed to add to a predetermined amount of another liquid to reach the desired temperature and carry out an experiment to confirm your calculation.

OBJECTIVES

This experiment aims to create a solution of coffee with a desired temperature.

CONCEPTS

This experiment uses the concepts of heat capacity, heat exchange, density, and insulation.

TECHNIQUES

Correct use of graduated cylinders and thermometers are some of the techniques encountered in the experiment.

PROBLEM DESCRIPTION

During the summer after you finish your first undergraduate year, you are lucky enough to get a job making coffee at Starbuck on campus. An eccentric chemistry professor stops every day and orders 250 mL of hot coffee at precisely 95 degrees Celsius. He then adds enough milk at 4 degrees Celsius to drop the temperature of the coffee to 90 degrees Celsius.

a) Calculate the amount of milk (in mL) the professor must add to reach this temperature. Show all your work and circle the answer.
b) Use the Virtual Lab to make the milk-coffee solution and verify the answer you calculated in a).

Assume that coffee and milk have the same specific heat capacity 4.186 J/g C, and that they also have the same density 1 g/mL.
You will need to perform an experiment to create a solution of coffee with a desired temperature.

PROCEDURE

In a real experiment coffee and milk are replaced by hot water and cold water. The procedure as following:

1. Pour about 200 mL water into a 500-mL beak, and heat it to 60-70°C using an electrical hearter.

2. Pour 150 mL of cold water from the original containers a 250-mL graduated cylinder into a calorimeter (an insulate the beaker) and a beaker separately and measure the temperature of the cold water using a thermometer. Record the temperature as t_d (cold) =

3. Take 50 mL hot water using a 50-mL graduated cylinder, and measure the temperature of the hot water using a thermometer. Record the temperature as t_d (hot) =

4. Transfer the hot water to the two beakers that contain cold water.
5. Record the temperature of liquid in the beaker every 15 second until the temperature does not change.

Pre-lab Discussion

1. What will happen if you do not insulate a hot or cold substance?

2. Calculate the amount of milk at 4 °C (in mL) must be added to 250 mL of coffee at 95 °C to reach 90°C. Show all your work and circle the answer.

Name (PRINT) | Date (of Lab Meeting) | Instructor

Course/Section | Partners' name (if appropriate)

Report Form

TITLE OF EXPERIMENT:______________________________________

RESULTS

the temperature of the lab: t =

Non-insulated coffee and milk		**Insulated coffee and milk (calorimeter)**	
t_d (cold) = **t_d (hot) =**		**t_d (cold) =** **t_d (hot) =**	
Time (s)	**t**	**Time (s)**	**t**
15		15	
30		30	
45		45	
60		60	
90		90	
120		120	

ANALYSIS

1. Why were the temperatures of the non-insulated coffee and milk change over time?

2. Did the calculated results and the experimental data match? Why?

Concentration: Classification of Alcoholic Beverages by Measuring Their Densities

INTRODUCTION

The concentration of a solution is the quantity of a solute in a particular quantity of solvent or solution. Knowing the concentration of solutes is important in controlling the stoichiometry of reactants for solution reactions. It is also important in dosage calculation in medical practice.

There are different ways to express the relative amounts of solute and solvent in a solution, including percent composition (by mass or by volume), molarity, molality, and mole fraction.

Percent composition by mass, so-called mass fraction, is calculated by the following equation:

$$Percent\ by\ mass = \frac{mass\ of\ solute}{mass\ of\ solution} \times 100$$

Percent composition by volume is calculated by the following equation:

$$Percent\ by\ volume = \frac{volume\ of\ solute}{volume\ of\ solution} \times 100$$

Molarity is calculated by the following equation:

$$Molarity = \frac{moles\ of\ solute}{volume\ of\ solution\ in\ liters}$$

Molality is calculated by the following equation:

$$Molality = \frac{moles\ of\ solute}{mass\ of\ solvent\ in\ kilograms}$$

The mole fraction of A, X_A, in a solution consisting of A, B, C, ... is calculated using the equation:

$$X_A = \frac{moles\ of\ A}{moles\ of\ A + moles\ of\ B + moles\ of\ C + \cdots}$$

In many cases, the density of solutions relates to their solute concentration. Hence, measuring the density of a solution is sometimes a quick and low-cost method to approximate its solute concentration.

OBJECTIVES

This experiment aims to determine the concentration of two alcohol solutions by their density.

CONCEPTS

This experiment uses the concepts of volume percent concentration, molarity, and density.

TECHNIQUES

Correct use of scales, volumetric flasks, and graduated cylinders are some of the techniques encountered in the experiment.

