Experiment 2

MEASUREMENT AND THE METRIC SYSTEM

Materials and Equipment

Sodium Chloride, NaCl, ice, centigram and digital balances, ruler, and thermometer.

Introduction

Chemistry, being an experimental science, is fundamentally based on measurements. Therefore it is important to acquire the necessary skills needed to make these measurements and to use them properly.

Unit Prefixes, The SI System

The scientific community almost exclusively uses the International System of Units, (Systéme Internationale d'Unités). It is based on the metric system, the decimal system of units and measurements. The basic set of units includes the meter, the gram, and the liter. Factors of 10 are used to express larger or smaller multiples of these units. Prefixes are added to the names of the units to express smaller or larger units. The most familiar of these prefixes are listed in the table below.

Prefix	Decimal Equivalent	Power of 10
Deci	0.1	10^{-1}
Centi	0.01	10^{-2}
Milli	0.001	10^{-3}
Kilo	1000	10^{+3}

Example:

A kilogram is equivalent to 10^3 multiplied by the base unit, the gram. This gives 1000 grams. A millimeter is 10^{-3} the distance of the meter, giving 0.001 meter.

Temperature

The SI unit of temperature is the Kelvin (K). The Kelvin scale is absolute and therefore does not go below zero Kelvin. More commonly we see temperature measured in Celsius (˚C) or Fahrenheit (˚F). Notice that the degree sign is not used for Kelvin temperatures.

Temperature	Boiling Point of Water	Melting Point of Water
Fahrenheit, ˚F	212 ˚F	32 ˚F
Celsius, ˚C	100 ˚C	0 ˚C
Kelvin, (K)	373 K	273 K

Conversion between temperature scales is straightforward using the following equations.

Conversion of Fahrenheit to Celsius. $°F = (1.8 \times °C) + 32$

Conversion of Celsius to Fahrenheit. $°C = (°F - 32)/1.8$

Conversion between Celsius and Kelvin. $K = °C + 273$ or $°C = K - 273$

Measuring Temperature

It is relatively easy to make errors when measuring temperatures. Precision is limited by many factors. Some of these include the calibration of the scale as well as improper placement of the thermometer bulb. To minimize human error involved in thermometer placement the following procedures should be followed:

1. Keep the thermometer away from the container walls.
2. Allow the thermometer enough time to reach equilibrium with the sample involved.
3. If applicable, be sure the sample is adequately mixed.

Mass

Mass is the measurement of the quantity of matter. You are probably familiar with the English unit, pound (lb.) to measure weight. In the sciences we use the gram to measure mass. The gram is the root unit, and the metric prefixes mentioned above are used to modify the quantity.

There are 453.6 g in 1 lb.

Measuring Mass

Chemistry experiments can be performed quite nicely using a 0.01 gram to a 0.0001 gram precision balance. Your instructor will advise you of the balance required for a specific experiment. When measuring mass the following procedures should be adhered to:

1. On an electronic balance be sure it is "zeroed" or "tared" before anything is placed on the pan. The use of balances without a "tare" or "T" button will be demonstrated by your instructor.

2. Never put reagents directly on the pan. Weighing paper, weighing boats or other containers should always be used. Spills should be cleaned up immediately.

3. Never try to make adjustments while using the balance. If something is amiss, inform your instructor.

Volume

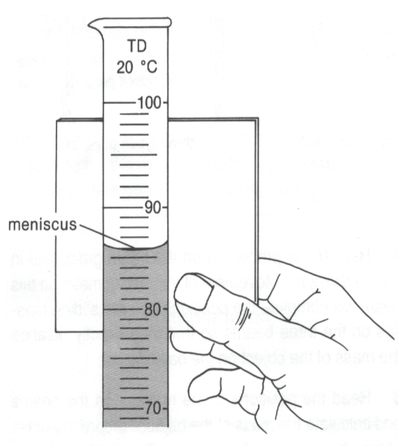
Volume is the measurement of the amount of space that matter occupies. You are probably familiar with the English units for volume such as: fluid ounce (fl. oz.), pint (pt.), quart (qt.), gallon (gal.). Remember, there are 32 fl. oz. in a quart and 4 quarts in a gallon.

