EXPERIMENT 2

Measurements

INTRODUCTION

In this experiment we will become familiar with several instruments. The accuracy of every measurement that is made depends on the equipment used to make the measurement. We will take mass measurements on a multiple beam balance and an analytical balance. When reading a graduated piece of equipment, such as a multiple beam balance, the tolerance, or uncertainty, of the measurement is taken as one-half the closest divisions. We will use a multiple beam balance in which the closest divisions represent 0.1 g. Dividing the closest divisions by 2 gives us the tolerance of this multiple beam balance: 0.05 g. Because the tolerance is five hundredths of a gram, the mass is recorded to the hundredths of a gram to match the recorded mass with the instruments tolerance. Two different measurements from such a balance may be written as

\[ 3.24 \text{ g} \text{ or } 17.50 \text{ g} \]

Our analytical milligram balances have a tolerance of one thousandth of a gram. Measurements made with this instrument should always be recorded to the thousandths place, inferring that its tolerance is in the thousandth of a gram range. Measurements made on an analytical milligram balance may be written as

\[ 64.203 \text{ g} \text{ or } 15.528 \text{ g} \]

We will make volume measurements of liquids in graduated cylinders. When reading a graduated cylinder, always read the bottom of the meniscus, the lens-shaped surface of the liquid. Observe the meniscus at eye level in order to avoid a reading error. Once again, when reading a graduated piece of equipment the tolerance of the measurement is taken as one-half the closest divisions. We will use our smallest graduated cylinder in which the closest graduations represent 0.1 mL. Dividing the closest graduations by 2 gives us the tolerance of this graduated cylinder: 0.05 mL. Because the tolerance is five hundredths of a milliliter, the volume is recorded to the hundredths of a milliliter to match the recorded volume with the instruments tolerance.

Two different measurements from such a graduated cylinder may be written as

\[ 7.00 \text{ mL} \text{ or } 3.25 \text{ mL} \]
On our largest graduated cylinder the closest graduations represent 1 mL, and therefore has a tolerance of 0.5 mL. Two different measurements from such a graduated cylinder may be written

\[ 31.0 \text{ mL or } 42.5 \text{ mL} \]

Temperature measurements will be made using a thermometer in which the closest divisions represent 1 C°, and therefore has a tolerance of 0.5 C°. Two different measurements from this thermometer may be written as

\[ 11.0 \text{ C° or } 78.5 \text{ C°} \]
We will make length measurements using two different metric rulers. On the first ruler below the closest divisions represent 1 cm, and therefore has a tolerance of 0.5 cm. A measurement of the length of the copper rod from this ruler may be written

12.5 cm

On the second ruler below the closest divisions represent 0.1 cm, and therefore has a tolerance of 0.05 cm. A measurement of the length of the same copper rod from this ruler may be written as

12.55 cm

When doing multiplication or division operations involving measurements, the number of significant figures in the answer must equal the number of significant figures in the factor that has the least number of significant figures. When multiplying 2.7 cm by 9.4 cm, because each factor has 2 significant figures, the answer must be rounded to 2 significant figures. Our answer must be given as

\[ 2.7 \text{ cm} \times 9.4 \text{ cm} = 25 \text{ cm}^2 \]

When multiplying 2.76 cm by 9.35 cm, because each factor has 3 significant figures, the answer must be rounded to 3 significant figures. Our answer must be given as

\[ 2.76 \text{ cm} \times 9.35 \text{ cm} = 25.8 \text{ cm}^2 \]

Begin each experiment by taking the necessary safety precautions. Get in the "good habit" of always putting on your safety goggles and lab coat. All materials that will not be used in the lab should be placed out of the laboratory working area. This would include books, lunches, etc. The best way to become familiar with chemical apparatus is actually to handle the pieces yourself in the laboratory.
PROCEDURE

1. Students will work individually for this experiment. Except for the laboratory handout, remove all books, purses, and such items from the laboratory bench top, and placed them in the storage area by the front door. For laboratory experiments you should be wearing closed-toe shoes. Tie back long hair, and do not wear long, dangling jewelry or clothes with loose and baggy sleeves. Open your lab locker. Put on your safety goggles, your lab coat, and gloves.