PROBLEM DESCRIPTION

A traditional way of determining the concentration of alcohol in alcoholic beverages is by measuring the density of the solution since these two characteristics of the solution (density and percent alcohol) are related. This is a convenient determination method because it is low cost and can be done quickly. This is why customs officials sometimes use density measurements to classify alcoholic beverages and spirits. In the stockroom, you will find a variety of solutions, including two alcoholic beverages. You will need to perform an experiment to classify the two alcoholic beverages into one of the following five categories of alcohol strength defined by Canadian importation laws:[3]

1. Less than 0.5 vol.%
2. 0.5 – 1.2 vol.%
3. 1.2 – 7.0 vol. %
4. 7.0 – 22.9 vol. %
5. More than 22.9 vol. %

PROCEDURE

1. Load the experiment *Alcohol Density Problem* from *Molarity and Density* in the *Virtual Lab.*
2. Use four 100-mL volumetric flasks and a scale to measure the density of distilled water, Alcoholic Beverage A, Alcoholic Beverage B, 1M alcohol, and alcohol 70%. Be sure to label the containers appropriately. Note that the weight of the volumetric flasks might be different.
3. Prepare seven water-alcohol solutions as suggested in the following table. Note that more than one workbench might be needed.

Table 1. Alcohol-water solution preparation

Beaker label	20/100	40/100	60/100	80/100	100/100	120/100	140/100
Alcohol 70% (mL)	20	40	60	80	100	120	140
Water (mL)	100	100	100	100	100	100	100

4. Measure the density of each solution using a volumetric flasks and a scale.
5. Use a MS Excel worksheet to build a graph of density versus concentration.
6. Add a trendline on the graph, and be sure that you obtain a slope value of at least 4 significant figures.
7. Use the trendline equation to calculate the concentrations of the 1M Alcohol, Alcoholic Beverage A and Alcoholic Beverage B.
8. Right-click on the workbench and select *Clear Workbench.*

[3] The problem description was copied from the Virtual Lab module written by Mr. Tim Palucka and Dr. Jordi Cuadros, Instituto Químico de Sarriá, 2011. All else was written by the author of this book.

Pre-lab Discussion

1. Which formula will you use to calculate the volume concentration of the prepared solutions?

2. Present the data that you have calculated in the following table:

Table 2. Volume percent concentration of the prepared solutions

Beaker label	**20/100**	**40/100**	**60/100**	**80/100**	**100/100**	**120/100**	**140/100**
Alcohol 70% (mL)	20	40	60	80	100	120	140
Water (mL)	100	100	100	100	100	100	100
Alcohol concentration (vol.%)							

Name (PRINT) *Date (of Lab Meeting)* *Instructor*

Course/Section *Partners' name (if appropriate)*

Report Form

TITLE OF EXPERIMENT:____

RESULTS

Table 3. The density dependence of the alcohol solution on the concentration

Concentration (vol.%)	0							70
Density (g/mL)								

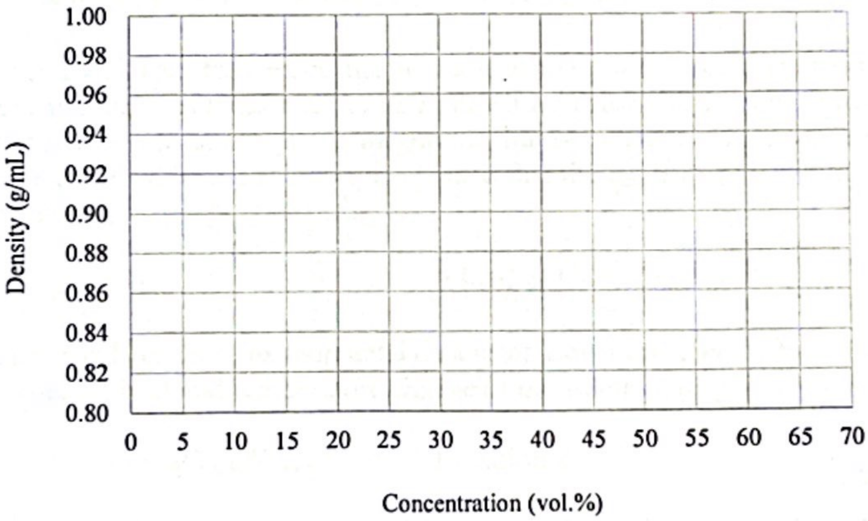

Figure 1. The density dependence of the alcohol solution on the concentration

ANALYSIS

1. How are densities and concentrations of the prepared alcohol solutions dependent on each other?

2. What are the volume percent concentrations of the 1M Alcohol, Alcoholic Beverage A and Alcoholic Beverage B?

3. What categories of alcohol strength do the 1M Alcohol, Alcoholic Beverage A and Alcoholic Beverage B belong to?

CONCLUSION

Date:__________________________ **Student's Signature:**__________________________________

