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Lab #2: Measurements and Density

PURPOSE:

During this lab, you will practice making measurements, performing calculations for volume and density, and converting between metric units.

INTRODUCTION:

The metric system of measurement is used by most countries in the world and all scientists. It is easy to convert between metric units because each conversion is some multiple of 10 larger or smaller than the base unit of measurement. Base units of the metric system include grams, meters, moles, liters, seconds, joules, and pascals which can all be manipulated by adding a prefix to the base unit. For example, meter is the base unit of distance. If you were working with a small distance, you might measure in centimeters. If you were working with a large distance, you might measure in kilometers.Derived units are obtained from equations and include more than one metric unit. One common derived unit is density which is calculated using the equation D= M/V. In the chemistry lab density is frequently measured in units of g/mL or g/cm^3.

PRELAB:

1. Units of Measurement: Identify the following abbreviated units as units of Mass, Length, Amount of Substance, Temperature, Volume, Area, Time, Density, Electric Current, Luminous Intensity, Energy, or Pressure.

a.) g/cm^3 Density
b.) Pa Pressure
c.) s Time
d.) m^2 Area
e.) cd Luminous intensity
f.) J Energy
g.) L Volume
h.) kg Mass
i.) m Length
j.) A Electric Current
k.) mol Amount of substance
l.) atm Pressure
m.) K Temperature
n.) cm^3 Volume

2. Arrange the units of measurement in each set from smallest to largest:

a. dam, cm, nm, Mm, Gm

nm, cm, dam, Mm, Gm

b. µg, dag, pg, Tg

pg, µg, dag, Tg

c. hL, mL, L, kL

mL, L, hL, kL

d. kPa, MPa, µPa, cPa (1000, 1,000,000, 10^{-6}, 10^{-2}) µPa, cPa, kPa, MPa

3. Fill in the blanks with the correct number to complete the inequality.

Ex. 1m = 100 cm

a. 1m = 10 dm
b. 1g = 10 dg
c. 1kg = 1000 g
d. 1L = 1,000 mL
e. 1 g = 1,000,000 µg
f. 1 Mm= 0.000001 m

4. Complete the following conversion factor problem. Show all dimensional analysis.

a. Convert 0.033 kilomoles to decimoles.

kmol → dmol

$\frac{0.033 \text{ kmol}}{1} \cdot \frac{10{,}000 \text{ dmol}}{1 \text{ kmol}} = 330 \text{ dmol}$

b. Convert 56 decaliters to hectoliters.

decaliters → hectoliters

$\frac{56 \text{ decaliters}}{1} \cdot \frac{1 \text{ hectoliter}}{10 \text{ decaliters}} = 5.6 \text{ hectoliters}$

c. Convert 459.11 kilograms to gigagrams.

kilograms → gigagrams

$\frac{459.11 \text{ kg}}{1} \cdot \frac{1 \text{ Gg}}{10^9 \text{ kg}} = 0.000\,459\,11 \text{ Gg}$

d. Convert 16.96 hectomoles to moles.

hectomoles → moles

$\frac{16.96 \text{ hmol}}{1} \cdot \frac{1 \text{ mol}}{0.01 \text{ hmol}} = 1696 \text{ mol}$

5. If the density of a substance is 0.525g/mL and the volume of a sample of this substance is 18.25mL, what is the mass of the sample in cg? (Remember sig figs and show work!)

$D = 0.525 \text{ g/mL}$ $\quad D = \frac{M}{V}$

$V = 18.25 \text{ mL}$ $\quad VD = M$

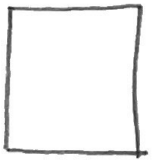
$m = (18.25 \text{ mL})(0.525 \text{ g/mL})$

$m = 9.58 \text{ g}$

$\frac{9.58 \text{ g}}{1} \cdot \frac{100 \text{ cg}}{1 \text{ g}} = \boxed{958 \text{ cg}}$

VD → M (g) → cg

6. A piece of paper is known to have an area of 30.2cm^2 and a volume of $5.2 \times 10^{-3} \text{cm}^3$. What is the thickness (height) of the paper in cm? (Remember sig figs and show work! Hint: Area= l x w, V= l x w x h)



$A = 30.2 \text{ cm}^2$

$V = 5.2 \times 10^{-3} \text{ cm}^3$

$A = l \cdot w$

$V = l \cdot w \cdot h$

$\frac{V}{A} = \frac{l \cdot w \cdot h}{l \cdot w} = h : \frac{5.2 \times 10^{-3} \text{cm}^3}{30.2 \text{ cm}^2} = \boxed{1.7 \times 10^{-4} \text{ cm}}$

