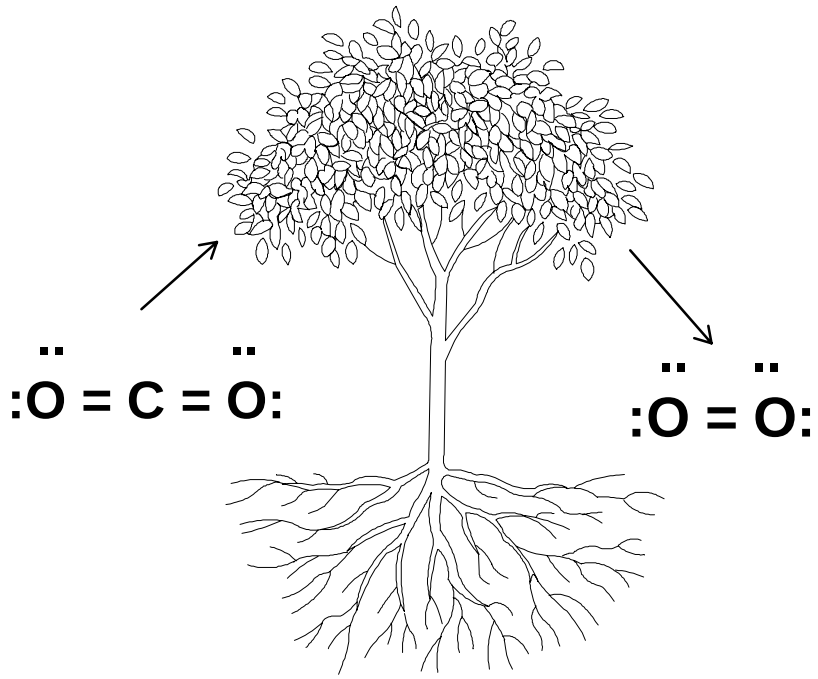
PREPARATION AND PROPERTIES OF ATMOSPHERIC GASES I:

Carbon Dioxide and Oxygen



INTRODUCTION

The atmosphere consists predominantly of three gases -- nitrogen (N_2) 78%, oxygen (O_2) 21% and argon (Ar) 0.9% -- which constitutes approximately 99.9% of this life-giving mixture. The remaining 0.1% by volume of the atmosphere contains such gases as carbon dioxide (CO_2), water vapor, methane (CH_4), CFCs, nitrogen oxides (NO_x), sulfur oxides (SO_x) and many other components which impact our lives on a daily basis. Our atmosphere is unique because it is the only one we know of that is capable of supporting organic life. Therefore, studying it, as well as preserving it, is important.

In this experiment, you will prepare and examine the properties of two atmospheric gases -- carbon dioxide (CO_2) and oxygen (O_2). The CO_2 will be generated by adding hydrochloric acid (HCl) to sodium bicarbonate (essentially baking soda, $NaHCO_3$):

$$NaHCO_3 + HCl \text{ ----> } NaCl + H_2O + CO_2$$

The O_2 will be generated using hydrogen peroxide (H_2O_2) and iron (III) chloride ($FeCl_3$). The $FeCl_3$ catalyzes the breakdown of hydrogen peroxide to form liquid water and O_2 gas. A catalyst is a substance that participates in a chemical reaction and influences the reaction's speed without undergoing a permanent change. If you have used household peroxide to clean a cut or scrape, you have witnessed such a catalytic reaction. A catalyst in your blood interacts with the peroxide forming bubbles of O_2.

$$2H_2O_2 \xrightarrow{\text{catalyst}} 2H_2O + O_2.$$

TECHNIQUES

Gas production

1. The gas-delivery flasks are designed such that when the valve is closed, the balloon will expand to accommodate any gases produced within the flask. When the valve is subsequently opened, pressure from the filled balloon pushes gas out the nozzle. The valve is closed when the valve handle is set at a 90-degree angle to the nozzle, and it is open when the valve handle is parallel to the nozzle.

2. To fill one of the gas-delivery flasks with a particular gas, remove the rubber stopper, put reactive substances into the flask, and promptly restopper the flask. You must hold the stopper in place due to the pressure being built up inside**. Make sure the rolled ridge of the balloon fits snuggly against the rim of the glass tubing coming out of the stopper, otherwise gas may leak out.**

3. Watch the balloon as it fills. It should never get larger than a grapefruit. If the balloon starts to over-inflate, simply open the nozzle and let gas bleed out to reduce the volume of the balloon.

4. **Make sure the valve is closed before adding reactive substances to the flask.** Reaction usually takes a minute to occur. Once the balloon is inflated, the gas-delivery flask is ready for use. **Hold the stopper in place at all times.**

SAFETY AND DISPOSAL

- The liquids used in this experiment, 10% hydrogen peroxide (H_2O_2)--three times as strong as household peroxide--and 6 M hydrochloric acid (HCl), are corrosive materials and should be handled cautiously. Use a clean, thin-stem, plastic pipet for each solution (one for H_2O_2, another for HCl, etc.). The H_2O_2 pipet will be labeled. Use it for H_2O_2 ONLY!
- If any corrosive liquids come in contact with your skin, you need to wash the affected area thoroughly under running water.
- Dispose of all used matches in the flasks provided, not down the drain.

