CHEMISTRY 111 LECTURE

# EXAM I Material
# REVIEW

## Part 1 NOMEMCLATURE

**I. COMPOUNDS**- Two or more elements chemically combined in definite proportions.

**COMPOUNDS**

| IONIC COMPOUNDS | MOLECULAR COMPOUNDS |
| --- | --- |
| Metal - Nonmetal | Nonmetal-Nonmetal |

## II Naming Ionic Compounds

**BACKGROUND:**

A. Metallic Cations - (+ charge)

1. Fixed Charged cations

2. Variable charged cations

B. Nonmetal Anions (-) charge

C. Polyatomic Ions

**Naming compounds**

Key: Compounds are neutral → no net charge

## III Naming Molecular compounds

Nonmetal - Nonmetal

Variable combinations

Ex.

1. Know prefixes: Di, tri, tetra...etc
2. Naming formula:
   Prefix element #1 + prefix stem of element #2 + ide

   Ex.

## IV ACIDS AND BASES

Formula starts with a "H" + (aq)
[$H_2O$ is excluded]

Ex. HCl (aq) "Dissolved in water" The HCl must be in $H_2O$ to have the properties of an acid.

**ACIDS**

Binary Acid ← ACIDS → Oxyacid/ Ternary Acid

Binary Acid: Does not contain "O"

Oxyacid/ Ternary Acid: Contains "O"

### A. Binary Acids (no "O")

Naming: Hydro + stem of element + ic Acid

Ex.

Exception: $H_2S$ →

B. OXYACIDS/TERNARY ACIDS (contains "O")

Naming Formula:

Ion name But Change ite ⇢ ous / Ate ⇢ ic + Acid

KEY: Recognize the ion part of the Acid

| ACID | ION |
|---|---|

EXCEPTION:

**PRACTICE:**

Name or give the chemical formula for the following:.

| | |
|---|---|
| oxalic acid | magnesium hydrogen carbonate |
| mercurous nitride | ammonium carbonate |
| silver nitrate | aurous iodide |
| plumbic acetate | iodine tribromide |
| calcium peroxide | hydrobromic acid |
| potassium phosphide | sulfurous acid |
| nickelous permangante | cobaltous sulfide |
| $CS_2$ | $Co_2O_3$ |
| $Ni(NO_2)2$ | $Bi(NO_3)_3$ |
| $Ba_3N_2$ | $HClO_3(aq)$ |
| $Ca(OH)_2$ | $N_2O_5$ |

$Sr(HSO_3)_2$

$Hg(HCO_3)_2$

$H_2CO_3(aq)$

$PbO_2$

$SO_3$

$HF$

$HBrO_2(aq)$

$HC_2H_3O_2(aq)$

$Au_3PO_4$

$N_2O_3$

$Cu(Cl0)_2$

$HCN(aq)$

$Al(OH)_3$

# Part 2 CHEMICAL FORMULA CALCULATIONS

**I. THE MOLE**

1 mole = $6.02 \times 10^{23}$ Particles

*Avogadro's number* → *memorize!!*

Conversions

$$\frac{1 \text{ mole H atoms}}{6.02 \times 10^{23} \text{ atoms}} \quad \text{or} \quad \frac{6.02 \times 10^{23} \text{ H atoms}}{1 \text{ mole atoms}}$$

**II. MOLAR MASS** (molecular wt.)

1 mole = AMU weight numerically in grams

| |
|---|
| 26<br>Fe<br>55.85 |

Atomic wt.
55.85 AMU
{1 atom}

Molar mass
55.85 g
= 1 mole of Fe atoms
= $6.02 \times 10^{23}$ Fe atoms

**IV. MOLES AND CHEMICAL FORMULAS**

$N_2O_5$

2 atoms N
5 atoms O
= 1 molecule $N_2O_5$

2 mole N
5 moles O
= 1 mole of $N_2O_5$

Ratios:

Problem:

How many moles of N in 13.5 moles of $N_2O_5$?

**V MOLES AND CHEMICAL CALCULATIONS:**

1. How many grams of Zn will combine with 34.00 g of nitrogen?

2. How many atoms of O are needed to produce 32 kg of phosphoric acid?

## VI Empirical and Molecular Formulas:

**A.** **Empirical formula** shows the smallest ratio of atoms in a compound.
Examples:

### B. Calculation of Empirical and Molecular Formula

The percentage composition of a compound is 63.133% C, 8.831% H, and 28.04% O.
The Molar mass = 171.21 g/mol
What is its empirical formula? What is its molecular formula?

