Density Lab

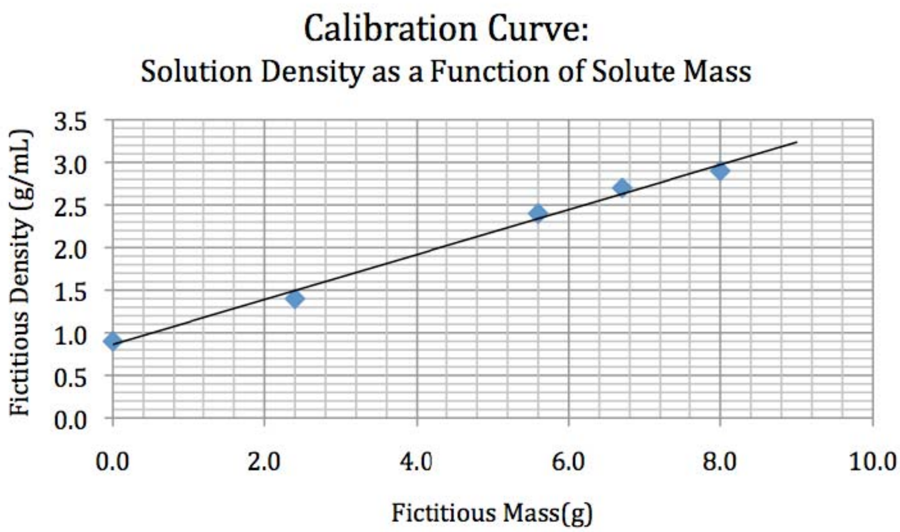
(Section 1: Modified procedure based on Cañada College CHEM 192 Laboratory Manual ©2009, Section II: Modified procedure based on Stanford University Chem31A section materials ©2009)

Section I. Density of Solutions

The density of a solution depends on how much matter is dissolved in it. Consider a bottle of syrup and an equally sized bottle of water. The sugar-rich syrup is heavier than the sugar-free water. In this lab, we will estimate the sugar content of sodas by analyzing the density of sugar solutions containing different masses of sugar.

Calibration Curve

A calibration curve is used to determine a trend using known quantities. A linear calibration curve shows a trend that can be described with a straight line. A straight line follows the generic equation: $y = mx + b$, where m is the slope and b is the y-intercept. The y-intercept is the point at which the line crosses the y-axis. The regression line describes the general trend of the data. Data points may not fall exactly on the line. Observe the example below. Even though the regression line does not go through any of the data points, it shows the trend followed by the data.



In this lab you will construct a calibration curve by dissolving different amounts of sugar in water. The amount of sugar in soda is then estimated by determining the density of the soda and determining its sugar content from the calibration curve.

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Procedure

Part A. Density Determination:

1. For Run #1:
   a. Zero the balance. Weigh the empty graduated cylinder and record its mass in the "Mass of Graduated Cylinder" column in the table below. Use this number for all four runs.
   b. Fill the graduated cylinder with water to 25.0 mL.
   c. Zero the balance. Weigh the filled graduated cylinder and record its mass in the "Total Mass of Sugar Solution and Cylinder" column.
2. For Run #2:
   a. Place a weighing boat on the balance and tare the balance.
   b. Weigh out approximately 2 g of sugar and record the actual mass in "Actual Mass of Sugar Added" column.
   c. Calculate the total amount of sugar added to the cylinder so far and record this mass in the "Total Mass of Sugar Added" column.
   d. Add the sugar to the graduated cylinder. Stir to fully dissolve all sugar. Record the actual volume in the "Actual Volume of Sugar Solution" column.
   e. Zero the balance. Weigh the filled graduated cylinder and record its mass.
3. Repeat step 2 for Run #3 and #4, weighing out an additional 2 g of sugar each time. The "Total Amount of Sugar Added" for Run #2, 3, and 4 will be approximately 2 g, 4 g, and 6 g.

