Measurements, Units and Conversion Factors

Experiment #1

Objective: To become familiar with units in the metric system and how to convert from metric units to English/American units or vice versa. To become familiar with scientific notation for large and small numbers and how to use international units or metric prefixes for powers of ten, and use of significant figures when representing various numbers with their appropriate units.

Introduction

Scientists and health professionals throughout the world generally use the International System of Units, or *Système International* (SI), which is the official system throughout the world, except in the United States. The standard SI units and metric units used in chemistry for length, volume, mass and temperature are given in Table 1.1.

Table 1.1. Units used in the SI system for all sciences and the metric system used in chemistry.

	Standard SI Units	Metric Units Used in Chemistry
Length	meter (m)	meter (m)
Volume	cubic meters (m^3)	liter (L)
Mass	kilogram (kg)	gram (g)
Temperature	kelvin (K)	degrees celsius (°C)

The metric system uses either kelvin or degrees celsius (°C) for temperature, whereas the United States still uses degrees Fahrenheit (°F) for temperature.

In addition to these standard units in the metric system, we also use prefixes to represent multiples of 10 times the unit. The prefixes *deci* (d) for one-tenth, *centi* (c) for one-hundreth, *milli* (m) for one-thousandth, and *micro* (the Greek letter μ or Latin mc) for one-millionth are used for smaller units (less than 1), while *kilo* (k) is used for larger units to represent one-thousand times, as shown in Table 1.2. In other words, 1000 mL is equal to 1 L and 1000 g is equal to 1 kg. It becomes a little trickier when we say that 1 dL = 100 mL, although 1 dL = 0.1 L and 0.1 L = 0.1 x 1000 mL = 100 mL. Similarly, 100 μL = 0.100 mL. It will be necessary to become familiar with these prefixes and units in order to succeed in chemistry and the health professions.

Table 1.2. Prefixes used in the metric system to represent powers of 10.

Prefixes less than 1	Power of 10	Prefixes greater than 1	Power of 10
deci- (d)	10^{-1} or 0.1	kilo- (k)	10^3 or 1000
centi- (c)	10^{-2} or 0.01	mega- (M)	10^6 or 1,000,000
milli- (m)	10^{-3} or 0.001	giga- (G)	10^9 or 1,000,000,000
micro- (μ or mc)	10^{-6} or 0.000001		

Although the liter is the standard unit of volume in the metric system and 1 mL is one-thousandth of a liter, another term is often used in medicine to represent 1 mL. That unit is the

cubic centimeter (abbreviated cm^3 or cc), which is equal to the volume of a cube with the dimensions of 1 cm on each side. As an aspiring health professional, you should become familiar with the relative size of 1 mL or 1 cm^3 or 1 cc, which are all the same and these units are often used to deliver specific dosages of liquid medications.

In this experiment you will practice using the metric system and the English/American system of units and converting the values from one system to the other. You will also learn to use scientific notation and the SI or metric prefixes used with units for large or small values of those units. You will also learn how to use significant figures when converting from one type of unit to another. This exercise can be done in a classroom with desks, rather than at the laboratory bench, since we will not be using laboratory equipment or chemicals.

Table 1.3. Some Useful Conversion Factors

Quant	American Unit	Metric Unit	Conversion Factor (Amer to Metric)	Conversion Factor (Metric to Amer)
Mass	Pound (lb)	Gram (g)	1 lb = 454 g	1 kg = 2.205 lb
	Ounce (oz)	Gram (g)	1 oz = 28.35 g	1 g = .03527 oz
Length	Inch (in)	Centimeter (cm)	1 in = 2.54 cm	1 cm = 0.3937 in
	Foot (ft)	Meter (m)	1 ft = 0.3048 m	1 m = 3.281 ft
Vol	Fluid Ounce (fl oz)	Milliliter (mL)	1 fl oz = 29.57 mL	1 mL = 0.0338 fl oz
	Quart (qt)	Liter (L)	1 qt = 0.946 L	1 L = 1.057 qt

The conversion of temperature is a little more complicated:
The American unit for temperature is degrees Fahrenheit (°F): °F = (1.8 x °C) + 32
The metric unit for temperature is degrees Celsius (°C): °C = (°F - 32)/1.8 or (°F - 32) x 0.555

In addition, the American system uses multiple units for mass, length and volume, whereas the metric system places a prefix for powers of ten before the standard unit when using large or small values for those units, as shown below.

<u>American Units</u>

16 oz = 1 lb

12 in = 1 ft; 3 ft = 1 yd; 36 in = 1 yd

8 fl oz = 1 cup; 2 cup = 1 pt; 2 pt = 1 qt

<u>Metric Units</u>

1000 g = 1 kg; 1000 mg = 1 g;
1000 µg = 1 mg; 1 x 10^6 µg = 1 g

100 cm = 1.00 m; 1000 m = 1.00 km

100 mL = 1 dL; 1000 mL = 1 L; 10 dL = 1 L

Name _____ Section _____

Measurements, Units and Conversion Factors

Experiment #1 **Prelab Exercise**

1. Convert the following measurements to different units as indicated (give all answers with the proper number of significant figures):

a) 3 ½ inches = _____ cm

b) 28 mm = _____ cm

c) 0.0583 kg = _____ g

d) 15.4 cm = _____ in

e) 98°F = _____ °C

2. Convert the following values for the indicated units.

0.0000348 g = _____ µg (mcg)

68700 g = _____ kg

85.3 dL = _____ mL

15700 mL = _____ L

3. A person has a serum total cholesterol reading of 234 mg/dL. What is the concentration of cholesterol in this person's serum in grams per liter? Show work.