STEP 1. Calculate the Empirical Formula

STEP. 2 Calculate the Empirical Formula weight.

STEP. 3 Determine the number of E.F. units in the molecular formula
{ Divide the molar mass by the E.F. wt.}

## Part 3 CHEMICAL REACTIONS

A chemical reaction occurs when there is a change in chemical composition.

### I. Evidence of a reaction- One of the following would be observed:

a. A precipitate is formed or dissolved
b. A change of color
c. Effervescence occurs (gas formation)
d. Energy in the form of heat, light, or electricity is released

### II Types of Chemical Reactions--> Know and complete

A. Combination Reactions - One product is formed:

1. Metal + Nonmetal $\xrightarrow{\text{combines to form}}$ an Ionic compound

2. Metal Oxide + $H_2O$ $\xrightarrow{\text{combines to form}}$ a Base

3. Nonmetal Oxide + $H_2O$ $\xrightarrow{\text{combines to form}}$ an Acid

B. Decomposition-A single reactant will form two or more products

1. Carbonates ($CO_3^{2-}$) $\xrightarrow{\text{decomposes}}$ to oxides and $CO_2(g)$

2. Sulfites ($SO_3^{2-}$) $\xrightarrow{\text{decomposes}}$ to oxides and sulfur dioxide gas

3. Metal oxides $\xrightarrow{\text{decomposes}}$ to metal + Oxygen gas

4. Ionic Compounds $\xrightarrow{\text{decomposes}}$ to Metal + Nonmetal

5. Hydroxides $\xrightarrow{\text{decomposes}}$ to Metal oxides + water

6. Nitrates $\xrightarrow{\text{decomposes}}$ to Nitrites + Oxygen gas

7. Peroxides $\xrightarrow{\text{decomposes}}$ to Oxides + Oxygen gas

8. Chlorates $\xrightarrow{\text{decomposes}}$ to chlorides + Oxygen gas

C. Combustion Reactions involves organic compounds:

*General Form:* $(C_xH_yO_z)$ + $O_2(g)$ $\rightarrow$ $CO_2(g)$ + $H_2O(g)$

D. Single displacement Reactions/ Replacement Rxns.
A more active element displaces a less active element
TYPES:

Type 1: Metal + $H_2O$ $\rightarrow$ Base + $H_2(g)$

Type 2: Metal + Acid $\rightarrow$ Salt + $H_2(g)$

Type 3: $Metal_1$ + $Salt_1$ $\rightarrow$ $Metal_2$ + $Salt_2$

Type 4. $Nonmetal_1$ + $Salt_1$ $\rightarrow$ $Nonmetal_2$ + $Salt_2$

# SOLUBILITY RULES FOR IONIC COMPOUNDS

| Ion contained in the Compound | Solubility | Exceptions |
|---|---|---|
| Group IA | Soluble | |
| $NH_4^+$ | Soluble | |
| $C_2H_3O_2^-$ | Soluble | |
| $NO_3^-$ | Soluble | |
| $Cl^-$, $Br^-$, and $I^-$ | Soluble | $Ag^+$, $Pb^{2+}$, $Hg_2^{2+}$ |
| $SO_4^{2-}$ | Soluble | $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Pb^{2+}$ |
| $CO_3^{2-}$, $PO_4^{3-}$, $CrO_4^{2-}$ | insoluble | group IA and $NH_4^+$ |
| $S^{2-}$ | insoluble | group IA, IIA, and $NH_4^+$ |
| $OH^-$ | insoluble | group IA, $Ca^{2+}$, $Ba^{2+}$, $Sr^{2+}$ |

| STRONG BASES | |
|---|---|
| LiOH | CsOH |
| KOH | $Sr(OH)_2$ |
| RbOH | $Ba(OH)_2$ |
| NaOH | $Ca(OH)_2$ |

| STRONG ACIDS | |
|---|---|
| $HNO_3$ | HCl |
| $HClO_4$ | HBr |
| $H_2SO_4$ | HI |

E. Double Exchange (Ion Exchange) Reactions

1. In a double displacement (ion exchange) reaction, the positive end and negative end of compounds "change partners" to form new products:

a. Precipitate

*Note: A ppt **must** form for the rxn to occur. ( if it doesn't...Then NR!)

b. Less Ionized Substance.(Molecule formation)

(1) Gas

(2) Neutralization

(3) A weak acid or base is formed

## Part 4 STOICHIOMETRY: CHEMICAL REACTION CALCUATIONS:

The numerical relationship among the reactants and products in a balanced equation (Chemical reaction)