Experiment 11 Name: ______________________

THER 42 Mo CHEMISTRY: HEAT OF 10 Ne UTRALIZATION

In this experiment, you will use calorimetry to experimentally determine the heat of neutralization of NaOH-HCl, or the enthalpy of the acid-base reaction between NaOH and HCl. The calorimeter is a thermos container equipped by a thermometer to monitor temperature and magnetic stirrer to ensure the contents are at uniform temperature. The thermos is assumed to be a perfect insulator such that no heat comes in or out of it. When a reaction is allowed to occur in it, the amount of heat absorbed or released by the reaction can be determined by monitoring the temperature change. If the reaction releases heat (exothermic), the solution in the thermos absorbs the heat released, thus showing a temperature increase. On the other hand, the reaction may absorb heat (endothermic) from the solution, which in turn shows a temperature decrease.

When aqueous solutions of NaOH and are mixed in the calorimeter, the chemical equation for the reaction that occurs is:

$$NaOH\ (aq) + HCl\ (aq) \rightarrow H_2O\ (l) + NaCl\ (aq)$$

Assuming NaOH and HCl fully react, the solution in the calorimeter is composed of salt and water. Because the thermos is assumed to be a perfect insulator, the amount of heat absorbed or released by the reaction (q_{rxn}) is equal in magnitude, but opposite in direction, to the amount of heat released or absorbed by the solution (q_{soln}), such that the q_{rxn} is just the negative of the q_{soln} as shown in Equation 1.

$$q_{rxn} = -q_{soln} \qquad \text{Equation 1}$$

The q_{soln} can be calculated from experimental data using Equation 2, where m_{soln}, $C_{s,soln}$, and ΔT_{soln} are the mass, specific heat and temperature change of the solution, respectively:

$$q_{soln} = m_{soln} C_{s,soln} \Delta T_{soln} \qquad \text{Equation 2}$$

As an example, let us calculate the enthalpy of the reaction below in kJ per mole of AgCl produced.

$$1\ AgNO_3\ (aq) + 1\ HCl\ (aq) \rightarrow 1\ AgCl\ (s) + 1\ HNO_3\ (aq)$$

In a calorimetry experiment, when 25.0 mL of 0.100 M $AgNO_3$ and 25.0 mL of 0.100 M HCl are mixed in a thermos container, an increase in temperature from 23.42 °C to 24.27 °C.

Since the solution warmed up, this means that the reaction released heat, and is thus exothermic. The q_{soln} is calculated from Equation 2, and q_{rxn} is the negative of q_{soln} by Equation 1. First, we will assume that volume is additive and that the density of the solution is the same as that of water at 1.00 g/mL, allowing us to calculate the m_{soln}. The $C_{s,soln}$ is also assumed to be the same as that of water which is 4.184 J/g·°C.

V_{soln} = 25.0 mL $AgNO_3$ soln + 25.0 mL HCl soln = 50.0 mL solution
m_{soln} = 50.0 mL (1.00 g/mL) = 50.0 g

q_{soln} = (50.0 g)(4.184 J/g·°C)(24.27 °C - 23.42 °C) = 178J
q_{rxn} = -178 J

The reaction released 178 J of heat. However, we need to calculate the heat of reaction in kJ per mole of AgCl produced. For the reaction that released 178 J of heat, the number of moles of $AgNO_3$ and HCl that reacted are calculated from the molarities and volumes of the solutions before they were mixed:

moles $AgNO_3$ = (0.100 M)(0.0250 L) = 2.50×10^{-3} moles $AgNO_3$
moles HCl = (0.100 M)(0.0250 L) = 2.50×10^{-3} moles HCl

Using the moles and molar relationships from the balanced chemical equation, the number of moles of AgCl can be calculated. But first, you must check if there is a limiting reagent in the reaction.

$$2.50 \times 10^{-3}\text{moles AgNO}_3 \cdot \left(\frac{1\ mol\ HCl}{1\ mol\ AgNO_3}\right) = 2.50 \times 10^{-3}\text{moles HCl}$$

This is equal to the amount of HCl used; therefore, there is no limiting reagent. This means that the number of moles of either $AgNO_3$ or HCl can be used to calculate the number of moles of AgCl.

$$2.50 \times 10^{-3}\text{moles AgNO}_3 \left(\frac{1\ mol\ AgCl}{1\ mol\ AgNO_3}\right) = 2.50 \times 10^{-3}\text{moles AgCl}$$

When 2.5 $\times 10^{-3}$ moles of both $AgNO_3$ and HCl react, 178 J of heat is released, which must be converted to kJ to calculate ΔH in kJ.

$$-178\text{ J}\left(\frac{1\ kJ}{1000\ J}\right) = -0.178\text{ kJ}$$

The enthalpy of reaction in terms of kJ per mole of AgCl produced can then be calculated as:

$$\Delta H = \frac{-0.178\text{ kJ}}{2.50 \times 10^{-3}\text{ mol AgCl}} = -71.2\ \frac{\text{kJ}}{\text{mol AgCl}}$$

PROCEDURE

1. Dry the thermos and the thermometer with a paper towel. Using a dry, clean graduated cylinder, measure 50.0 mL of 1.0 M NaOH and pour it in the thermos. Put a dry, clean magnetic stirring bar into the thermos and put the thermos on top of a stirring plate.

