Chemistry 51
Experiment 2
Measurements

It is necessary in science to quantify any hypothesis or theory, that is, anyone should be able to reproduce anywhere and at anytime an experiment which supports that theory. This need for reproduction leads to measurements being a vital aspect of science. Measurements can be either precise or accurate or both or neither. Precision refers to the ability to reproduce a set of data within a specific error range. Accuracy refers to how close the data is to the "true" value.

Measurements made in the laboratory involve using tools specifically made for length, volume, mass, temperature or time. Length is usually measured with a ruler, volume uses a graduated cylinder, mass is weighed on a balance, a thermometer is used to take the temperature, and a watch measures time.

There are two major systems of measurements - the English system and the metric. The English system of units uses inches, feet, and miles for length; ounces, quarts, and gallons for measurements of volume; and ounces, pounds, and tons for mass measurements. A volume ounce is different than a mass ounce. There are 32 fluid ounces in a quart but 16 ounces in a pound. If we look at length only we find that 12 inches is equal to 1 foot, 3 feet is 1 yard, and there are 5280 feet in one mile. On your next road trip try to figure out how many inches you plan to travel. Did you know that there are 3 teaspoons to 1 tablespoon, or that 1-tablespoon holds 0.5 fluid ounces? In many ways the English system can be quite confusing. There are a large number of conversion units that need to be memorized in order to convert from one unit to another. Scientists generally try to find simplicity amid complexity so the preferred measurement system should be relatively simple. The metric system is based on units of 10 and usually only requires repositioning of the decimal point. For example, 10 millimeters (mm) equals one centimeter, 10 centimeters (cm) is 1 decimeter, and 10 decimeters (dm) is one-meter (m). The following table gives the decimal units most commonly used in the laboratory.

Table 1 Decimal System for Measurement - The Metric System

prefix:	kilo	base unit	deci	centi	milli
decimal:	1000	1	1/10 or 0.1	1/100 or 0.01	1/1000 or 0.001

This table is read as "1 deci-base is equal to 1/10 base or 0.1 base". Another example is "1 milli-base is equal to 1/1000 base or 0.001 base". The base unit for a measurement using the metric system depends on the type of measurement being made, just like in the English system. The next table gives the metric units most commonly used in the laboratory.

Table 2 Units used in the Metric System

suffix:	length	volume	weight	temperature	time
name	meter	liter	gram	Celsius	second
symbol	m	L	g	^{o}C	s

By combining these two tables, one is able to make measurements in a chemistry laboratory. Distance or length (or width or thickness, etc.) requires a ruler (or meter stick) and the measurements collected are in units of meters or centimeter or millimeters.

PROCEDURE:

Part 1: LENGTH MEASUREMENTS

Obtain a meter stick. On the report sheet answer the following questions. (1) How many meters are in a meter stick? (2) How many centimeters are in a meter stick? (3) How many millimeters are in a meter stick?

To calculate the number of decimeters in a meter stick, we will learn a problem solving skill called unit (or dimensional) analysis. Start with the number given, in this case 1 meter, then find the conversion factor from the table that contains both the desired unit and the starting unit. In this case, 1 decimeter is equal to 1/10 or 0.1 meters. Next set up the math problem such that the starting metric unit can be canceled out by dividing by that conversion:

$$1m\left(\frac{1dm}{0.1m}\right) = 10dm$$

(1) Using the meter stick or a ruler measure the height, in centimeters, of a 250-mL beaker. Then convert that measurement to meters, millimeters, kilometers, and inches using unit analysis described above. Do not forget about significant figures.

The number of significant digits in any measurement is dependent on the instrument used to make that measurement. A meter stick can be read to the nearest 0.5 mm, that is you can estimate between two lines, therefore a meter stick can give a precision of + 0.5 mm. For example, lets say the height of the beaker was 16.55 cm, your answer should include all 4 significant digits, a digit for each line on the ruler plus one digit for guessing whether the measurement falls exactly on the line or in between.

(2) Measure the length and width of this page to the nearest 0.1 mm. After measuring, convert all lengths to the specified units on the report sheet. Be sure to show all your work for the conversions.

Part 2: VOLUME MEASUREMENTS

Fill a 50 or 100-mL beaker to the brim with tap water. Using a 100.0-mL graduated cylinder, measure the volume of water contained in the beaker, to the nearest 0.1-mL. A graduated cylinder is read by matching the bottom of the meniscus with a line. Next fill the 250-mL beaker to the brim with tap water. Using the same graduated cylinder, measure the volume of water contained in the beaker. Transfer the water to the graduated cylinder, stopping at 100.0 mL, dump that water then fill the graduated cylinder up again to 100.0 mL. Repeat this until your last measurement is below 100.0 mL. Add up your total volume.