EXPERIMENTAL PROCEDURE

will appear to remind you of potential dangers and hazards.

I. Setting up the 24-well plate

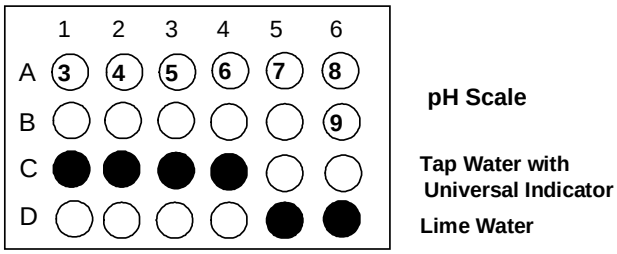
IN ORDER TO CONSERVE TIME, THE 24-WELL TRAY WILL BE SET-UP ONLY ONCE. **DO NOT** EMPTY YOUR 24-WELL TRAY UNTIL YOU HAVE COMPLETED BOTH PARTS OF THE EXPERIMENT!

A. Wash the well plate with soap and thoroughly rinse with water. Use a swab to dry out the wells.

B. Add 7 drops of pH 3 buffer solution to well A1, 7 drops of pH 4 buffer solution to A2, etc. to construct a pH scale from 3-8 across the top row of your well plate. Add 7 drops of pH 9 to well B6. Add 1 drop of universal indicator to each pH buffer. You should have solutions in 7 wells each with a specific pH. Universal indicator is a mixture of acid-base indicators whose color depends on the pH of the solution. Thus, the buffer solutions will be used as a pH comparison scale for later parts of the experiment. Note that a lower pH indicates a more acidic solution.

C. In Row C of the well plate, fill wells C1 through C4 one-half full with tap water and then place 1 drop of universal indicator in each of these wells. The water should be green. If it is not, your well needs to be recleaned. You will use wells C3 and C4 in Part III of Atmoshperic Gases II.

D. Setting up the limewater solutions
In the fourth row of the well plate, fill wells D5 and D6 one-half full with limewater ($Ca(OH)_2$) solution. This will give a basic solution. Note that the formation of calcium carbonate in basic solution gives a cloudy solution. Put the top back on the well tray.



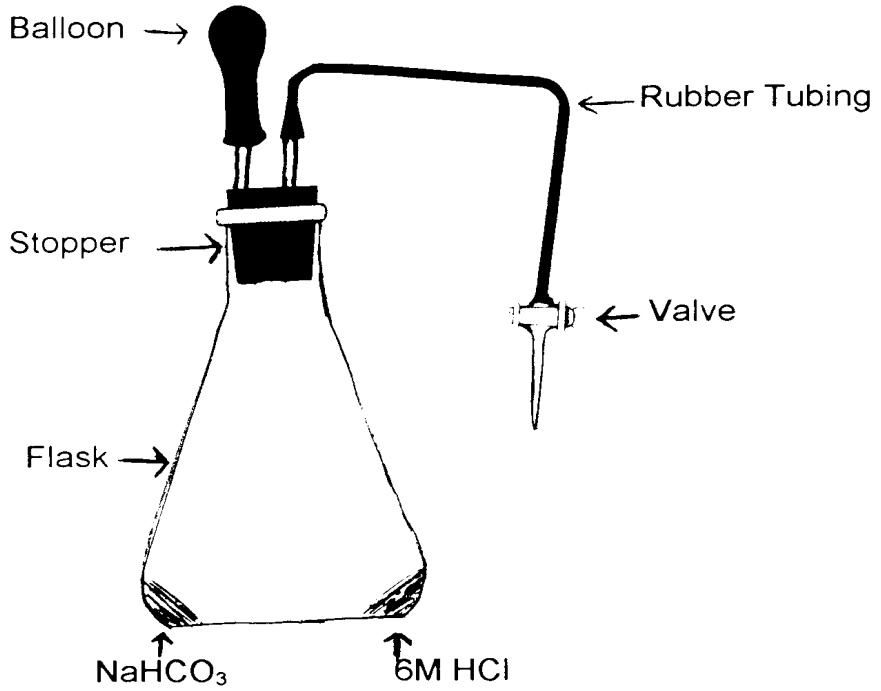
II. Generating Gases

A. Carbon Dioxide

1. Using the top loading balance, estimate 2 grams (~ mass of a penny) of sodium bicarbonate ($NaHCO_3$) and place it in the bottom to one side of the appropriately labeled flask.
2. Generously fill a thin-stem, plastic pipet with 6 M hydrochloric acid (HCl). Don't put pipets into the stock bottles of solutions. Dispense a small amount in a weigh boat or other available container.

Hydrochloric acid (HCl) is a corrosive material. Be careful not to spill any on yourself, your clothing, or the benchtop.