$\frac{V}{A} \rightarrow h$

EXPERIMENTAL PROCEDURE: Determining Density of a Liquid

Go to: https://chemcollective.org/activities/vlab/69

You will solve the following problem using the virtual lab found at the link above. Go to the stockroom and drag the materials you need (solutions, graduated cylinder, and balance) onto the workbench. For more information about how to manipulate the virtual lab simulation you can watch the video here: https://chemcollective.org/chem/common/vlab_walkthrough_html5.php

The Problem: You work for a company that has many different research groups, and your group has just developed a new food preservative which has been named "Compund A"

Another group in your company has developed a new neurotoxin, which they have unfortunately also called "Compound A"

An intern was reorganizing the chemical storage stockroom, and placed all the bottles labeled "Compound A" on the same shelf.

You would like to begin testing the new food preservative, but don't know which bottle contains the food preservative and which contains the neurotoxin. It would clearly not be a good idea to put neurotoxin into your food products. You have asked a theoretical chemist what to do, and he said that the preservative will have a higher density

Your Task: Design an experiment to determine which bottle of Compound A contains the food preservative.

In detail, write out the steps of your procedure below and the information collected. Your instructions should be detailed enough that someone else could duplicate your steps. Create a data table showing the information you collected for both of the two solutions, then calculate the density of each solution. Which solution do you believe contains the food preservative?

Procedure

1.) Drag compound A-1 and A-2 into the workbench.

2.) To calculate volume, drag a 1,000 mL beaker into the workbench. Drag compound to beaker and enter "1000" then click pour. A message at the bottom will state the mL transferred which is the volume. A-1 Vol: 138.39 mL
A-2 Vol: 163.50 mL

3.) To calculate mass, drag a scale onto the workbench. To measure the mass of the liquid, first subtract the weight (tare) of the beaker. Pour liquid into the 1000 mL beaker and place the beaker onto the scale and click "tare". Pour liquid back into beaker and place on scale to measure mass (g). A-1 Mass: 174.2400g
A-2 Mass: 135.9730g

4.) Divide mass by volume to derive density in g/mL.

5.) Compare densities to determine which beaker contains the food preservative.

Data Table

	Mass	Volume
Compound A-1	174.2400 g	138.39 mL
Compound A-2	138.9730 g	163.50 mL

$D = \frac{M}{V}$

D_{A-1} : $\frac{174.2400\ g}{138.39\ mL} = 1.2600\ g/mL$

D_{A-2} : $\frac{138.9730\ g}{163.50\ mL} = 0.84999\ g/mL$

$D_{A-1} > D_{A-2}$

I believe Compound A-1 contains the food preservative.

POSTLAB: SHOW ALL WORK AND DIMENSIONAL ANALYSIS!!!

1. The speed of light in a vacuum is 2.998×10^8 m/s. What is its speed in km/hr?

$\frac{2.998 \times 10^8 \text{ m}}{1 \text{ s}} \cdot \frac{1 \text{ km}}{1000 \text{ m}} =$ **3.079800 km/s.**

2. A cylindrical rod formed from silicon is 16.8 cm long and has a mass of 2.17kg. The density of silicon is 2.33 g/cm^3. What is the diameter of the cylinder? (The volume of a cylinder is given by $\pi r^2 h$, where r is the radius and h is its height or length.)

$D = \frac{M}{V}$ $\quad VD = M$ $\quad V = \frac{M}{D}$

$V = \frac{2.17 \text{ kg}}{0.00233 \text{ kg/cm}^3} \cdot \frac{2.33 \text{ g}}{1 \text{ cm}^3} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} = 0.00233 \text{ kg/cm}^3$

$V = 931 \text{ cm}^3$

$931 \text{ cm}^3 = \pi r^2 (16.8 \text{ cm})$

$55.4 \text{ cm}^2 = \pi r^2$

$\sqrt{17.6 \text{ cm}^2} = \sqrt{r^2}$ $\quad r = d$

$4.20 \text{ cm} = r$ $\quad 2(4.20) = d$

d = 8.40 cm

3. Gold can be hammered into extremely thin sheets called gold leaf. If a 200mg piece of gold (density= 19.32g/cm^3) is hammered into a sheet measuring 2.4 ft x 1.0 ft, what is the average thickness of the sheet in centimeters?

