General Chemistry Lab Spring

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Online:
< http://cnx.org/content/col10506/1.56/ >

C O N N E X I O N S

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Collection structure revised: April 3, 2009
PDF generated: October 26, 2012
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Chapter 1

Practical Examples of the Gas Laws[1]

Practical Examples of the Gas Laws
Objectives

- Learn and understand physical properties of gases and explain observations in terms of the kinetic molecular theory of gases.
- Plot and calculate the root mean square speed of the Carvone molecules. (Comparison with speed in vacuum).
- Estimate volume and volume change of a balloon when it goes from room temperature (RT) to liquid nitrogen temperature.
- Observe and explain behavior of gas in: a soda can, a balloon in a flask, Cartesian diver, etc., when a change in pressure or temperature is applied.

1.1 Grading

You grade will be determined according to the following:

- Pre-lab (10%)
- Lab Report Form (80%)
- TA points (10%)

Introduction

Expanding and contracting balloons, imploding soda cans, exploding marshmallows are just some of the demonstrations that are often used to illustrate the empirical gas laws and the kinetic molecular theory of gases. In this experiment, you will be performing these and other 'demonstrations' and using your understanding of the physical properties of gases to explain your observations.

There will be two demonstrations laid out at each of the seven different stations around the room and you will go as a group, half the group working at each station (you don't need to start with #2). If your group starts with, for example station 5, you should then follow the following order: 5, 6, 7, 8, 2, etc. Your group should spend no more than 15 minutes at each station, in some cases 5 minutes is sufficient. Perform the experiment by following the instructions placed at each station. Then discuss your observations with your group. For each of the activities, it is important to ask yourself what is going on; "how can our observations be explained using the kinetic molecular theory of gases?" Remember that for some demonstrations calculations may also be required. Be thorough and precise in your explanations.

Important Safety Notes:

Remember to use tongs, hot grips as appropriate when dealing with hot liquids, vapors and containers.

[1]This content is available online at <http://cnx.org/content/m19475/1.4/>.

Liquid nitrogen is extremely cold, with a boiling point of $-196\,°C$ and if it comes into contact with skin can result in severe frostbite.

The vacuum dessicator should be regarded as a potential implosion hazard when evacuated. Handle it carefully.

When doing the egg experiment do not put the hot flask immediately in the water bath (let it for at least 3 minutes sitting on the bench) as it will crack.

Observe and record what happens in your laboratory report form and explain your observations in terms of the Kinetic Molecular Theory of Gases.

You are encouraged to discuss among yourselves possible explanations to your observations.

Experimental Procedure

Diffusion:

- The goal of this experiment is to measure the rate of diffusion of carvone, a major component of spearmint oil. We will do these trials altogether, with volunteers, at the end of the pre-lab lecture. You will all stand in a line, with the first person in the group holding the bottle of carvone and several paper towels. All four people should be 1 meter apart. You will need to know the distance each person is from the bottle of carvone. The fourth person should act as the timekeeper.
- When the timekeeper gives the signal, the first person should place a few drops of carvone on the paper towels. Record the time that it takes for each person to smell the carvone. Seal the paper towel in a plastic bag when you are finished.
- After the odor has dissipated, we will repeat the experiment twice with more volunteers.
- Using Excel plot the data in distance traveled versus time. Obtain a least squares fit (R^2, R squared value) for this data and determine from it the rate of diffusion of carvone in meters per second. Create a graph for each trial. Calculate the average of the rates for the three trials. Calculate the root mean square speed of carvone molecules at $25\,°C$. Your TA will help you with this equation. Compare the result with the diffusion rate you measured.
- If they are significantly different, offer an explanation.
- Would the diffusion take place faster in a vacuum?

Note: The formula of carvone is $C_{10}H_{14}O$, MW=150.22 g/mol.

Since, PV = nRT

and nRT = (1/3)Nm μ^2.

Solving for μ gives:

$\mu = \sqrt{3\mathrm{RT}/M}$.

where M = mN/n or the molar mass in kg/mol, T is in k, and R is 8.3145 kg $* m^2/s^2 *$ mol $* K$. The μ, we are using is the root mean square speed, as it is the root of the sum of the squares of the individual velocities.

The plots can be prepared when you have finished the lab.

