Measurement and Density - Experiment 1

Purpose: The purpose of this experiment is to acquaint you with some common metric units of length, volume, and mass. You will also measure the density of an unknown metal and use this to try to identify the metal.

Procedure: Record all of your observations in the blanks provided using the **metric system**. Include the **units** on each measurement and show all of your calculations. For lengths, use centimeters (cm); for volume, cubic centimeters (cm^3); and for mass, grams (g). Note that 1 cm^3 = 1 milliliter (mL) and 1000 mL = 1 Liter (L).

Experiment #1

1. **Measure and record the length, width, and thickness of a book. (You can following the example but you will get different values).**

	(*Example*)	(Your book)
a. Length (L) :	27.20 cm	_____
b. Width (W) :	18.05 cm	_____
c. Thickness (T) :	2.00 cm	_____

The above three are examples of **direct measurements**.

Indirect measurements follow from mathematical operations (addition, subtraction, multiplication, division) on direct measurements.

2. **Using, length, width, and height, we indirectly "measure" the volume.**

For the *Example*, a calculator will help you determine that its volume must be near 981.92 units. The volume is reported as 982 cm^3.

a. What is the volume of your book (show your work)?

_____

b. The volume was found by a (direct / indirect) measurement. (Choose one)

3. **Now measure the mass of the book.**

a. What is the mass of the book? _____

b. How many sheets of paper are in the book? _____

4. Indirect measurements.

a. What is the thickness of each sheet ? _____ *HINT: thickness of book / # sheets*

b. What is the mass of each sheet ? _____

c. Would you expect to get the same answer if you weighed one sheet by itself, why?

Experiment #2 - There is a sample of unknown liquid on your desk.
In this next experiment you will identify an **unknown liquid**. This liquid was found in a bottle labeled "organic unknown - experiment #4". A search of our stockroom found an old organic lab prep notebook describing "experiment #4". It said there were four possible organic unknowns: butanol, water, carbon tetrachloride, and chloroform. We will do some measurements on the unknown liquid to help us determine which one of these four compounds is in the bottle.

1. What is the number on your unknown bottle ? _____

2. Determine the mass (g) of your unknown liquid.
a. What is the mass of the empty 50 mL erlenmeyer flask which is on your lab bench ?
_____ (± 0.01 g)

Fill the 50 mL erlenmeyer flask about 3/4 full with your unknown liquid.

b. What is the mass in grams (g) of the flask and unknown liquid ? _____ (± 0.01 g)

c. What is the mass in grams (g) of the unknown liquid alone ? _____ (± 0.01 g)
HINT: ((mass of liquid and flask) – (mass of flask))

3. Determining the volume of your unknown liquid.
Use a small plastic funnel to carefully pour the unknown liquid into a 100 mL graduated cylinder. The volume is measured at the bottom of the curved upper surface.

a. What is the volume of the unknown liquid ? _____ (± 0.1 mL)

Pour the unknown liquid back into the unknown bottle.

b. Calculate the weight in grams (g) of 1 milliliter (1 mL) of your unknown liquid?
HINT: mass of liquid / volume of liquid _____ (± 0.1 g/mL)

……

What we have calculated in the previous step is the **density** of the unknown liquid. Density is defined as weight per unit volume. With liquids, density is usually reported as grams per milliliter (the number of grams in **one** milliliter). With solids, density is usually reported as grams per cubic centimeter (the number of grams in **one** cubic centimeter).

$$Density = \frac{mass}{volume} = d = \frac{m}{v}$$

……

The density is a characteristic property of any substance and can be used in the identification of that substance. In order to determine the identity of our unknown liquid, we must look up the known value for each of the densities of our four possible liquids.

4. Find the known value of densities in the <u>Handbook of Chemistry and Physics</u>.

chloroform _____ butanol _____
(Methane, trichloro-) (1-butanol)

carbon tetrachloride _____ water_____
(Methane, tetrachloro-)

Based upon these four known values and the value you calculated for your unknown liquid, what is the identity of the unknown liquid?