The Balanced equation

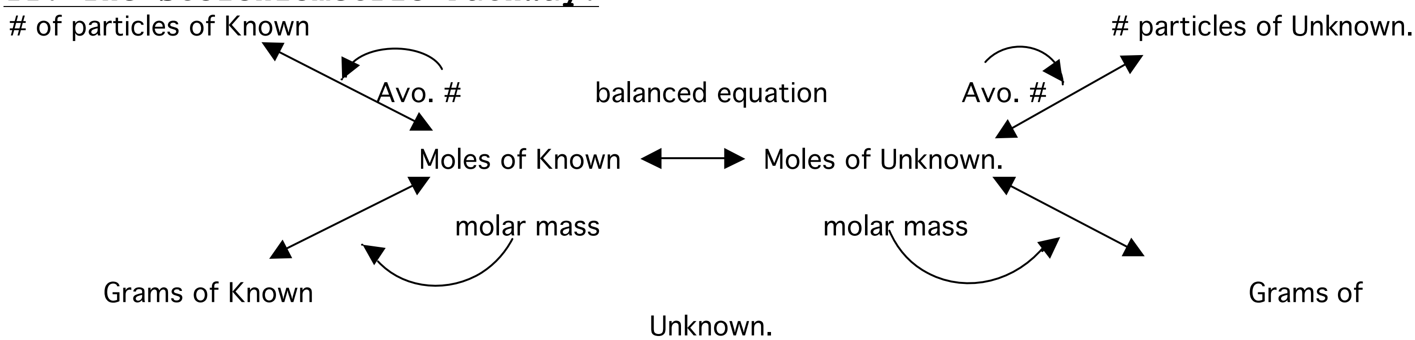
A balanced equation shows a chemical reaction in shorthand:
For example: Two magnesium atoms (a solid) when ignited, reacts with oxygen atoms to form solid magnesium oxide

The meaning of a balanced Chemical Equation: A bookkeeping system

The balanced equation - mole to mole ratios

These mole to mole ratios are exact numbers.

### II. The Stoichiometric Pathway:




### III. Stoiciometric Calculations

1. The reaction: Chromium metal is reacted with copper (II) chloride
   *Key:* You must have a balanced equation!!

   How many grams of chromic chloride reacts with 6.0 mole Cr?

2. How many grams of oxygen gas are required for the complete combustion of 694 g of methane $CH_4$(g) in a sample of natural gas?

## IV. LIMITING REACTANTS

When most reactions are performed, some of the reactants is usually present in excess of the amount needed. If the reaction goes to completion, then some of this *excess reactant* will be left-over. The **limiting reactant** is the reactant used-up completely and it "limits" the reaction.
For example:

PROBLEMS:

1. Zinc nitrate is reacted with sodium hydroxide.

   a. How many grams of Zinc hydroxiode is produced when 13.0 grams of zinc nitrate and 17.0 grams sodium hydroxide are mixed? How much excess reactant is left?

   *METHOD: Find the L.R. → Calculate the moles of product that each reactant may produce.*

   BALANCED EQUATION:

   (1) Find the L.R.

   (3.) Determine the MASS of product made from the L.R.

   (4.) Calculate the grams of excess reactant

**VI. PERCENT YIELD**

The amount of product that has been previously calculated from chemical equations show the maximum
yield (100%). However, many reactions fail to give a 100% yield of product.

The theoretical yield is the calculated amount of product.

The Actual yield is the amount of product actually obtained

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

PROBLEM:

5.000 g of $Ag_2S$ was produced from 5.000 g of Ag and an excess of sulfur according to the reaction:

$$2\ Ag + S \rightarrow Ag_2S$$

What is the percent yield?

## Stoichiometry Problems

1) A mixture consists of 22.0 % Cu(NO3)2 and 78.0 % Fe(NO3)3 by mass. What is the total number of nitrate **ions** in 25.00 g of mixture?

2) A certain alloy of Au, Cu, and Ni contains these elements in the atomic proportions 3: 2: 1 , respectively. What is the mass, in grams, of this alloy containing a total of 1.00 x 1024 atoms?

3) A carbon containing compound is treated chemically to convert all its carbon into $CaC_2O_4$ (s). A 17.88 g sample of the compound gave 15.04 g $CaC_2O_4$

a) What is the percent of carbon in the compound?

b) Calculate the molar mass of the compound, if there are **7** carbon atoms in each molecule of the compound. (Molar mass : $CaC_2O_4$ = 128.08 g/mole) .