1. Gas Laws in a Soda Can:

1. Pour 15 mL of water into an aluminum soda can. Set the can on a hot plate and turn on to a high temperature setting. While the can water heats, fill a 1000-mL beaker with cold water (You may have a metal tin set out for this purpose). Continue heating the can until the water inside boils vigorously and until steam escapes from the mouth of the can for about 20 seconds.
2. Using the hot grips to grip the can near the bottom, quickly lift the can from the burner and invert it in the beaker of cold water so water covers the mouth of the can.
3. Describe what happens.
4. Explain why it happens. You may repeat this experiment using a second soda can if you wish.
5. Why is it necessary to invert the can in the water? What would happen if a rigid container were used?
6. Balloon in liquid nitrogen:

Review the safety notes above regarding the handling of liquid nitrogen.

1. Inflate a balloon and tie the end (several balloons may have already been inflated and tied). Using tongs, place the balloon in a Dewar flask containing liquid nitrogen. After the balloon stops changing size, remove it from the Dewar and allow it to warm to room temperature.
2. Observe and record the changes (you should be able to measure the radius and estimate volume). Estimate the size of the balloon in liters.
3. What is the pressure inside the balloon before it is placed in the liquid nitrogen?
4. What is the pressure inside the balloon after it is placed in the liquid nitrogen?
5. Use the ideal gas law to calculate the percent change in volume expected on going from room temperature to liquid nitrogen temperature.
6. Is the volume of the cold balloon consistent with what you calculated, or is it larger or smaller?
7. Suggest an explanation for your observation. Explain all of your observations in detail using the kinetic molecular theory of gases.
8. How does the liquid nitrogen cool the gas in the balloon?

1. Kissell's tygon tube in liquid nitrogen:

Review the safety notes above regarding the handling of liquid nitrogen.

1. Place a 2 foot long tygon clear tube in a Dewar with liquid nitrogen.
2. Observe what happens and explain.
3. Balloon in a flask:

1. Place about 5 mL of water in a 125-mL Erlenmeyer flask. Heat the flask on a hot plate until the water boils down to a volume of about 1 mL.
2. Meanwhile, inflate a balloon and then let the air out (this may not be necessary if balloons on table have been previously used).
3. Remove the flask from the heat, hold it with a towel, and immediately place the open end of the balloon over the mouth of the flask.
4. Observe the effect as the flask cools.
5. Can you get the balloon back out again?
6. If you can, How?
7. Cartesian diver:

The Cartesian diver is named for Rene Descartes (1596-1650), noted French scientist and philosopher. At this station, you will find a plastic soda bottle containing a medicine dropper, water, and air. Squeeze the bottle.

What happens? Why?

1. The Egg:

1. Lightly grease the inside of the neck of a 1 L Erlenmeyer flask with stopcock grease. Clamp the flask onto the stand. Place about 5 mL H_2O in the flask and gently warm it with a Bunsen burner until the water vaporizes. Do not boil the water to dryness.
2. Meanwhile, prepare an ice water bath in an evaporating dish. While the flask is warm, seat the egg, narrow end down, in the mouth of the flask. Unclamp the flask, allow to cool slightly sitting on the bench and then immerse it in the ice water. (Read the safety notes above to avoid breaking the flask)
3. Can you get the egg back out again?
4. Assuming that the flask reaches the maximum vacuum (minimum pressure) possible before the egg is drawn into the flask, calculate the minimum pressure reached in the flask.
5. Expanding balloon:

1. Partially inflate a balloon. Place the balloon inside the vacuum chamber and close the chamber with the black rubber circle and the top of the chamber carefully centered on the base (A partially inflated balloon may already be in the dessicator).
2. Close the needle valve (at the bottom of the black rubber tubing) by turning it clockwise. Turn the stopcock to the up position to connect the chamber to the vacuum pump.
3. What happens? Explain? To open the chamber, turn the stopcock to the left position and open the needle valve.

Moore's bonus 2 points:
1pt to name a real life example of the physical properties of gases at work
1pt for a good explanation of how and why it works according to what you have learned in the lab.