3. <u>Check for proper placement of balloon on glass rod. Make sure valve is closed.</u> Place the 6M hydrochloric acid in the flask on the side opposite from the $NaHCO_3$ and immediately restopper the flask. Mix the chemicals together by slowly shaking, while holding the stopper on the flask.
4. KEEP THE FLASK CLOSED. The balloon located atop the stopper should start expanding. Record your observations.
5. You now have a flask and balloon filled with CO_2.
6. Go to section III (Properties of carbon dioxide and oxygen) and perform all the tests dealing with CO_2.



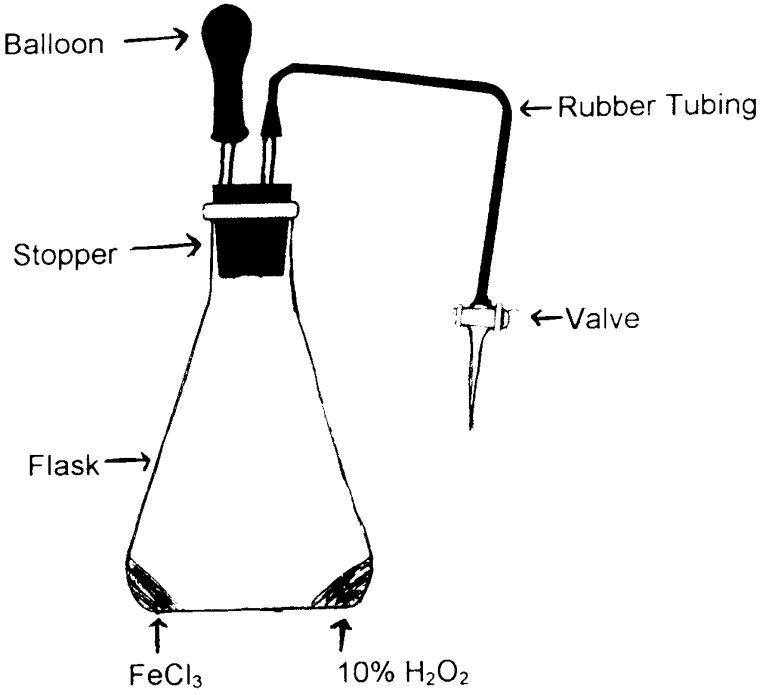
B. Oxygen

1. Using a top loading balance, estimate 1 gram (~ 1/2 mass of a penny)of iron (III) chloride ($FeCl_3$) and place it in the bottom to one side of the appropriately labeled flask.
2. Generously fill the pipet labeled "H_2O_2" with 10% hydrogen peroxide (H_2O_2). Don't put pipets into the stock bottles of solutions. Dispense a small amount in a weigh boat or other available container.

10% H_2O_2 is corrosive and will cause burns! Handle with care!

3. <u>Check for proper placement of balloon on glass rod. Make sure valve is closed.</u> Place the 10% H_2O_2 in the flask on the side opposite from the iron (III) chloride and immediately restopper the flasks. Mix the chemicals together slowly by shaking, while holding the stopper on the flask.

4. KEEP THE FLASK CLOSED. The balloon located atop the stopper should start expanding. Record your observations.
5. You should now have a flask and balloon filled with O_2.
6. Go to section III (Properties of carbon dioxide and oxygen) and perform all the tests dealing with O_2.



III. Properties of carbon dioxide and oxygen

Perform the tests on each of the gases you generated in this experiment. Refer to the Techniques Section for operating instructions of the valves used to deliver the gases.

A. Tap water/Indicator solutions
   1. Bubble the CO_2 gas into well C1 containing tap water and universal indicator by slowly turning the handle to the parallel position (See Techniques Section). Be careful not to use all of the CO_2 gas for this part. By comparing colors with the buffer solutions in row A and B, determine the pH of the dissolved carbon dioxide in C1. Record your results in the data table.
   2. Bubble the O_2 gas into well C2 containing tap water and universal indicator by slowly turning the handle to the parallel position (See Techniques Section). Be careful not to use all of the O_2 gas for this part. By comparing colors with the buffer solutions in row A and B, determine the pH of the dissolved oxygen in C2. Record your results in the data table.

B. Lime water

1. Bubble the CO_2 gas into well D5 containing limewater by slowly turning the handle to the parallel position (See Techniques Section). Be careful not to use all of the CO_2 gas for this part. What did you observe? Record your results in the data table.

2. Bubble the O_2 gas into well D6 containing limewater by slowly turning the handle to the parallel position (See Techniques Section). Be careful not to use all of the O_2 gas for this part. What did you observe? Record your results in the data table.

C. Wood splint

1. Ignite the end of the wood splint. After it has burned for a second or two, blow out the flame and then blow on the embers so that they glow.
2. With the tip very near the glowing ember, open the valve on the flask containing the O_2 gas, releasing the gas directly toward the ember. Observe and record the results.
3. Repeat the test with the following exception, instead of releasing CO_2 gas using the valve, remove the rubber stopper and immediately put the wood splint ½ way down into the flask. Observe and record observations.