Chemistry 101
HEAT AND TEMPERATURE
Pre-Lab Exercises

Student:_____
Date:_____
Instructor:_____
Section:_____

1. Define specific heat:

2. An immersion heater is placed in 26.89 g of ethanol and the temperature increases from 19.5 ^{o}C to 48.7 ^{o}C. Assuming a specific heat for ethanol of 0.59 cal/g^{o}C, how much heat has been added to the ethanol?

cal

3. The temperature of 36.76 g of liquid bromine increases from 21.2 ^{o}C to 33.0 ^{o}C when 23.4 cal of heat are added. Calculate the specific heat of bromine.

cal/g^{o}C

4. When 254.1 g of lead cools from 96.5 ^{o}C to 35.1 ^{o}C, 481 cal of heat are released. What is the specific heat of lead?

cal/g^{o}C

5. The specific heat of iron is 0.107 cal/g^{o}C. If a 15.54 g piece of hot iron releases 798 cal when cooling to a temperature of 45.7 ^{o}C, calculate the temperature change, ΔT, that the iron undergoes and the initial temperature of the iron.

$\Delta T=$	^{o}C
$T_{initial}=$	^{o}C

Chemistry 101
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Partner:_____
Instructor:_____
Section:_____ Date: _____

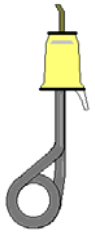
PROCEDURE AND REPORT

Heat Released by an Immersion Heater

Warning: If immersion heaters are plugged-in while the element is not in a liquid, they will be destroyed.

In this section you will determine the amount of heat released by an immersion heater in 45 seconds. The data you obtain from this section will be used in the next section. Be sure to use the same immersion heater for the first two sections of this lab.

1. Place a styrofoam cup in a 250 mL beaker. Place the cup and beaker on the balance and press tare.
2. Obtain about 100 mL of tap water in a graduated cylinder. Remove the cup from the balance and place the water in the cup. Return the cup to the balance and record the mass of water in the cup.
3. Place a cool immersion heater (one that is not plugged into the outlet) and a thermometer into the water. Be careful not to puncture the cup with the sharp end of the thermometer. While stirring with the heater, measure the initial temperature of the water. Remove the thermometer.



Immersion Heater

4. With the heater still in the water, plug it into an outlet for 45 seconds. While it is heating, stir the water with the heater and be sure that the heater does not rest on the cup. If it does, it will melt the styrofoam. At the completion of 45 seconds, unplug the heater, insert the thermometer and continue to stir with the thermometer and heater until the highest stable temperature is obtained. Record the final temperature.
5. Calculate the change in temperature, ΔT, of the water.
6. Calculate the heat absorbed by the water assuming that the specific heat of water is 1.00 cal/g^{o}C. This is the amount of heat the heater releases in 45 seconds.
7. Dry the styrofoam cup, the heater, and the thermometer and repeat steps 1-6. Calculate the average heat released by the heater (or heat absorbed by water) for the two trials.

Calculations:

Trial	Mass of Water (g)	$T_{initial}$ (^{o}C)	T_{final} (^{o}C)	ΔT (^{o}C)	Heat Absorbed (cal)
1					
2					
				Average Heat	

Specific Heat of a Liquid

In this section, you will use the immersion heater apparatus and the data generated in the previous section to determine the specific heat of antifreeze (propylene glycol).

1. Dry the styrofoam cup, the heater, and the thermometer used in the previous section. Place the cup in a 250 mL beaker. Place the cup and beaker on the balance and press tare.
2. Remove the cup from the balance and place about 100 mL of antifreeze in the cup**. Do not pour antifreeze into the cup while the cup is on the balance!** Return the cup to the balance and record the mass of antifreeze in the cup.
3. Place a cool immersion heater (one that is not plugged into the outlet) and thermometer into the antifreeze and while stirring with the heater, measure the initial temperature of the antifreeze. Remove the thermometer.
4. With the heater still in the antifreeze, plug it into an outlet for 45 seconds. While it is heating, stir the antifreeze with the heater and be sure that the heater does not rest on the cup. At the completion of 45 seconds, unplug the heater, insert the thermometer and continue to stir with the heater and thermometer until the highest stable temperature is obtained. Record the final temperature.
5. Calculate the change in temperature, ΔT, of the antifreeze.
6. Return the antifreeze to the proper container. Rinse and dry the cup, heater and thermometer.
7. Using the amount of heat released by the heater in 45 seconds, determined in the previous section, calculate the specific heat of antifreeze.

Calculations:

Amount of heat released by the immersion heater in 45 seconds (see page 1): _____

	Mass of Sample(g)	$T_{initial}$ (^oC)	T_{final} (^oC)	ΔT (^oC)	Specific Heat (cal/g^oC)
Antifreeze					

Specific Heat of Solids

In this section you will determine the specific heat of copper. You will then use the specific heat you determine for copper to indirectly measure the temperature of a Bunsen burner flame.