Chapter 2

Colligative Properties and Ice Cream[1]

Colligative Properties and Ice Cream

Objectives

- To record facile and fast data collection from the computer interface, ubiquitous in industry and, in this case, to calculate the molecular weight of the unknown solute using freezing point depression
- To learn the definition of molality and the importance of molality in colligative property calculations
- To learn to calculate the molality of a solution
- To measure the freezing point depression caused when adding antifreeze to tert-butanol
- To calculate the molecular weight of the unknown solute using freezing point depression

2.1 Grading

You will be determined according to the following:

- Pre-lab (10%)
- Lab Report Form (80%) – including temperature plots
- TA evaluation of lab procedure (10%)

Introduction

Although colligative properties involve solutions, they do not depend on the interactions between the solvent and the solute molecules but rather on the number of solute particles dissolved in solution. Colligative properties include vapor pressure lowering, osmotic pressure, boiling point elevation, and freezing point depression. In this experiment you will explore freezing point depression using a solution of ethylene glycol in tert-butanol. You will then use freezing point depression to calculate the molar mass of an unknown solute that is dissolved in tert-butanol.

Ethylene glycol, (CH2OH)2 the major component of antifreeze, is a large organic molecule that dissolves easily in water. The structure of ethylene glycol is shown in Figure 1.

[1]This content is available online at <http://cnx.org/content/m19545/1.4/>.

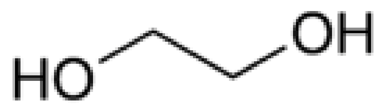

Figure 2.1

Antifreeze keeps the water in a car's radiator from freezing because the ethylene glycol molecules get in the way when water tries to crystallize into ice. It is more difficult for the ice crystals to form, due to the fact that the water must be at a lower kinetic energy. Therefore, the water freezes at a lower temperature than if the glycol molecules were not present. The effect of the ethylene glycol molecules present in a solutioncan be quantified by the following equation:

ΔT = iKfm Equation 1

where Δ T = Tpure - Tsolution, the difference between the freezing temperature of the pure solute and the freezing temperature of the solution. Kf is the freezing point depression constant of the solvent, having units of °C/m, and m is concentration of the solution using units of molality. This equation reflects the fact that a more concentrated solution results in a greater change in freezing temperature.

Most of the previous work that we have done with solutions probably has involved units of molarity, or moles per liter of solution. Freezing point depression calculations (as well as those for boiling point elevation) use molality, or moles of solute per kilogram of solvent. By definition, a freezing point depression or boiling point elevation involves a change in temperature. When the temperature of a solution changes, its volume also changes. Since molarity depends on the volume of the solution, a change in temperature will change the solution's molarity. Molality depends on the mass of the solvent, and this does not change with temperature.

The solvent we will use in this experiment is tert-butanol (IUPAC name: 2-Methyl-2-propanol) also called tert-butyl alcohol. It has a characteristic camphor type smell and is used in paint removers, to boost octane in gasoline and in perfumes. Its structure is given in Figure 2.

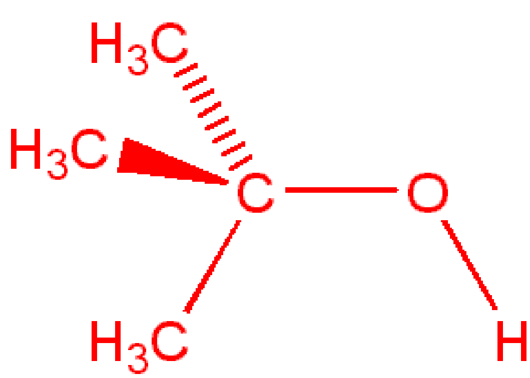

Figure 2.2

In this experiment we will measure the freezing temperature of pure tert-butanol, then measure the freezing point of a solution containing 3-5 grams of ethylene glycol added to tert-butanol. The difference in freezing temperatures for the two solutions gives the Δ T in Equation 1. Since the purpose of this experiment is to find the molecular weight of the solute, Equation 1 can be rewritten to include molecular weight of the solute:

$$\Delta T = iK_f m = K_f\left(\frac{\text{moles solute}}{\text{kg of solvent}}\right) = K_f\left[\frac{\left(\frac{\text{grams solute}}{\text{molar mass of solute}}\right)}{\text{kg of solvent}}\right] \qquad \text{Equation 2}$$

Figure 2.3

For this experiment, use a Kf for tert-butanol of 8.37 °C/m.