Table 1: Measurements of Sugar and Sugar Solution
Grey areas denote calculated values

Run #	Mass of Graduated Cylinder (g)	Actual Mass of Sugar Added (g)	Total Mass of Sugar Added (g)	Actual Volume of Sugar Solution (mL)	Total Mass of Sugar Solution and Cylinder (g)	Mass of Sugar Solution (g)	Density of Sugar Solution (g/mL)
1		0.000	0.000	25.0			
2							
3							
4							

4. Enter your data into the Excel worksheet provided to calculate the mass of the sugar solution ($m_{sugar\ solution} = m_{sugar\ solution\ and\ cylinder} - m_{cylinder}$) and the density of the sugar solution (d = m/v).
5. Print out a copy of the calibration curve for use in Part II.

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Part B. Determine the density of a sample of a soft drink.

1. Rinse and dry out your 50 mL graduated cylinder.
2. Zero the balance. Weigh the dry empty graduated cylinder and record its mass in the table below.
3. Fill the graduated cylinder with 25.0 mL of a regular soda. Record the name of sample used.
4. Weigh the filled graduated cylinder and record its mass in the table below.
5. Calculate the mass of the solution.
6. Calculate the density (d = m/v).
7. Repeat steps 1-6 for the corresponding diet soda.

Table 2: Measurements of a Drink Sample
Grey areas denote calculated values

Drink	Mass of Cylinder (g)	Volume of Drink (mL)	Total Mass of Drink and Cylinder (g)	Mass of Drink (g)	Density of Drink (g/mL)
Soda ___________		25.0			
Diet Soda ___________		25.0			

8. Use the calibration curve obtained in Part I to figure the mass of sugar per 25 mL of sample tested.

   Mass of sugar per 25 mL of soda: ______________________

   Mass of sugar per 25 mL of diet soda : ______________________

9. Joe drank a can of regular soda. (a) How many grams of sugar did he consume? (b) How does the experimentally estimated sugar content compare to the sugar content indicated on the label?

10. Josephine drank a can of diet soda. (a) How many grams of sugar did she consume? (b) How does the experimentally estimated sugar content compare to the sugar content indicated on the label? (c) Is there a difference between (a) and (b), and if so, what may be the cause for the discrepancy?

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Section II. Density of Gases

In 1811, Avogadro hypothesized that equal volumes of gases at the same temperature and pressure contain the same number of particles. The mass, volume (and therefore density!) of a gas can be measured, just as with a liquid. Using these measurements and applying Avogadro's Law, we can determine the identity of an unknown gas.

Procedure

Three unknown gases are provided in balloons. Perform the following for each unknown gas:

1. Take your plastic syringe and push the plunger all the way into the syringe. Close the valve and *with the valve closed*, pull out on the plunger until the hole in the side of the plunger is accessible. Insert the nail through the hole to keep the plunger from closing. Record the volume of space available in the syringe in the table below (be sure to convert to liters!).
2. Zero the balance. Weigh the syringe and record its mass in the table.
3. Attach the syringe to the valve on the gas balloon and open the valves on both the syringe and the gas balloon, allowing a sample of gas inside the syringe.
4. Close both valves. Detach the syringe.
5. Reweigh the syringe and record its mass in the table.

Sample #	Syringe Volume (L)	Mass of syringe (g)	Mass of syringe + gas (g)	Mass Difference (g)	Identity of unknown gas
1					
2					
3					

6. Determine the mass of gas by calculating the mass difference between step 2 and step 5 for each of the gases and record your value in the table.

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7. Avogadro's Law says that at standard pressure and room temperature, the number of molecules of any gas in a given volume is 2.46×10^{22} molecules/L, or 0.0409mol molecules/L. How many molecules of gas are in your syringe when it is filled? (Hint: give your total in mol)

8. Using your masses from question 6 and your calculation from number 7, determine the molecular weight of each of the unknown gases. Use the table provided to identify your unknown gases.

Gas	**Molecular weight (grams/mol)**
Hydrogen	2
Helium	4
Methane	16
Air	28 (average)
Oxygen	32
Carbon Dioxide	44
Butane	58
Chlorine	71

9. Just as certain items can float in water (a fluid), we can also consider air a fluid in which items can float. Considering the mass densities of each gas – would a balloon of pure carbon dioxide float in air? Why does a balloon of helium float?

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