Chemistry 101 Laboratory
Fall 2005 - 06

Lecture 7
Ideal Gas law
Determination of n of CO_2

Purpose

- Understand the principles of the Ideal Gas Law.

- Measure the amount (n) of CO_2 gas generated in a chemical reaction by mixing baking soda ($NaHCO_3$) and HCl in a flask.

Ideal Gas Equation

Boyle's law: $V \propto \frac{1}{P}$ (at constant n and T)

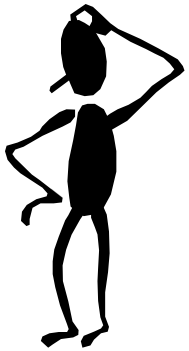
Charles' law: $V \propto T$ (at constant n and P)

Avogadro's law: $V \propto n$ (at constant P and T)

$$V \propto \frac{nT}{P}$$

$$V = \text{constant} \times \frac{nT}{P} = R\frac{nT}{P}$$ R is the **gas constant**

$$\boxed{PV = nRT}$$



What is the volume (in liters) occupied by 49.8 g of HCl at STP?

$T = 0\ ^0C = 273.15\ K$

$P = 1\ atm$

$PV = nRT$

$$V = \frac{nRT}{P}$$

$$n = 49.8\ g\ x\ \frac{1\ mol\ HCl}{36.45\ g\ HCl} = 1.37\ mol$$

$$V = \frac{1.37\ \cancel{mol}\ x\ 0.0821\ \frac{L \cdot atm}{\cancel{mol} \cdot \cancel{K}}\ x\ 273.15\ \cancel{K}}{1\ \cancel{atm}}$$

$V = 30.6\ L$

0.6673 g sample of $NaHCO_3$ is allowed to react with excess HCl to produce 578 mL of CO_2 gas at 251.0 torr and 23.5ºC.

a- Calculate the experimental number of moles of CO_2 produced.

P = 251.0 torr / 760 torr/atm = 0.3303 atm.

T = 23.5ºC + 273 K = 296.5 K

V = 0.578 L

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(0.3303\ atm)(0.578\ L)}{(0.0821\ L.\ atm.mol^{-1}K^{-1})(296\ K)}$$

$n = 7.86 \times 10^{-3}$ mol

b- Calculate the theoretical number of moles of CO_2 produced.

$$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$$

n of $NaHCO_3$ = 0.6673 g/ 84.02 g/mol

= 7.942×10^{-3} mol

n of CO_2 = n of $NaHCO_3$ (from stoichiometry)

n of CO_2 = 7.942×10^{-3} mol

Experimental Procedure (Main Steps)

- Weigh using the analytical balance about 0.65 g of sodium bicarbonate (limiting reagent) and transfer quantitatively to an Erlenmeyer flask.
- Measure 5 mL of 6.0 M HCl (excess reagent) in a graduated cylinder and empty it in a small test tube.
- Tilt the Erlenmeyer flask and carefully slide the small test tube down inside so that no HCl is spilled inside the flask.
- Place the rubber stopper followed by the sensors in the Erlenmeyer flask and make sure it is secure.

Experimental Procedure (Cont'd)

- Click the '**start**' button to begin collecting data
- While holding the rubber stopper, slowly rotate the flask until the HCl empties out.
- Try to hold the stopper in place without putting your hands on the flask.
- Determine the volume of the reaction assembly. Account for the volume occupied by the test tube, the rubber stopper and the sensors.
- By means of a graduated cylinder measure and record the volume of water contained in the flask. (**Hint:** subtract the volume of HCl used from the total volume)

Report

- Complete the report form and show your calculations.
- Include a print out of your graphs.
- Answer the questions.