The only unknown in equation 2 is the molar mass of the solute. If you algebraically rearrange Equation 2, you can then solve for molar mass. This algebraic manipulation is left as an exercise for you to complete.

SAFETY PRECAUTIONS: Ethylene glycol and tert-butanol are safe if handled properly, but are mildly poisonous if swallowed. These chemicals can also cause allergic reactions with skin contact. Wear plastic gloves when pouring and measuring these chemicals. If you spill any on your hands, wash immediately with soap and water. Be sure to wear safety glasses at all times during this experiment.

Experimental Procedure

Part 1: Freezing point of tert-butanol

1. Open the MicroLab Program by clicking on the shortcut to MicroLab.exe tab on the desktop.
2. On the "Choose an Experiment Type" tab, enter a name for your experiment, and then double click on the MicroLab Experiment icon.
3. Click "Add Sensor", choose sensor = Temperature (thermistor).
4. To choose an input, click on the red box that corresponds to the port which the thermistor is connected.
5. Choose label = Thermistor, sensor units = ° C, click next.
6. Click "Perform New Calibration".
7. Click "Add Calibration Point" and place the thermistor and a thermometer in an ice water bath. Wait until the temperature is constant, then read the temperature on the thermometer and enter that value into the "Actual Value" box in MicroLab and hit "ok".
8. Again, click "Add Calibration Point" and place the thermistor and a thermometer in a warm water bath. Wait until the temperature is constant, then read the temperature on the thermometer and enter that value into the "Actual Value" box in MicroLab and hit "ok".
9. Under Curve Fit Choices, click on "First order (linear)" and then "Accept and Save this Calibration", when prompted to enter units, enter as "deg C". Save as your name-experiment data.
10. Click "Add Sensor", choose sensor = Time
11. Choose an input, click on the red box that corresponds any of the timers.
12. Label = Time 1, click next, click finish.
13. Left click on thermistor and drag to: the Y-axis over "data source two", column B on the spreadsheet, and the digital display window.
14. Left click on time and drag to: the X-axis over "data source one", column A on the spreadsheet, and the digital display window.
15. When ready to obtain data, click start.
16. Take a clean, dry 10cm test tube, and fill it half-way with tert-butanol, dispensed by your TA.

NOTE: The tert-butanol must be distributed by your TA to avoid impurities that will cause tremendous errors in the experiment. You will need a very clean and very dry test tube for each of your experiment runs. If any impurities (especially water) mix with the tert-butanol, your data will be severely affected.

ANOTHER NOTE: Make sure that your solution in your test tube is below the level of the water in the water bath

1. Warm the test tube to 30-35 °C by placing it in a warm water bath. Start your data acquisition program, and place the test tube in an ice/water bath. You must constantly stir the tert-butanol to prevent supercooling.
2. The temperature of the tert-butanol should steadily drop, then level off, as the liquid freezes. When the tert-butanol is completely solid and the temperature starts decreasing again, you may stop your experiment. This will be the freezing temperature you use as Tpure when you calculate Δ T. Record this value in your data sheet. If your cooling curve does not flatten out very well and it is difficult to determine the freezing temperature, warm your sample with the hot water bath, and measure the freezing point again.

Note: If you do not get an acceptable curve (your TA can verify if it's acceptable) on your second try, then you should ask for a new sample of tert-butanol. The rest of your results for this lab depend on this measurement being accurate.

Part 2: Freezing point depression

1. After finding the freezing temperature of pure tert-butanol you will make a solution of tert-butanol and antifreeze. Set your test tube inside a 50 or 100 mL beaker and then place the beaker on the balance to weigh your sample.
2. First, weigh only the empty test tube and record this value in your data sheet.
3. Fill the test tube half full of tert-butanol (again from your TA), weigh again, and record this value.
4. Finally, add a few drops of antifreeze (3 or 4 drops is sufficient), weigh the beaker/test tube combination a third time, and record this value. Use the same balance for all three weighings. Use subtraction to find the masses of the tert-butanol and the added antifreeze. It is not critical how many drops you add, but the mass that you measure is the important value.
5. Find the freezing temperature for your solution in the same way you found the freezing temperature for pure tert-butanol. The flat portion of your temperature curve will be smaller and more difficult to see for your mixed solution than for the pure tert-butanol. If you are running a live graph in your program, you should be able to tell where the freezing point of your solution occurs. As before, you may re-warm your solution and run it again if your cooling curve does not show a clear freezing point. If time permits, you may want to perform more than one run on each solution to confirm your freezing temperatures.
6. Subtract the freezing temperature your solution from the freezing temperature of pure tert-butanol. Record this Δ T value in your data sheet.
7. Use the information recorded in your data sheet to calculate the molar mass of ethylene glycol. Calculate the percent error for your experimentally determined molar mass. See your TA if you are unsure how to make this calculation.
8. Repeat Steps 1 through 5 for the unknown solutes. After calculating the molar mass of the unknowns, identify them using the following information:

