Experiment #2. Measurements and Conversions.

Goals

1. To measure and record length, volume and mass accurately with the correct number of significant figures
2. To convert between units using conversion factors.

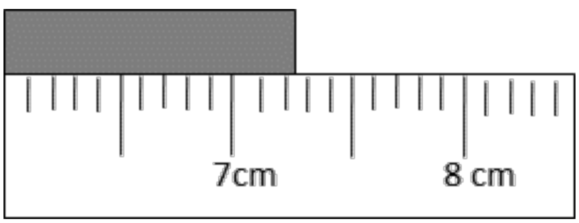
Making Measurements

Measurements are central to science and medicine. Scientists and medical professionals need to read and report measurements accurately and precisely to convey information to others. In this lab you will to learn how to read scientific instruments and report the results with the correct number of significant figures. Measurements contain certain and uncertain digits. The final digit of a measurement is assumed to have uncertainty and is usually estimated from the instrument being read. You will be expected to carefully and correctly record measurements using the procedures below for rest of the course.

Units of Length

We will use rulers to measure length. The standard unit of length in the metric system is the meter (m). A meter is divided into 100 centimeters (cm). Each centimeter is divided into 10 millimeters (mm).

Measurements taken with instruments with a scale, such as rulers, should be recorded to the nearest 1/10 of the smallest division. Two examples are below.



Smallest division on the ruler:	0.1 cm
1/10 of smallest division:	0.01 cm
Measurement should be read to the nearest:	0.01 cm

The object lies between the 7.2 and 7.3 cm lines. The space between the lines should be mentally divided into 10 to estimate the last digit of the measurement.
A correct reading of this instrument could be **<u>7.24 cm</u>**.

Units of Volume

Volume is a derived unit based on length. The unit of basic metric unit of volume is the liter (L). 1 liter is equal to 1 cubic decimeter $(dm)^3$. There are 1000 mL in 1 L. A milliliter is the same volume as 1 cm^3.

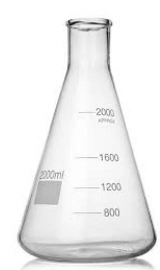
$$1 \text{ liter} = (1dm)^3 = (10\text{ cm})^3 = 1000\text{ cm}^3 = 1000\text{ mL}$$

We will use several types of instruments to measure volume in chemistry class.

<u>Beakers</u>

- glass containers with straight sides
- used to hold, mix and heat liquids
- markings give an approximate volume
- *beakers are <u>not</u> used for careful volume measurements*

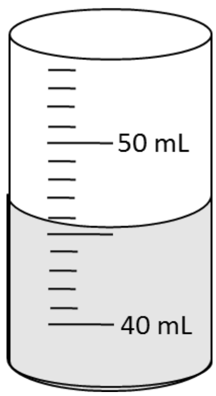
<u>Erlenmeyer Flasks</u>



- glass containers with tapered sides and a narrow opening.
- the shape is useful for swirling liquids without spilling and for limiting evaporation
- markings give an approximate volume
- *Erlenmeyer flasks are <u>not</u> used for careful volume measurements*

Graduated Cylinders

- long narrow cylinders with volume markings (also known as graduations)
- used to accurately measure volume
- some have a plastic guard to prevent breaks – it should be at the top of the cylinder.
- *graduated cylinders are not used to heat liquids* – the shape of the base does not transfer heat well
- *graduated cylinders are never used to mix substances or hold solids* – solids get stuck at the bottom of the cylinder and are difficult to mix and clean.
- using graduated cylinders
  - various sizes are available, generally the smallest cylinder that can accommodate the volume is used
  - if two scales are shown, always read the scale that increases up the cylinder
  - read at eye level
  - read the measurement at the lowest point of the meniscus (the curved surface of the liquid)
  - read to the nearest 1/10 of the smallest division



Smallest division on the cylinder:	1 mL
1/10 of smallest division:	0.1 mL
Measurement should be read to the nearest:	0.1 mL

The lowest part of the meniscus is between the 45 and 46 mL marks, somewhat closer to 45mL. Since the measurement must be to nearest 0.1 mL, 45 mL would NOT be a correct measurement. A correct reading of this volume could be **45.3 mL**. The final digit has uncertainty, so 45.2 or 45.4 mL would also be correct.

Units of Mass

A laboratory balance is used to measure mass. Mass is the measure of the amount of material or matter. The metric unit for mass is the gram (g) while the SI unit of mass is kilogram (kg).

The balance has a metal pan to weight materials on. Around the pan, there is a plastic shield and a cover. These protect the balance from fluctuations caused by drafts.