> CAUTION: You are provided with a combination heat/stir plate but will be using only the stirring function. **Do not turn the heat on as this will ruin the thermos.**

2. Rinse the graduated cylinder and wipe dry the inside. Measure 50.0 mL of 1.0 M HCl and pour it into a dry, clean beaker.

3. Measure the temperature of the acid. Rinse and wipe the thermometer, then measure the temperature of the base. The temperatures of the two solutions must be within 0.5 °C of each other. If not, warm the HCl by holding the beaker in your hands or cool by immersing the beaker in tap water.

4. Record the temperature of the NaOH solution; this will be your initial temperature and enter it as the temperature at 0 s.

5. Insert the thermometer into the thermos lid, making sure it passes through the top side of the lid then through the bottom side.

6. Add the HCl solution from the beaker to the NaOH solution in the thermos quickly, but taking care not to splash any solution to the sides of the thermos. Stir gently, close the lid, and lower the thermometer to the solution. Record the temperature 15 s after the addition of HCl. Continue recording the temperature every 15 s for 3 min.

   The temperature rises at the beginning then stabilizes. Note the highest temperature that was achieved by the system; this will be the final temperature. If your readings show ΔT less than 4 °C, your thermometer is likely defective, and you need to repeat the experiment using another thermometer. Rinse and wipe the thermometer then turn it off when finished with the experiment.

7. Empty the thermos into the appropriate waste container and thoroughly rinse it and the stir bar.

8. Repeat Steps 1-7 two more times. Average the ΔT from all three trials.

CLEAN-UP

- Dispose of wastes in the container in the hood.
- Wash all glassware and the thermos container. Return all materials where they belong. Return the stir bar on top of the heat/stir plate.
- Make sure the thermometer is rinsed, wiped and turned off.

Name: ______________________________ Date: ____________________

Partner's Name: ______________________

THERMOCHEMISTRY: HEAT OF NEUTRALIZATION

DATA

Trial 1

$T_{initial}$ (temperature at 0 seconds): ________________

Time (s)	Temp (°C)	Time (s)	Temp (°C)
15	________	105	________
30	________	120	________
45	________	135	________
60	________	150	________
75	________	165	________
90	________	180	________

T_{final} (highest temp): ________________

ΔT ($T_{final} - T_{initial}$): ________________

Trial 2

$T_{initial}$ (temperature at 0 seconds): ________________

Time (s)	Temp (°C)	Time (s)	Temp (°C)
15	________	105	________
30	________	120	________
45	________	135	________
60	________	150	________
75	________	165	________
90	________	180	________

T_{final} (highest temp): ________________

ΔT ($T_{final} - T_{initial}$): ________________

Trial 3

$T_{initial}$ (temperature at 0 seconds): ____________________

Time (s)	Temp (°C)	Time (s)	Temp (°C)
15	____________	105	____________
30	____________	120	____________
45	____________	135	____________
60	____________	150	____________
75	____________	165	____________
90	____________	180	____________

T_{final} (highest temp): ____________________

ΔT ($T_{final} - T_{initial}$): ____________________

Average ΔT: ____________________

The specific heat (C_s) of water is 4.184 J/g·°C

CALCULATIONS

Show clearly the complete calculations with correct number of significant figures and units.

$$\_\_ NaOH (aq) + \_\_ HCl (aq) \rightarrow \_\_ H_2O (l) + \_\_ NaCl (aq)$$

1. Calculate the mass of the solution in g.

2. Calculate the q_{soln} in J using Equation 2. Use the average ΔT.

3. Determine q_{rxn} in J using Equation 1.

4. Calculate the number of moles of NaCl produced.

5. Calculate the enthalpy of the reaction in kJ per mole NaCl produced.

6. The combustion of methylhydrazine (CH_6N_2), a liquid rocket fuel produces N_2 (g), CO_2 (g), and H_2O (l):

$$\_\_ CH_6N_2 (l) + \_\_ O_2 (g) \rightarrow \_\_ N_2 (g) + \_\_ CO_2 (g) + \_\_ H_2O (l)$$

When 4.00 g of methylhydrazine is combusted in a bomb calorimeter, the temperature of the calorimeter increases from 25.00 °C to 39.50 °C. In a separate experiment, the heat capacity of the calorimeter is measured to be 7.794 kJ/°C. Calculate the heat of reaction for the combustion of a mole of CH_6N_2.