$D = 19.32 \text{ g/cm}^3$

$M = 200 \text{ mg} \cdot \frac{1 \text{ g}}{1000 \text{ mg}} = 0.2 \text{ g}$

$D = MV$ $\quad \frac{D}{M} = V$

$\frac{19.32 \text{ g/cm}^3}{0.2 \text{ g}} = 96.60 \text{ cm}^3$

$A = 2.4 \text{ ft}^2$ (2.4 ft × 1 ft)

$2.4 \text{ ft}^2 \cdot \frac{30.48 \text{ cm}}{1 \text{ ft}} \cdot \frac{30.48 \text{ cm}}{1 \text{ ft}} = 2229.6729 \text{ cm}^2$

$M(mg) \rightarrow M(g) \rightarrow \frac{D}{M} \rightarrow V(cm^3) \rightarrow \frac{V}{A} = h(cm)$ $\quad A(ft^2) \rightarrow cm^2$

$\frac{V}{A} = \frac{96.6 \text{ cm}^3}{2229.6729 \text{ cm}^2}$

0.043 cm

4. An individual suffering from a high cholesterol level in her blood has 232 mg of cholesterol per 100 mL of blood. If the total blood volume of the individual is 5.2L, how many grams of total blood cholesterol does the individual contain?

$D = \frac{232 \text{ mg}}{100 \text{ mL}}$ $\quad V = 5.2 \text{ L}$

$\frac{232 \text{ mg}}{100 \text{ mL}} \cdot \frac{1 \text{ g}}{1000 \text{ mg}} \cdot \frac{1000 \text{ mL}}{1 \text{ L}} = 2.32 \text{ g/L}$

$D = \frac{M}{V}$ $\quad M = DV$

$M = (2.32 \text{ g/L})(5.2 \text{ L})$

$M = 12.064 \text{ g}$

$D(mg/mL) \rightarrow D(g/L) \rightarrow M(g)$

12 g

5. The recommended adult dose for a medication is 6mg/kg of body mass. Calculate the dose in milligrams for a 150 lb person.

$D = \frac{M}{V}$ $\quad V = \frac{M}{D}$

$\frac{6 \text{ mg}}{1 \text{ kg}} \cdot \frac{1 \text{ kg}}{2.20462 \text{ lb}} = 2.7\ldots \text{ mg/lb}$

$\frac{150 \text{ lb}}{2.7 \text{ mg/lb}} =$ **55.1155 mg**

$D(mg/kg) \rightarrow D(mg/lb) \rightarrow \frac{M(lb)}{D(mg/lb)} \rightarrow V(mg)$

6. You have 1.5 lbs of gold. Find its volume in cubic meters if the density of gold is 19.3 g/cm^3.

$D = 19.3 \text{ g/cm}^3$

$M = 1.5 \text{ lb}$

$D = \frac{M}{V}$ $\quad V = \frac{M}{D}$

$\frac{19.3 \text{ g}}{1 \text{ cm}^3} \cdot \frac{1 \text{ lb}}{453.59237 \text{ g}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} = 42549.2166 \text{ lb/m}^3$

$\frac{1.5 \text{ lb}}{42549.2166 \text{ lb/m}^3} =$ **3.5×10^{-5} m^3**

$D(g/cm^3) \rightarrow D(lb/m^3) \rightarrow \frac{M(lb)}{D(lb/m^3)} = V(m^3)$

7. A block of dry ice has a density of 90.0 lbs per cubic foot. Convert this density to g/cm^3. If the density of water is 1.0g/cm^3 will dry ice float in water?

$\frac{90.0 \text{ lb}}{1 \text{ ft}^3} \cdot \frac{453.59237 \text{ g}}{1 \text{ lb}} \cdot \frac{1 \text{ ft}}{30.48 \text{ cm}} \cdot \frac{1 \text{ ft}}{30.48 \text{ cm}} \cdot \frac{1 \text{ ft}}{30.48 \text{ cm}} = 1.44 \text{ g/cm}^3$

$D(lb/ft^3) \rightarrow D(g/cm^3)$

$D_{dry\ ice} = 1.44 \text{ g/cm}^3$

$D_{water} = 1.0 \text{ g/cm}^3$

$D_{dry\ ice} > D_{water}$ ... dry ice will not float in water.

8. The flow rate is 12 cm^3/s. Convert this to L/hr.

$\frac{12 \text{ cm}^3}{1 \text{ s}} \cdot \frac{1 \text{ L}}{1000 \text{ cm}^3} \cdot \frac{3600 \text{ s}}{1 \text{ hr}} =$ **43 L/hr**

$cm^3/s \rightarrow L/hr$