Compound	Molar Mass (g/mol)
Acetone	58.08
Ethyl Acetate	88.10
Water	18.02

Table 2.1

Part 3: Chemistry of Life: Ice Cream

As we found above, adding a solute to a solvent lowers the freezing point of that solvent. This occurs because as a substance freezes, a crystal is formed, but if a solute is added to the solvent more kinetic energy must be removed from the solvent in order to freeze, since it's harder for the solvent molecules to form the regular pattern of the crystal. Therefore, the more solute molecules you add, the lower the freezing point becomes. We can use this to our advantage to lower the freezing point of water by enough to freeze ice cream, since ice cream is mostly water.

This is a recipe that you could use at home:

Put 59.15 ml ($\frac{1}{4}$ cup) of sugar, 118.29 ml ($\frac{1}{2}$ cup) of milk, 118.29 ml ($\frac{1}{2}$ cup) of whipping cream, and 1.23ml ($\frac{1}{4}$ teaspoon) vanilla (4-hydroxy-3-methoxybenzaldehyde) into a one-quart Ziploc ™ bag. Seal the bag and mix well by carefully shaking.

Put this one-quart Ziploc ™ bag into a one-gallon Ziploc ™ bag that has 2 cups of ice..

1. However, we are going to cheat by using 6 packets of Junket ice cream mix + 7 $\frac{1}{2}$ cups of whole milk + 4 $\frac{1}{2}$ cups of whipping cream in a one galloon jug.
2. Measure and record the temperature of the ice with your thermometer in the one-gallon Ziploc ™ bag .
3. Weigh and pour 177.44 ml ($\frac{3}{4}$ cup) of sodium chloride into the gallon bag.
4. Place the smaller bag inside the larger bag and seal the large bag securely.
5. Holding the large bag by the zipper seal, carefully shake the bag back and forth.

NOTE: Do not touch the part of the bag with the ice as it could cause tissue damage.

1. Continue until your ice cream is solid, approximately 10 – 15 min.
2. Measure and record the temperature of the salt/ice mixture.
3. Remove the frozen ice cream and place into a Styrofoam cup and enjoy!

Chapter 3

Pervasive Polymers[1]

Pervasive Polymers

3.1 Objectives

In this laboratory you will become familiar with the classifications of polymers by synthesizing and examining several of the following:

- a polyamide (nylon)
- a cross-linked condensation copolymer (Glyptal ™ resin)
- a cross-linked polyvinyl alcohol
- a loosely cross-linked silicon-based condensation polymer (a polymethylsiloxane)

Additional information about polymers can be found in Chapter 12 of your textbook.

3.2 Grading

Your grade will consist of the following:

- Pre-lab (10%)
- Correctness and thoroughness of your observations and the answers to the questions on the report form (80%)
- TA evaluation of lab procedure (10%)

Before Coming to Lab . . .

- Complete the pre-lab exercise
- Read the introduction and any related materials provided to you

NOTE: If you wear contact lenses, for this week's lab, you may prefer to wear your prescription glasses.

Introduction

Approximately 50% of the industrial chemists in the United States work in some area of polymer chemistry, a fact that illustrates just how important polymers are to our economy and standard of living. These polymers are essential to the production of goods ranging from toys to roofing materials. So just what exactly are polymers? Polymers are substances composed of extremely large molecules, termed macromolecules, with molecular masses ranging from 10^4 to 10^8 amu. Macromolecules consist of many smaller molecular units,

[1] This content is available online at <http://cnx.org/content/m19573/1.4/>.