Experiment #3 - There is a sample of unknown metal on your desk.
The city of Monmouth is cleaning up an old abandoned metallurgy factory. They find several crates containing unidentified cans filled with metal. In order to dispose of these metals properly, they must first be identified. Luckily they also found several shipping receipts so they know that the metal is Aluminum, Nickel, Lead, Tin (white), Cadmium, Bismuth, or Zinc. We will **indirectly determine** the **density of these metals** so the workers can properly dispose of them.

The volume of an irregular solid is not easily determined by measuring its dimensions, but can be determined by the displacement of water.

1. What is the number of your unknown metal? _____

2. Determine the mass of your unknown metal.
a. What is the mass of your unknown metal and container ? _____ (± 0.01 g)

b. What is the mass of the container ? _____ (± 0.01 g)

c. What is the mass of the unknown metal (m) ? _____ (± 0.01 g)

Pour exactly 50.0 milliliters of water into your 100 mL graduated cylinder (note: 1 milliliter equals 1 cubic centimeter). Hold your graduated cylinder at an angle of 45 degrees. SLOWLY AND CAREFULLY add the metal to the water in the cylinder. ***Use ALL of your metal****. Gently tap the graduated cylinder with your hand to displace any air bubbles which are attached to the pieces of metal.*

3. Determining the density of your unknown metal.
a. What is the volume of water that you put in your cylinder? _____(± 0.1 mL)

b. What is the volume of the metal and the water combined? _____ (± 0.1 mL)

c. What is the measured volume of the metal alone (V) ? _____ (± 0.1 mL)

d. What is the density (m / V) of your unknown metal ? _____ (± 0.01 g/mL)

4. Look up the known value of these densities in the Handbook of Chemistry and Physics. *The metals listed on the shipping receipts are listed below.*

Aluminum _____ Nickel_____ Zinc _____

Lead _____ Cadmium _____ Bismuth _____

Tin (white) _____

5. Use your calculated density and the "literature" values to identify your unknown metal so the workers can properly dispose of it.
a. Which metal is your unknown?_____

TA checking unknown liquid and metal:

Unknown Liquid _____

Unknown Metal _____

When you are finished, leave the metal pieces on a paper towel on top of your desk.

Post-Lab Calculations – To be done before leaving lab for the day!!!

The following calculations are all based on a cultural chemistry lab book .

The length (L) of the book in centimeters is 21.6 cm (± 0.1 cm).

The length (L) of the book in inches is 8.5 in (± 0.1 in).

1. How many centimeters are present in one inch ? _____ (± 0.01 cm)

2. How many centimeters (cm) are present in 7.7 inches ? _____ (± 0.1 cm)

3. How many meters (m) are present in 7.7 inches ? _____ (± 0.001 m)

4. How many millimeters (mm) are present in 7.7 inches ? _____ (± 1 mm)

5. How many inches (in) are present in 27.9 centimeters ? _____ (± 0.1 in)

6. How many inches (in) are in 1.74 meters ? _____ (± 0.1 in)

7. How many inches (in) are in 28.4 millimeters ? _____ (± 0.01 in)

8. How many millimeters (mm) are in 1.39 meters (m) ? _____ (± 10 mm)

9. How many centimeters (cm) are in 1.83 meters (m) ? _____ (± 1 cm)

10. How many meters (m) are in 43 millimeters (mm) ? _____ (± 0.001 m)

11. How many meters (m) are in 27 centimeters (cm) ? _____ (± 0.01 m)

Continuing with our calculations on the cultural chemistry book:

The length (L) of the book in centimeters is 21.6 cm (± 0.1 cm).

The width (W) of the book in centimeters is 15.5 cm (± 0.1 cm).

The thickness (T) of the book in centimeters is 1.3 cm (± 0.1 cm).

The mass (m) of the book in grams is 237.4 g (± 0.1 g).

12. Calculate the volume of the book (L*W*T) cm^3 _____ (± $1cm^3$)

13. If 1 cubic centimeter is equal to 1 mL, what is the volume of the book in mL?
_____ (± 1 mL)

14. Calculate the volume of the book in liters (L) : _____ (± 0.001 L)

15. What is the weight of the book in kilograms ? _____ (± 0.0001 kg)

16. What is the weight of the book in milligrams (mg) ? _____ (± 100 mg)

17. What is the density (in grams per cm^3) of the paper used to print the book?

_____(± 0.01 g/cm^3).