4) By analysis, a compound with the formula, $AsH_3O_x$ , is found to contain 52.78 % by mass arsenic. What is the value of the integer, x ?

5) A certain compound contains only lead, carbon and hydrogen. if it contains 64.07 % lead by mass, and if there are **two** carbon atoms present for every **five** hydrogen atoms, what is the empirical formula ?

6) Suppose that 50.32 g of a metal nitride, $M_3N_5$, reacts with $H_2$ to produce the metal, M, and 9.550 g $NH_3$ only.
a) Write a balanced equation for the reaction.
b) Calculate the molar mass of the metal, M.

7) A compound contains 42.85 % chlorine. If it is found that **each** molecule of the compound contains **four** atoms of chlorine, what is the molar mass of the compound?

8) Treatment of 10.00 g of $XCl_2$ with excess chlorine forms 12.55 g $XCl_4$. Calculate the molar mass of the element, X.

9) A sample of a mixture of H2S and CS2 is burned in oxygen. The equations for the reactions are:
2 H2S + 3 O2 2 H2O + 2 SO2
CS2 + 3 O2 CO2 + 2 SO2
7.32 g of SO2, and 0.577 g of CO2 are produced along with some H2O.
a) What percentage, by mass, of the original sample is H2S?
b) What is the percent CS2 in the mixture?

10) A 7.221 g sample of a compound containing only C, H, and S is burned completely in oxygen. The products are $CO_2$, $H_2O$ and $SO_2$. If the mass of $CO_2$ is 6.601 g and that of $H_2O$ is 5.406 g :
a) Calculate the mass of $SO_2$ produced.
b) What is the empirical formula of the compound?
c) Balance the equation for the above reaction.

## Part V GASES-

# Chapter 5 (pages 178-216)

I. Properties of gases

II. Measurements-Review

A. Pressure =

1. Conversions:

` 1 atm= 760 mm Hg = 760 torr (exactly)

$1.013 \times 10^5$ Pa= 1 atm = 14.68 psi

2. Barometer

3. Manometer

B. Temperature - Kelvin

K = $^{\circ}$C + 273

C. Volume

1. The volume of a gas is the volume of the container it occupies.

2. Units: liters or milliliters

III. RELATIONSHIP BETWEEN $^{\circ}$T, VOLUME, AND PRESSURE.-Review

A. Boyle's law P & V

As the pressure increases the volume decreases in the same proportion.

B Charles's law $^{\circ}$T & V

As the temperature (Kelvin) is increased the volume is increased proportionally.

C Gay-Lussac's Law

When temperature (K) increases pressure increases proportionally.

D Avogadro's Law: Volume and Amount (in moles, n)

When the amount (moles,n) increases volumne increases proportionally.

E. COMBINATION OF THE GAS LAWS-Review:

P,V, and $^oT$ varying. Assume that the mass is constant.

Prob: A certain mass of gas occupies 5.50 L at 34$^\circ$C and 655 mm Hg. What will its volume in liters be if it is cooled to 10.0$^o$C and its pressure remains the same.

E. GAY-LUSSAC'S LAW OF COMBINING VOLUMES-Review:

At the same $^oT$ and Pressure, the volumes of gases that combine in a chemical reaction are in the ratio of small whole numbers.

F. IDEAL GAS EQUATION-Review:

Derivation:

KNOW: $PV=nRT$ Where: n = moles of gas

$R = \dfrac{0.0821 \text{ L-atm}}{\text{mole-K}}$

1. What volume in liters will be occupied by 6.00 mol carbon dioxide gas at 105 mm Hg and 28$^\circ$C?

G MOLAR VOLUME at Standard Temperature and Pressure-Review:

At the same temperature and pressure the same number of moles of different gases have the same volume. The Molar Volume is the volume of one mole of any gas at a given $^oT$ & P. [STP]

Standard Temperature and Pressure = [STP]:

At: 273 K and 1 atm (760 torr)

The density of an unknown gas is 1.43 g/L at $0^{\circ}C$ and 760 torr. What is the molar mass of the unknown gas?

WHEN TO USE:

1. PV = nRT

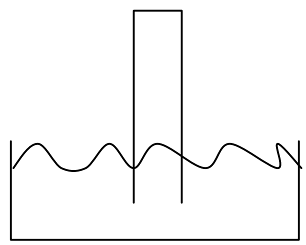
2. at STP

3. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

H. MIXTURES OF GASES AND PARTIAL PRESSURES (DALTON'S LAW OF PARTIAL PRESSURES) a mixture of gases is equal to the sum of the partial pressures exerted by each gas.