Specific Heat of Copper

1. Obtain and measure the mass of a copper coil. Record the mass in the table below.
2. Place the copper coil and 50 to 75 mL of distilled water in a 100 mL beaker. Support the beaker using wire gauze on a ringstand and heat the water to boiling using a Bunsen burner. While you are waiting for the water to boil, go on to the next step.
3. Place an empty, dry 50 mL beaker on the balance and press tare. Remove the beaker from the balance and add 25 to 30 ml of room temperature tap water to the beaker. Dry the outside of the beaker if necessary and return the beaker to the balance and record the mass of water in the beaker.
4. Measure and record the temperature of the water in the 50 mL beaker. This is the initial temperature of the water. While measuring the temperature, be sure to stir the water with the thermometer.
5. When the water in the 100 mL beaker has boiled for at least 2 minutes, measure and record the temperature. This is the initial temperature of the copper. Cool the thermometer back to room temperature using water from the tap. Dry the thermometer.
6. Using tongs, remove the copper from the boiling water, quickly tap it flat on a paper towel to remove excess water, and place the hot copper in the 50 mL beaker. (**Note**: You must tap the copper to remove the hot water, just shaking it is not adequate.) Stir the water with a thermometer and measure the highest stable temperature. This is the final temperature of the water and the copper.
7. Calculate the change in temperature, ΔT, for water.
8. Calculate the heat gained by water assuming a specific heat for water of 1.00 cal/g^{o}C.
9. For every ^{o}C increase in water temperature, the beaker absorbs approximately 6.5 cal. Calculate the heat absorbed by the beaker by multiplying the change in water temperature by 6.5 cal/^{o}C.
10. Assuming that the heat gained by the water and the beaker is equal to the heat lost by the copper, calculate the heat lost by the copper.
11. Calculate the change in temperature, ΔT, for copper.
12. Using the heat lost, the mass, and ΔT for copper, calculate the specific heat of copper.

SPECIFIC HEAT OF COPPER

	Trial #1
1. Mass of Cu	
3. Mass of H_2O	
4. $T_{initial}$ H_2O	
5. $T_{initial}$ Cu	
6. T_{final} H_2O and Cu	
7. ΔT for H_2O	
8. Heat gained by H_2O	
9. Heat gained by beaker	
10. Heat lost by Cu	
11. ΔT for Cu	
12. Specific Heat of Cu	

Calculations:

Temperature of a Burner Flame

1. Record the mass of the copper coil determined in the previous section in the table below.
2. Place an empty, dry 50 mL beaker on the balance and press tare. Remove the beaker from the balance and add 25 to 30 ml of room temperature tap water to the beaker. Return the beaker to the balance and record the mass of water in the beaker.
3. Measure and record the temperature of the water in the 50 mL beaker. This is the initial temperature of the water.
4. Light and properly adjust a Bunsen burner so that there is a distinct inner blue cone in the flame. Using tongs, hold the copper coil flat in the hottest part of the flame for about 1 minute (the coil should begin to glow).
5. Remove the copper from the flame and immediately place it in the beaker. *Do not place the tongs in the water but be careful not to break the beaker by dropping the copper from too high above the water.* **Warning: The tongs are extremely hot!! Set them on the metal base of the ring-stand to cool after placing the coil in the beaker.**
6. Stir the water with a thermometer and record the highest stable temperature.
7. Calculate ΔT for water.
8. Calculate the heat gained by water assuming a specific heat for water of 1.00 cal/g^{o}C.
9. For every ^{o}C increase in water temperature, the beaker absorbs approximately 6.5 cal. Calculate the heat absorbed by the beaker by multiplying the change in water temperature by 6.5 cal/^{o}C.
10. Assuming that the heat gained by the water and the beaker is equal to the heat lost by the copper, calculate the heat lost by the copper.
11. Using the specific heat of copper determined in the previous section, the heat lost and the mass of copper, calculate the change in temperature for the copper.
12. Calculate the temperature of copper in the flame by adding the change in temperature of the copper to the final temperature of copper in the water.

TEMPERATURE OF A BURNER FLAME

	Trial #1
1. Mass of Cu	
2. Mass of H_2O	
3. $T_{initial}$ H_2O	
6. T_{final} H_2O and Cu	
7. ΔT for H_2O	
8. Heat gained by H_2O	
9. Heat gained by beaker	
10. Heat lost by Cu	
11. ΔT for Cu	
12. T of Flame	

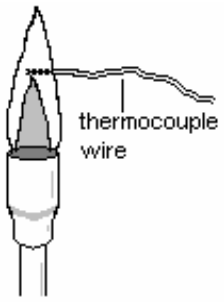
Calculations:

Direct Temperature Measurement of a Burner Flame

Note #1: Do not insert a normal thermometer in a burner flame. The thermocouple used in this section is specially designed to measure high temperatures.

Note #2: Use the same burner for this section that you used for the previous section.

Note #3: When using the thermocouple, place only the uninsulated tip of the thermocouple wire in the flame as shown in the diagram on the right, do not burn any additional insulation off of the wires!!



Using a Thermocouple

Use a thermocouple to directly measure the burner flame temperature.

1. Turn on the sensor display connected to a thermocouple. Press the MODE button until the units of *mV* are displayed. Place the end of the wire thermocouple coming from the red post in the hottest part of the flame. Allow the displayed value to stabilize then record the value with units of V.

   Temperature of the flame: _____V

2. Convert the value measured by the thermocouple to ^{o}C using the conversion factor 1 V = 552.6 ^{o}C.

   Temperature of the flame: _____ ^{o}C

3. Assuming that the temperature measured by the thermocouple is accurate, calculate the percent error in the temperature of the flame estimated using copper in the previous section.

   Percent error: _____

4. To compare the temperature in different regions of the flame, use the wire thermocouple to measure the temperature in the base of the flame. Place the tip of the wire in the center of the flame just above the burner. Allow the displayed value to stabilize then record the value with units of V and convert this temperature to ^{o}C. Turn off the sensor display.

   Temperature of the base of the flame: _____V

   Temperature of the base of the flame: _____ ^{o}C

Describe the difference in the temperature at the base of the flame and the tip of the flame.