

CHEMISTRY LAB: SPECIFIC HEAT OF A METAL

WHAT TO TURN IN:

Data Table 1 ~ Data Table 2 ~ Data Table 3 ~ Calculations ~ Questions #1-7

Introduction

Chemists identify substances on the basis of their chemical and physical properties. One physical property of a substance is the amount of energy it will absorb per unit of mass. This property can be measured quite accurately and is called *specific heat* (C_p). Specific heat is the amount of energy measured in joules, needed to raise the temperature of one gram of the substance one Celsius degree. Often applied to metallic elements, specific heat can be used as a basis for comparing energy absorption and transfer.

To measure specific heat in the laboratory a *calorimeter* of some kind must be used. A calorimeter is a well-insulated container used in measuring energy changes. The calorimeter is insulated to reduce the loss or gain of energy to or from the surroundings. Energy always flows from an object at a higher temperature to an object at a lower temperature. The heat gained by the cooler substance equals the heat lost by the warmer substance, if we assume no loss of heat to the surrounding environment.

$$\text{heat lost} = \text{heat gained}$$

In this experiment, you will determine the specific heat of a metal sample. The metal sample will be heated to a high temperature then placed into a calorimeter containing a known quantity of water at a lower temperature. Having measured the mass of the water in the calorimeter, the temperature change of the water (ΔT) and knowing the specific heat of water (4.184 J/g °C) the heat gained by the water (lost by the metal) can be calculated as follows:

$$\text{heat gained by the water} = \text{mass of water (g)} \times \text{change in temperature } (\Delta T) \times \text{specific heat of water (4.184 J/g } ^\circ\text{C)}$$

The specific heat of the metal can now be calculated:

$$\text{Specific heat of metal} = \frac{\text{heat gained by the water}}{\text{mass of metal (g)} \times \Delta T \text{ of metal } (^\circ\text{C})}$$

Procedure

- 1) Fill a large beaker approximately half full of water. Place the beaker of water on a hot plate (or on a ring clamp on a ring stand with wire gauze). Begin heating the water to the boiling point. Turn the hot plate on high; or light your burner and adjust so that the hottest part of the flame is touching the bottom of the beaker through the gauze.
- 2) Determine the mass of a small beaker to 0.01 g. Add a piece of metal of 2-3 spoonfuls as directed. Mass again and subtract to find the mass of the metal.
- 3) Obtain a calorimeter cup. Record the mass carefully to two decimal places.
- 4) Fill the calorimeter approximately half full with distilled water at room temperature and record the mass to two decimal places.
- 5) CAREFULLY transfer the metal to a large test tube. Clamp the test tube, suspending it in the beaker of water (from step 1). Boil at least 10 minutes.
- 6) While the metal is still in the boiling water bath, measure the temperature of the water carefully with a thermometer and record to tenths, one decimal place. (It will be assumed that the temperature of the metal is the same as the boiling water.)
- 7) Measure the temperature of the water IN THE CUP and record to tenths.

- 8) After the metal has been heating 10 minutes, remove the test tube from the bath by its utility clamp. Immediately pour the metal into the calorimeter cup so that the metal is covered by the water. Cover the calorimeter with its cover. Turn off the hot plate or burner.
- 9) Carefully insert the thermometer through the small hole in the cover. Stir very slowly with a stirring rod, and record the highest temperature reached by the water to tenths.
- 10) Remove the calorimeter cover, retrieve and dry the metal. Return metal to its original place. Pour the water down the sink. Rinse and dry the calorimeter cup
- 11) Repeat the entire procedure with a different metal if time permits.

Calculations: show all units!

Heat gained by water— use the second equation in the introduction

Experimental specific heat—use the third equation in the introduction

$$\text{Percent error} = \frac{|\text{experimental} - \text{standard}|}{\text{standard}} \times 100$$

Questions

- 1) What is the purpose of this lab?
- 2) What physical properties, other than specific heat, could you use to help you identify the metal samples?
- 3) Why is water an excellent material to use in the calorimeter?
In an insulated environment, HEAT LOST = HEAT GAINED.
- 4) What substance lost heat in this experiment?
- 5) What substance gained heat?
Metals have a lower specific heat than that of water.
- 6) Was this true in what you observed?
- 7) Explain with a “low specific heat” means in terms of heat retention and heat requirements.

DATA TABLES ON THE NEXT PAGE...

DATA TABLE #1: MASS DATA

MATERIAL	MASS (g), trial 1	MASS (g), trial 2
Metal	_____	_____
Calorimeter	_____	_____
Calorimeter + water	_____	_____
Water	_____	_____

DATA TABLE #2: TEMPERATURE DATA

MATERIAL	TEMP. (°C), trial 1	TEMP. (°C), trial 2
Boiling water	_____	_____
Water in calorimeter	_____	_____
Water in calorimeter after metal was added	_____	_____
ΔT for the water	_____	_____
ΔT for the metal	_____	_____

DATA TABLE #3: HEAT DATA

	TRIAL 1	TRIAL 2
Heat gained by the water (J)**	_____	_____
Experimental specific heat (J/g °C)	_____	_____
Standard specific heat (J/g °C)	_____	_____
Percent error**	_____	_____