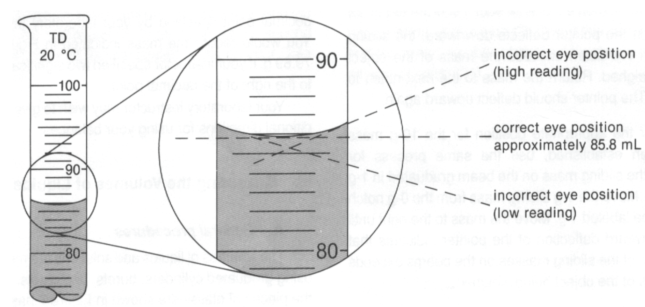
There are 1.06 qt. in 1 L.

Remember: 1 milliliter (mL) is equivalent to 1 cubic centimeter (cm^3).
1 mL = 1 cm^3

Measuring Volume

It is not useful to use beakers or erlenmeyer flasks for volume measurements. The measurement marks on these pieces are only approximate volumes. Therefore volume measurements are usually made using graduated cylinders. When reading a graduated cylinder the bottom of the curved surface, the meniscus, of the liquids is the point where the reading is taken (See figures below.). Graduated cylinders are usually read to the 0.1 milliliters.





Precision and Accuracy

The precision of a measurement allows us to estimate its reproducibility. Precision is described in terms of deviation, (observed value – average value). Whereas accuracy is the extent to which a measurement agrees with the believed to be true value. Accuracy is described in terms of error, (observed value – true value). However, not all measurements can be compared to a known value. For a small number of measurements significant figures account for precision.

Significant Figures

When a measurement is made to the highest precision possible for the measuring instruments, the digits in the measurement are significant and are called significant figures. Significant figures in a measurement include all of the certain digits in a measurement plus one "doubtful" digit.

It is often unnecessary to measure exact quantities of substances while conducting experiments. For example, the procedure might state, "Weigh approximately 3 grams of potassium chlorate". This indicates to the experimenter that the measured quantity of this salt should be about 3 grams plus or minus a small amount. In this case a measured quantity of 2.8 grams to 3.2 grams is sufficient. It is waste of time to weigh exactly 3.0, 3.00 or 3.00 grams when the instructions call for "about 3 grams".

On the other hand, it is sometimes necessary to measure an amount of substances precisely within the acceptable range. For instance, if the instructions direct you to weigh about 3 grams to the nearest 0.001 g, this does not mean the amount must be 3.000 grams. Rather, the amount should be between 2.8 grams and 3.2 grams and the measurement recorded to the nearest 3 decimal places. For example, 2.956 g would be acceptable. Always record every significant digit offered by your measuring device.

Procedure

Part 1: Temperature and Mass

Record all temperatures to the nearest 0.1°C.

1. Fill a large beaker (400 mL) halfway with tap water. Follow the procedure for temperature readings. Read and record the temperature of the water.

2. Fill a small beaker (150 mL) halfway with tap water. Set up a ring stand with a ring and wire gauze. Adjust the height of the ring so that the hottest part of the flame from the Bunsen burner reaches the bottom of the beaker. Heat the water to boiling. Read and record the temperature of the boiling water.

3. Fill a medium sized beaker (250 mL) about one quarter full with tap water and add about 100 milliliters of ice. Without stirring, place your thermometer on the bottom of the beaker. Read and record the temperature. Next, stir the mixture for about a minute. Hold the thermometer the proper way and record the temperature reading. Save the ice water for step 4.

4. Weigh an empty, clean, and dry 100 mL beaker (If you don't have a 100 mL beaker, anything close will suffice.) to the nearest 0.01 g (If you use the electronic balance you will be able to measure it to the nearest 0.001g). Record the mass of the beaker. Add a small amount of NaCl to the beaker and re-weigh the beaker. Do this until there is approximately 6 grams of sodium chloride in the beaker. Transfer this NaCl to the ice water. Stir the mixture for about a minute. Add more ice if necessary. Read and record the temperature.