Using a balance

- Press the button labeled "tare" or "zero" until the numbers stabilize at zero.
  - If weighing a chemical, place a weigh boat on the balance before zeroing. Never put chemicals directly on the balance.
- Place the material on directly on the pan, or scoop into the weigh boat with a spatula.
- If the last digit fluctuates, you may estimate its value.
- If the value continues to go up or down, use the shield and cover.
- *Write every digit on the balance on your data sheet - never round off a mass measurement*. The final digit is considered uncertain.
- Weigh boats are single use. Dispose of them once used.
- Use the same balance for all measurements in an experiment
- Only weigh objects that are at room temperature.

weigh boats

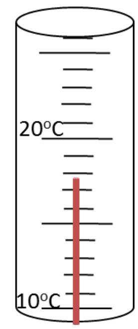
Procedures will often say “accurately weigh about 5g of X”, this means that you do need exactly 5.000 grams, but whatever mass you portion out should be recorded accurately. For instance 5.080 g and 4.952 g might be recorded as an accurate mass of approximately 5 g. Trying to hit exactly 5.000 g is unnecessary and a waste of time.

Additionally, the objects you weigh should be at room temperature. Warm objects create air currents that cause the balance to be inaccurate. You should also use the same balance for all measurements in an experiment.

Units of Temperature

A thermometer is used to measure temperature in the laboratory. Usually lab thermometers are in units of Celsius. We can use the following conversion equations to change to units of Kelvin or Fahrenheit.

$T_K = T_C + 273$ $\qquad\qquad$ $T_F = 1.8T_C + 32$



Reading a Thermometer

- The bulb of the thermometer should be completely submerged.
- The bulb should not touch the sides or bottom on of container, especially while heating.
- Wait for the temperature to stabilize before reading.
- Like all other instruments with scales, read the measurement to the smallest marking then estimate one additional digit. For the thermometer on the right, the smallest division is 1°C, so the measurement should be estimated to the tenths place such as: **17.8°C**

Conversion Factors

Conversion factors are often used in chemistry to convert one unit to another. A conversion factor can be made out of any two quantities that are equal to each other. We multiply by their ratio, the original units cancel, and measurement is converted to the new unit.

Equality: 1 m = 3.28 ft $\qquad$ Conversion factors: $\frac{1\ \text{m}}{3.28\ \text{ft}}$ or $\frac{3.28\ \text{ft}}{1\ \text{m}}$

To convert 2.68 m to feet, multiply by the second conversion factor – the unit you want to cancel should be in the denominator.

$$2.68\ \cancel{\text{m}} \times \frac{3.28\ \text{ft}}{1\ \cancel{\text{m}}} = 8.79\ \text{ft}$$

More than one conversion factor can be used in sequence when there is no one conversion factor to go between units. For example we can use two conversion factors to convert 2550 ft to km:

$$2550\ \cancel{\text{ft}} \times \frac{1\ \cancel{\text{m}}}{3.28\ \cancel{\text{ft}}} \times \frac{1\ \text{km}}{1000\ \cancel{\text{m}}} = 0.777\ \text{km}$$

When doing conversion problems, always write out units, always be sure that they are cancelling properly and verify that the only unit left is the unit of you desired answer (in the case above, km).

Laboratory Activity

Materials:	string	meterstick	wooden block	beaker	graduated cylinders
	Ruler	metal block	sand	ice	thermometer

Procedure

A. Measuring Length

1. Measure the circumference of your wrist using the metric side of a ruler. To do so cut a piece of string so that fits around your wrist, then measure the string. *When measuring be sure that you are estimating a digit!*
2. Measure your height in centimeters using a meterstick and the help of your lab partners. Convert your height in inches to centimeters and compare.
3. Choose a wooden block and note its letter on your data sheet. Measure the length, width and height to the correct number of significant figures. Multiply these values to find the volume in cubic centimeters.
4. Make your own conversion factor – measure the height of a 250 mL beaker in inches and in centimeters. Divide these numbers to find the centimeters per inch. Compare this the actual value 2.54 cm = 1 in.