PART A – MASS MEASUREMENTS

2. Determine the mass of a 250-mL beaker on a multiple beam balance, and record the measurement in your Data Table.

3. Determine the mass of the same 250-mL beaker on an analytical milligram balance, using the following procedure:
   (a) If it is not on, turn the milligram balance on by pressing the "\(\mathbb{C}\)" key in the upper left-hand corner of the display panel with your glove-free hand.
   (b) Before weighing anything on the milligram balance, press one of the “tare” keys with the symbol "\(\rightarrow T/0 \leftarrow\)" with your glove-free hand, and make sure the display reads "0.000 g".
   (c) Carefully open the side sliding door of the milligram balance. Watch for debris in the track of the sliding door and clean it out if it is present because the sliding door is one of the most fragile parts of the balance. Place the 250-mL beaker on the balance pan and close the door. When the display shows a mass with three places past the decimal point followed by a "g" for grams, this is the mass of the beaker. Record the measurement in your Data Table. Record all digits shown.
   (d) Remove the beaker and close the sliding door. The balance should be left clean for the next user.
PART B – LENGTH MEASUREMENTS

4. Measure the diameter of one of your watch glasses on metric ruler A, found below, and record the measurement in your Data Table.

6. Measure the diameter of the same watch glass on metric ruler B, found below, and record the measurement in your Data Table.

PART C – VOLUME MEASUREMENTS

7. Two sets of graduated cylinders will be found on the lab bench in front of the instructor’s desk. The graduated cylinders are labeled A, B, and C, followed by their set number, either 1 or 2. You will be reading the volumes of water in only one of the two sets. Record the set you will be reading in your Data Table. Measure the volume of water in graduated cylinder A, and record the measurement in your Data Table.

8. Measure the volume of water in graduated cylinder B, found on the lab bench in front of the instructor’s desk, and record the measurement in your Data Table.

9. Measure the volume of water in graduated cylinder C, found on the lab bench in front of the instructor’s desk, and record the measurement in your Data Table.
PART D – TEMPERATURE MEASUREMENTS

10. Half fill the 250-mL beaker with deionized water. Obtain a ceramic-centered wire gauze from drawer 028 and an iron ring from drawer 029 at the back of the lab room. Place the beaker on the ceramic-centered wire gauze, supported by the iron ring on a ring stand, in order to boil the water using a laboratory burner, as show below. When heating substances in glassware by means of a gas flame, the glassware should be protected from direct contact with the flame through the use of a ceramic-centered wire gauze, which will prevent the glassware from breaking.

![Diagram of a beaker on a ring stand with a ceramic-centered wire gauze and an iron ring]

11. Obtain either a Bunsen or Fisher burner from drawer 016 or drawer 017, and a striker from drawer 031 at the back of the lab room. Check the burner’s rubber tubing for cracks or holes. If necessary, obtain new rubber tubing. Attach the rubber tubing to the gas outlet at your lab station.

**CAUTION:** Before you light the burner, check to see that you have taken the following safety precautions against fires: you are wearing safety goggles, long hair is tied in back of the head and away from the front of the face, long sleeves on shirts, blouses, and sweaters are rolled up away from the wrists.

Place the burner on the ring stand below the beaker. Adjust the height of the iron ring so there is 5 cm of space between the top of the burner and the ceramic-centered wire gauze. Temporarily remove the burner from ring stand.
12. Turn the gas on full, hold the striker about 5 cm above the top of the burner and proceed to light it. If the flame quickly blows out, turn down the gas at the gas outlet and try again. The flame should be free of yellow color, nonluminous, and also free from the "roaring" sound caused by admitting too much air. Control the height of the flame so that it is about 8 cm high by using the gas valve, and allow in more air by slowly unscrewing the barrel to reduce any yellow color or "roaring". The flame should be quiet and steady with a sharply defined light blue inner cone. This gives the highest possible temperature with your burner, with the hottest part of the flame being at the tip of the light blue inner cone.

![Burner diagram](image1)

13. Place the burner on the ring stand below the beaker. Heat the water to boiling with the laboratory burner as shown below. When the water is boiling, hold the thermometer off the bottom of the beaker to avoid an erroneously high reading. Record the hottest observed temperature.