Part 2: Volume

Use the appropriate graduated cylinder for the following volume measurements to maximum precision, usually 0.1 milliliters. Be sure to read the volume at the meniscus.

1. Fill a test tube to the brim with tap water and measure the volume. Record your data.

2. Measure 5.0 mL of water in a graduated cylinder and pour it into a test tube. With a ruler, measure the height in centimeters and mark it with a grease pencil.

3. Measure 10.0 mL of water the same way as in the preceding step. Again, mark the height with a grease pencil.

4. You will find that this is a convenient way to estimate volumes of 5 milliliters and 10 milliliters by observing the height of liquids in test tubes.

Part 3: Drops in a mL

You will need you 10 mL graduated cylinder, and you should record your volumes to 0.01mL.

1. Place approximately 5 mL of water into your 10 mL graduated cylinder. Record this volume to a precision of 0.01 mL.

2. Add water with a dropper, dropwise while counting the drops until there is approximately 8 mL of water in the graduated cylinder. Record the number of drops and the final volume of water in the graduated cylinder.

3. Calculate the number of drops per mL.

Report

Name	
Date	
Section	

Part I: Temperature and Mass	
Temperature of room-temperature water (˚C)	
Temperature of boiling water (˚C)	
Temperature of ice water before stirring (˚C)	
Temperature of ice water after stirring for 1 min. (˚C)	
Mass of empty beaker (g)	
Mass of beaker and NaCl (g)	
Mass of NaCl(g) (*This salt will now be added to the ice water to determine how it affects the temperature).*	
Temperature of ice water with salt added (˚C)	
Part 2: Volume	
Volume of test-tube (mL)	
Height of 5 mL of water in test-tube (mm)	
Height of 10 mL of water in test-tube (mm)	
Part 3: Drops in a mL	
Initial volume of water in graduated cylinder (mL)	
Final volume of water in graduated cylinder (mL)	
Number of drops water added to graduated cylinder	
Drops/mL	
Show set-up and calculations for determining drops/mL here.	

Remember that the problems on the following page are part of this lab report and must be turned in with the lab report. Show all work and box the answers.

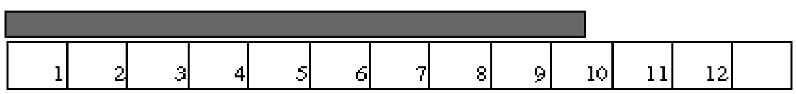
Problems

Name

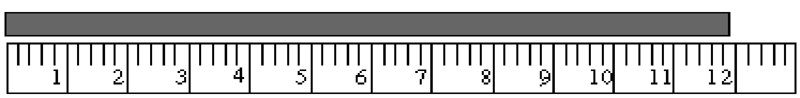
1. How many seconds in 8.0 years?

2. Calculate the number of mm in 2.0 miles.

3. Record each of the following to the correct precision:



cm



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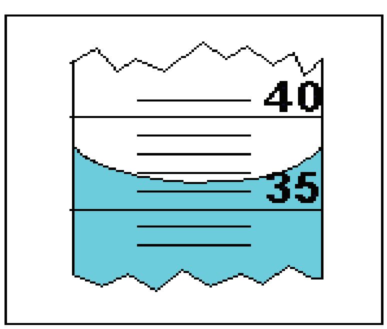
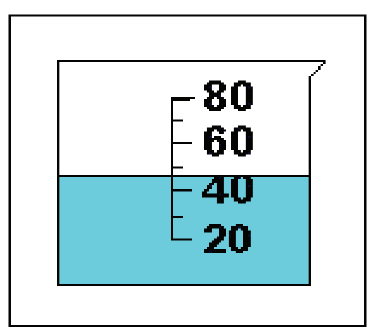


mL



mL

4. A 50 mL graduated cylinder is filled with 23.0 mL of water. Water is then added to the cylinder dropwise until 36.0 mL of water are in the cylinder. If it took 265 drops to increase the volume in the cylinder to 36.0 mL, how many drops are in 1 mL?

5. A parsec is the distance that light travels in 3.26 years. How many kilometers does light travel in 1.0 parsec if light travels at a velocity of 3.00×10^8 m/s?