(over)

Name _____ Section _____

4. Body mass index (BMI) is frequently used to indicate whether a person is of ideal weight, overweight, obese, or morbidly obese. Body mass index is defined as a person's mass in kg divided by that person's height in meters squared: BMI = mass (kg)/(height (m))^2

For each of the following individuals, calculate the body mass index (BMI). Show work below each listing.

A) Weight = 65 kg and height = 165 cm: BMI = _____

B) Weight = 290 lb and height = 5 ft 11 in: BMI = _____

C) Weight = 228 lb and height = 72 in: BMI = _____

Name _____ Section _____

Measurements, Units and Conversion Factors

Experiment #1 **Report Sheet**

Procedure

A. Measurements with a meter stick. Obtain a meter stick. On one side find the English length unit of inches (in) and on the other side centimeters (cm). Give all answers using the proper units or the appropriate abbreviations (not just a number).

1) How many inches are in a meter (reading the stick)? _____

2) How many cm are in a meter (reading the stick)? _____

3) Notice that each cm on the stick has 10 divisions.
What is the length of each of the smallest divisions on the stick? _____

4) How many millimeters (mm) are in a meter? _____

5) From the number of inches in a meter you recorded in step 1 and the number of mm you recorded in step 4, calculate the conversion factor for inches to mm (*i.e.* 1 in = ? mm). Show work.

B. Converting English and metric units. Use the tables in the introduction for conversion factors and prefixes for metric units.

1) Measure the length and width of this paper or cover of the lab manual in inches.

Conversion to cm for step 2

Length: _____ in.

Width: _____ in.

2) Convert the length and width to cm using the proper conversion factor. Show work above.

Name _____ Section _____

3) Now measure the paper using the metric side of the stick. Give the values below.

Length: _____ Width: _____

4) Calculate the area of the paper using the measurements you made in inches. Show work below and give the proper units. [Note: area = length x width]

5) Calculate the area of the paper using the measurements you have in cm or mm. Show work below and give the proper units.

6) Which units do you find the most convenient for measuring the dimensions of the paper? Explain.

7) Working with a partner, have your partner measure your height in meters as accurately as possible (without shoes). While you are at it, measure your height in inches as well.

Height: _____ m Height: _____ in

8) Since scales are not available, give your weight in pounds as you remember it from the last time you weighed yourself. Then convert your weight in pounds to weight in kg. Show work.

Weight: _____ lb

Weight: _____ kg

9) Now calculate your body mass index (BMI) using the formula below (show work):
BMI = weight (kg)/(height (m))^2

10) The book gives the following formula: BMI = [703 x (weight (lb)]/[height (in)]^2.
Calculate your BMI using this formula. Show work.

Name _____ Section _____

C. Working with volumes and significant figures.

1) Draw a square in the space below on the left that is 1.0 cm on a side and another square to the right that is 10.0 cm on a side.

2) Calculate the area of the small square that is 1.0 cm on a side, giving proper units.

3) If the square on the left above is given a third dimension of 1.0 cm height, calculate the volume of the cube with 1.0 cm dimensions. Give the proper units and significant figures.

4) You should become familiar with these dimensions and what this solid cube with 1.0 cm on a side represents in terms of volume. Give the volume of this cube using different units of volume that are commonly used in chemistry (see table 1.1).

Name _____ Section _____

5) Calculate the area of the square that is 10.0 cm on a side (on the previous page).

6) If the square with 10.0 cm on a side is given a third dimension of 10.0 cm height, calculate the volume of a cube with 10.0 cm dimensions. Give the proper units significant figures. Show work.

7) Knowing that 1.0 cm^3 is 1.0 mL, calculate the volume in mL of the cube with 10.0 cm on a side.

8) Give the number of liters for the 10.0 cm cube, using the proper number of significant figures.

9) Calculate the number of liters in a cube that is 1.00 m on a side.

Name _____ Section _____

D. Determining dosages for given drugs.

1) An injectable liquid contains 20.0 mg/mL of morphine. A doctor prescribes a dose of 0.050 mg/kg for a patient and you will need to give the injection. How many cc of the injectable liquid should you administer to a 65 kg patient? Show your work.

2) A doctor recommends that a patient receive a dose of 75 μg/kg (micrograms/kg) per day of porcinin for a particular ailment. The drug comes in 2 mg tablets. How many tablets would you recommend the patient take per day if she or he weighs 80 kg? Show work.

3. A 160 lb adult has 10 pints of blood (1 pint = 16 fluid ounces) circulating in the body.
(a) What is this person's blood volume in liters? [See table 1.3 for conversion factors] (Show work)

(b) If this person has a blood alcohol content of 0.08 % (w/v), how many grams of alcohol would this person have in the blood? (Show work)