B. Measureing Volume

5. Partially filled 10 mL, 100 mL and 1000 mL graduated cylinders will be placed in the front of the classroom. Read these cylinders to the correct number of significant figures.
6. Obtain a metal block with a hook and string. Fill a 500 mL graduated cylinder approximately half full of water and record the volume. Submerge the block gently by lowering the string and record the new volume. Use these values to calculate the volume of the block.

volume of block & water – volume of water = volume of block

C. Measuring Mass

7. Before you begin using a balance, be sure that the shield is not sitting on the weigh pan. Turn on the balance and hit tare/zero until it reads 0.000 g.
8. Place the wood block from Part A on the balance and record the mass. *Always record <u>all</u> digits on a balance*. If the last digit fluctuates without settling, estimate it. Convert this mass to pounds.
9. Place the beaker from Part A on the balance and record the mass. Convert this mass to kg.
10. Powdered or granular solids are weighed in disposable plastic weigh boats, not directly on a scale. Place a weigh boat on scale and tear until it reads 0.000 g. Add sand from a provided vial into the weigh boat and record the mass of the sand. Put the sand back in the vial by folding the weigh boat and then put the weigh boat in the trash can. Convert this mass to μg.

D. Measuring Temperature

11. Fill a beaker about 1/3 with deionized water. Measure the temperature with a thermometer. Be sure to estimate one digit.
12. Add approximately the same volume of ice to the water in the beaker. Wait for the temperature to stabilize and record it on your data sheet. Convert both measurements to Kelvin and Fahrenheit.

Name___________________________

Team Name _______________________

CHM101 Lab – Measurements and Conversions – Grading Rubric

Criteria	Points possible	Points earned
Lab Performance		
Printed lab handout and rubric was brought to lab	3	
Safety and proper waste disposal procedures observed	2	
Followed procedure correctly without depending too much on instructor or lab partner	3	
Work space and glassware was cleaned up	1	
Lab Report		
Part A (data recorded with correct sig figs and units, calculations shown clearly, all questions answered)	2.5	
Part B (data recorded with correct sig figs and units, calculations shown clearly, all questions answered)	1.5	
Part C (data recorded with correct sig figs and units, calculations shown clearly, all questions answered)	1.5	
Part D (data recorded with correct sig figs and units, calculations shown clearly)	1	
Post Lab: Question 1	1	
Post Lab: Question 2 (work shown in detail with units)	1	
Post Lab: Question 3 (work shown in detail with units)	1	
Post Lab: Question 4 (work shown in detail with units)	1.5	
Total	20	

Subject to additional penalties at the discretion of the instructor.

Measurements and Conversion: Data Sheet **Name ________________________**

Include the proper units for all measurements and **show all your work** for any calculations. Report your answer to the correct number of significant figures.

A. Measuring Length

In all measurements be sure to estimate the final digit and write correct units.

Circumference of wrist _________________________

Your height in centimeters (measured) _________________

Your height in inches (known) ____________________

Convert your height in inches to centimeters using conversion factors. Show your work.

How does this compare to your measured height in centimeters?

Letter on wooden block ______

length __________ cm width __________ cm height _________ cm

Calculate the volume of the block in cm^3. Be sure to round to the correct number of significant figures.

Height of beaker in centimeters (A) ____________ Height of beaker in inches (to nearest 1/16) (B) ___________

Measured conversion factor (divide (A) / (B)) __________cm = 1 in

Actual conversion factor __________cm = 1 in

How does this compare to the actual conversion value? Why might it be different?

B. Measuring Volume

Step 5:

Graduated Cylinder	smallest marks go up by…	read to nearest…	volume measurement with correct significant figures
10 mL			
100 mL			
1000 mL			

Step 6 volume of water _________________

volume of water + block _________________

volume of block _________________

C. Measuring Mass

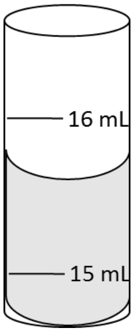
Item	measured mass	Convert to… (show work and units)
wood block		lb
beaker		kg
sand		μg

D. Measuring Temperature

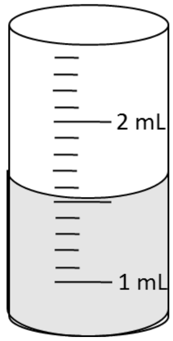
Substance	Temperature	Convert to … (show work)
water		^{o}F
Ice water		K

Measurements and Conversion: Post Lab Name ____________________________

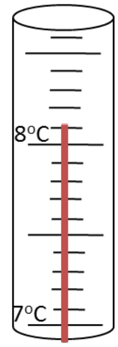
1. Read the following instruments to the correct number of significant figures.



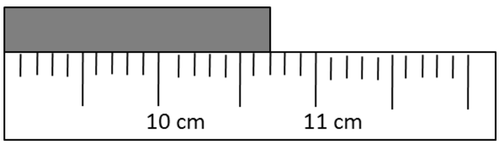
____



____



____



____

2. Convert 432 mg to pounds (lb)

3. Convert 5.8 gal to mL.

4. Convert 14.3 m to miles