Part 3: WEIGHT MEASUREMENTS

Your instructor will explain the operation of the balance you will use in your laboratory work. Using the centigram balance provided, weigh the dried 250-mL beaker to the nearest 0.01g.

Digital balances are very expensive and very sensitive to both liquid and salt spills. Always use caution when weighing a substance that could damage the balance. Before making the next measurement, it would be wise to determine how you would proceed. Ask yourself, "If I were asked to weigh a sample of water, exactly how I would make this measurement?"

_____

_____

_____

Now that you have a plan, weigh 25.0 mL of water. Use a graduated cylinder to measure out the volume of water. Record your data on the report sheet.

Part 4: TEMPERATURE MEASUREMENT

The "Bunsen" burner is commonly used for laboratory heating operations. There are several types of burners, differing from each other in details of construction, but each has a gas inlet, a tube for mixing air and gas, and an opening near the base of the tube for introduction of air. Find these parts on your burner and make a neat, labeled sketch of the burner.

Attach a ring clamp securely to a ring stand; place a wire screen on top of the ring clamp. Make sure everything is secure and can handle heavy weights. The Bunsen burner goes below the wire screen. Place the 250-mL beaker, already filled halfway with water, on top of the wire screen. Light the burner by partially closing the air vent, turning on the gas part way, and bringing a match in toward the top of the burner from the

side, touching the top of the tube. Slowly close the air hole at the base of the tube. Note the color of the flame. This flame does not have enough oxygen to burn adequately. This flame is not as hot as a flame that has ample oxygen. Open the air hole about half way and adjust the flame with the gas until the flame is about 4 to 8 cm high or until it touches the wire screen. The flame should be blue with a lighter inner blue cone. A blue flame is hotter than an orange flame. Have you ever heard the phrase "white hot"? Allow the water to boil. While you wait for the water to boil, find your thermometer. Record the room temperature. Convert that temperature to Fahrenheit.

Five minutes after the water reaches boiling, measure the temperature and then convert the temperature of boiling water to Fahrenheit. Wait 5 minutes more and record the temperature again. Repeat one more time. Does the temperature change as the water boils?

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Show all calculations on this report sheet.

Part 1:LENGTH MEASUREMENTS

How many meters are in a meter stick? _____

How many centimeters are in a meter stick? _____ (Count the large lines)

How many millimeters are in a meter stick? _____ (Count the small lines)

(1) Length of 250-mL beaker: _____ cm; _____ mm; _____ km
(show calculations in space below)

Calculate this length in inches: _____in
(show calculations in space below)

(2) Length of page: _____ cm; _____ mm; _____ km
(show calculations in space below)

Calculate this length in inches: _____in
(show calculations in space below)

(2) Width of page: _____ cm; _____ mm; _____ km
(show calculations in space below)

Calculate this length in inches: _____in
(show calculations in space below)

Part 2:VOLUME MEASUREMENTS

Volume of 150 mL beaker _____ mL; _____ L

Volume of 250 mL beaker _____ mL; _____ L
(show calculations in space below)

Part 3:WEIGHT MEASUREMENTS

1. Mass of 150-mL beaker: _____ g; _____ mg; _____ kg
   (show calculations in space below)

2. How many significant digits can be obtained from this instrument? _____

3. Mass of beaker _____ g

   Mass of beaker + water _____ g

   Mass of 25.0 mL of water _____ g

Part 4:TEMPERATURE MEASUREMENT

1. Sketch the burner below (Label all parts):

2. What is the appearance of the flame when the air intake is covered? _____

3. What temperature does the thermometer read as you retrieve it from your drawer? _____ ^{o}C

4. How many significant digits can be obtained from this instrument? _____

5. The conversion of Celsius to Fahrenheit uses this equation: $^{o}F = 1.8\ ^{o}C + 32$. Convert room temperature to Fahrenheit: _____ ^{o}F

6. The temperature of boiling water (after 5 minutes): _____ ^{o}C

7. The temperature of boiling water (after 10 minutes): _____ ^{o}C

8. The temperature of boiling water (after 15 minutes): _____ ^{o}C

9. Does the temperature of boiling water change over time? _____

10. Convert the temperature of boiling water to Fahrenheit: _____ ^{o}F

11. Water boils at 100.0 ^{o}C at sea level, is your thermometer calibrated accurately? _____