$P_{total} = P_1 + P_2 + P_3 + .....$

Collecting Gases over Water



Example: The total pressure in a 1.00 liter container is 725 mm Hg. The container contains water vapor and nitrogen gas.
If the partial pressure of the water vapor is 225 mm Hg, what is the partial pressure of the nitrogen gas.

$P_{total} = P_{N_2} + P_{H_2O}$

I. MOLE FRACTIONS; Mixtures of gases

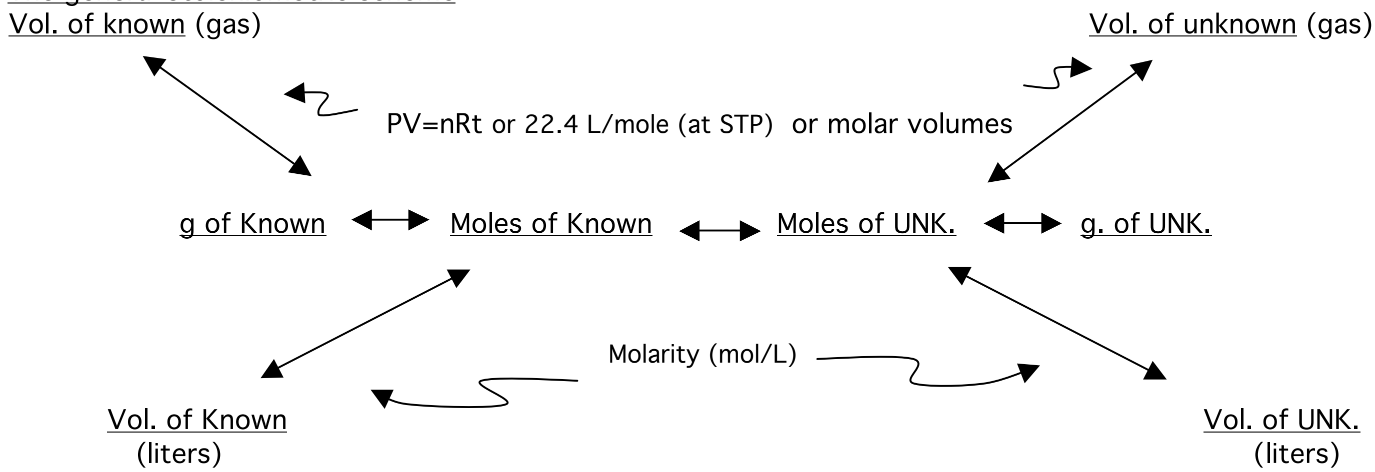
The mole fraction of a component is the fraction of moles of that component of the total moles of the gas mixture.

IV GASES IN CHEMICAL REACTIONS: STOICHIOMETRY--Review:

Certain chemical reactions involve gas as a reactant or product. For these types of reactions, the stoichiometric calculations involve the use of:

1) PV=nRT
2) 22.4 at STP
3) Molar volumes

The general stoichiometric scheme




Gas Problems:

1. How many liters of ammonia gas can be produced by the reaction of 735 ml hydrogen gas with an excess nitrogen gas at 425 $^{o}$C and 135 atm? Nitrogen + hydrogen --> ammonia

Ans.=0.490 L

2. How many liters of carbon dioxide gas at 0 $^{o}$C and 1 atm are produced by the complete combustion of 60.0 mol of liquid glucose, $C_6H_{12}O_6$?

Ans. = 9.10 x $10^3$ $CO_2$

3. How many liters of the air pollutant NO(g) could be produced at 985 $^{O}C$ and a pressure of 30.0 atm by the reaction of oxygen gas with 455 g of nitrogen gas.
Ans. = 112 L NO

4. A 655 ml gas cylinder filled with oxygen gas at a pressure of 95 atm and at 26.0 °C was used by a scuba diver. The pressure after it was used was 85 atm. How many moles of oxygen gas were used by the diver?
Ans = 0.2 mol $O_2$

5. A flask contained 1.017 mol of carbon dioxide. The gas exerted a pressure of 925 mm Hg at a temperature of 28 °C. When an additional 0.250 mole of Carbon dioxide was added to the flask the temperature increased to 35°C. What is the new pressure in the flask?
Ans.= 1.56 atm $CO_2$

6. A container with only He had a pressure of 544 torr at a temperature of 35 °C. When 0.810 g of Ne is added to this container, the pressure increases to 959 torr. Calculate the grams of He in the container.