![Experiment setup](image2)
PART E – MASS AND VOLUME OF AN UNKNOWN RECTANGULAR SOLID

14. Obtain a rectangular solid unknown from the back counter next to Fume Hood A and record its unknown number in your Data Table.

15. Measure the length, width, and thickness of the rectangular solid unknown using ruler A, and record the measurements in your Data Table. Calculate the volume of the rectangular solid unknown.

16. Measure the length, width, and thickness of the rectangular solid unknown using ruler B, and record the measurements in your Data Table. Calculate the volume of the rectangular solid unknown.

17. Clean and wipe dry your laboratory work area and all apparatus. When you have completed your lab report have the instructor inspect your working area. Once your working area has been checked your lab report can then be turned in to the instructor.
## EXPERIMENT 2 LAB REPORT

Name: ___________________________________________ Student Lab Score: ________________
Date/Lab Start Time: _________________________________ Lab Station Number: ________________

## DATA TABLE

### PART A

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of Beaker on Multiple Beam Balance</td>
<td>g</td>
</tr>
<tr>
<td>Mass of Beaker on Analytical Balance</td>
<td>g</td>
</tr>
</tbody>
</table>

### PART B

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of Watch Glass with Ruler A</td>
<td>cm</td>
</tr>
<tr>
<td>Diameter of Watch Glass with Ruler B</td>
<td>cm</td>
</tr>
</tbody>
</table>

### PART C

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of Water in Graduated Cylinder A</td>
<td>mL</td>
</tr>
<tr>
<td>Volume of Water in Graduated Cylinder B</td>
<td>mL</td>
</tr>
<tr>
<td>Volume of Water in Graduated Cylinder C</td>
<td>mL</td>
</tr>
</tbody>
</table>

### PART D

<table>
<thead>
<tr>
<th>Description</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature of Boiling Water</td>
<td></td>
</tr>
</tbody>
</table>

### PART E

<table>
<thead>
<tr>
<th>Description</th>
<th>Using Ruler A</th>
<th>Using Ruler B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Rectangular Solid</td>
<td>. cm</td>
<td></td>
</tr>
<tr>
<td>Width of Rectangular Solid</td>
<td>. cm</td>
<td></td>
</tr>
<tr>
<td>Thickness of Rectangular Solid</td>
<td>. cm</td>
<td></td>
</tr>
<tr>
<td>Volume of Rectangular Solid</td>
<td>. cm³</td>
<td></td>
</tr>
</tbody>
</table>

Rectangular Solid Unknown Number: __________
**POSTLAB QUESTIONS**

1. State the number of significant figures in each measurement.

   (a) 35 s ______________
   (b) 10.00 mL ____________
   (c) 1.05 cm ____________
   (d) 30.5 cm³ ____________
   (e) 21.50 mL ____________
   (f) -20.0°C ____________
   (g) 67.0 g ____________
   (h) 0.018 g ____________
   (i) 900 cm³ ____________
   (j) 40°C ____________

2. Perform each arithmetic operation and round off the answer to the proper number of significant figures. *Box your answer.*

   (a) \[50.4 \text{ g} + 50.07 \text{ g} + 50.213 \text{ g} = 150.723 \text{ g} \]
   (b) \[63.05 \text{ cm} - 11.4 \text{ cm} = 51.65 \text{ cm} \]

3. Perform each arithmetic operation and round off the answer to the proper number of significant figures. *Box your answer.*

   (a) \[(47.905 \text{ cm})(0.20 \text{ cm}) = 9.581 \text{ cm}^2 \]
   (b) \[639.5 \text{ mm}^3 = 24.5 \text{ mm} \]
4. Give the measurement indicated by each of the following. The reading must be consistent with the tolerance of the instrument.

RECTANGULAR SOLID cm cm cm cm

MAGNESIUM RIBBON cm cm

COPPER WIRE cm

GLASS TUBING cm

20 mL mL °C °C
5. Perform the indicated operations. \textit{Box your answers.}

(a) \quad D = \frac{m}{V} \quad \text{Solve for } V

(b) \quad pV = nRT \quad \text{Solve for } M \text{ if } n = \frac{g}{M}