Ans. = 0.212 g He

7. $6.53 \times 10^{28}$ molecules of Oxygen occupy 15.00 liters. What is the volume occupied by 66.5 g of carbon dioxide under the same conditions?

Ans. = $2.10 \times 10^{-4}$ L $CO_2$

9. A mixture containing 1.22 g Xe and 0.675 g $NO_2$ exerts a pressure of 1.44 atm. What is the partial pressure of $NO_2$?

Ans. = 0.883 atm $NO_2$

10. The complete combustion of 0.500 g of hydrocarbon, containing only C and H, produced 0.771 L of $CO_2$ at STP and 0.755 g of water. In another experiment, 0.218 g of sample occupied 185 ml at 23 °C and 374 mm Hg. What is the molecular formula of the compound?

Ans. = $C_4H_{10}$

11. A sample of an unknown gaseous hydrocarbon had a density of 1.56 g/L at 25.0 °C AND 1.33 atm. Calculate the molar mass of the gas.
Ans. = 28.7 g/mol

VI. KINETIC MOLECULAR THEORY-Review

A. Gases are composed of such extremely tiny atoms or molecules that are widely separated by empty space.

B. Gas particles move in a random,rapid, and continuous motion, thus has kinetic energy.

C. Gas particles moves so rapidly and are so far apart the there is essentially no force of attraction between the particles.

D. Particles collide frequently wtih each other and with the walls of the container, the collisions are perfectly "elastic" - (No net loss of energy as a result of a collision)

VII. TEMPERATURE AND MOLECULAR VELOCITIES: AVERAGE KINETIC ENERGY

The average kinetic energy (energy of motion) of the gas particles are directly proportional to its absolute $T^o$ (Kelvin)

## VIII MOLECULAR SPEEDS; DIFFUSION AND EFFUSION

### A. MOLECULAR SPEEDS

### B. DIFFUSION AND EFFUSION

Diffusion is the ability of two or more gases to spontaneously mix until it becomes a uniform, homogeneous mixture.

Effusion is the process by which gas particles flows thru a very small hole from a container of high pressure to a lower pressure.

Graham's Law of Effusion - The rate of effusion of a gas is inversely proportional to it's size [] at constant temperature and pressure.

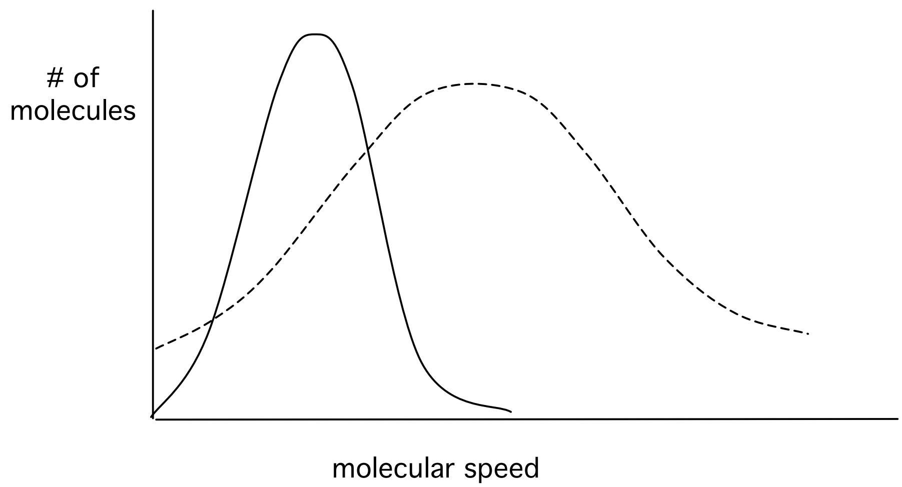
=

Problem #1: What is the rate of effusion for $H_2$ if 15.00 ml carbon dioxide of $CO_2$ takes 4.55 sec to effuse out of a container?

Problem #2: What is the molar mass of gas X if it effuses 0.876 times as rapidly as $N_2(g)$?

## IX REAL GASES

Gas laws describe the behavior of an ideal or "perfect" gas - a gas described by the kinetic molecular theory. Under normal conditions of typical pressure and temperature, gases follow the ideal gas laws fairly closely. At low temperature and/or high pressures gases deviate from the ideal gas laws.




### A. Intermolecular forces of attraction

### B. Molecular volume