Chemistry Notes 2013

Stoichiometry and Mole Concept

Introduction – How Many is One Mole?

Suppose every toothpick is exactly 0.01 g. Then it is possible to find the number of toothpicks by weighing rather than counting.

Atoms and molecules react in specific ratio. Scientists need to know the relationship between the mass of a given sample and the number of atoms or molecules contained in that mass of given sample. They key to this relationship is the mole.

Chemists count atoms using the mole. While the dozen is 12 and the ream is 480, the mole is 6×10^{23}. This number is also known as Avogadro's constant/number.

Molecular Mass and Rate of Diffusion

Gasses undergo effusion; that is, they can pass through small, sometimes molecular-sized openings. Molecules must pass through small molecular sized openings.

Some Guiding Principles

- The rate of escape depends on the gas – balloons filled with hydrogen or helium deflates more rapidly than balloons filled with air.
- As effusion may be considered a kind of diffusion, the rules that govern effusion also apply to diffusion and vice versa.
- In general, it is observed that a denser gas diffuses slower a less dense gas.

Since density of a gas is directly proportional to its molecular mass the general rules is:

> The gas with the larger relative molecular mass has a slower rate of diffusion.

Using Molar Mass

The mass of one mole substance is known as Molar mass. It is kind to note that the Molar mass is the mass of one mole of a substance and is numerically equal to the relative atomic mass of the substance expressed in grams.

For example: A_r of Carbon is 12 = molar mass of Carbon = 12 g mol^{-1}

For gases, just as one human head consists of 2 eyes, one mole of oxygen consists of two oxygen atoms. This is because most gases exist diatomically.

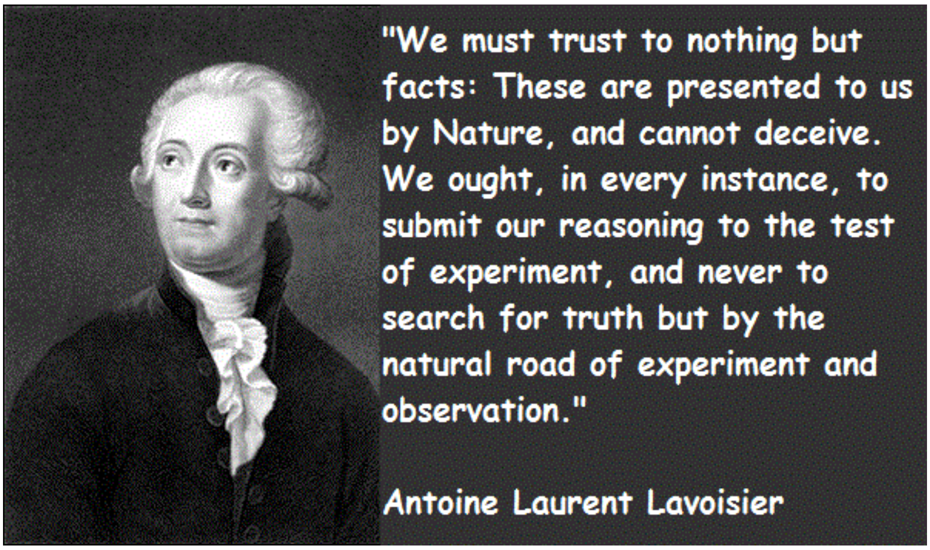
Calculations Involving Masses

Two important facts about any chemical equations:

1. All the atoms present in the reactants are also present in the products.

2. A balanced equation shows the number of molecules, atoms or ions taking part in the reaction.

These facts allow the masses involved in reactions to be calculated.



Example:

What is the mass of iron [III] oxide formed from the thermal decomposition of 583.2 g of iron [III] carbonate, $Fe_2(C0_3)_3$? [A_r: Fe = 55.8, C = 12, O = 16]

$$Fe_2(C0_3)_3 \rightarrow Fe_2O_3\ (s) + 3CO_2\ (g)$$

Mass of $Fe_2(C0_3)_3$:

No. of mol of $Fe_2(C0_3)_3$ decomposed:

From the equation, the mol ratio of $Fe_2(C0_3)_3 : Fe_2O_3$

Hence, no. of mol of Fe_2O_3 produced:

Molar mass of Fe_2O_3:

Mass of Fe_2O_3 formed:

[This is format is to be STRICTLY followed in examinations]

Empirical Formula

The empirical formula of a compound gives the simplest whole number ratio of atoms or ions present in the compound and can only be found though experiment.

Example:

Chloroform [one of the earliest known anaesthetics] is 10.04% by mass carbon, 0.837% by mass hydrogen and 89.12% by mass chlorine. Calculate the empirical formula of chloroform. [A_r: H = 1, C = 12, Cl = 35.5]

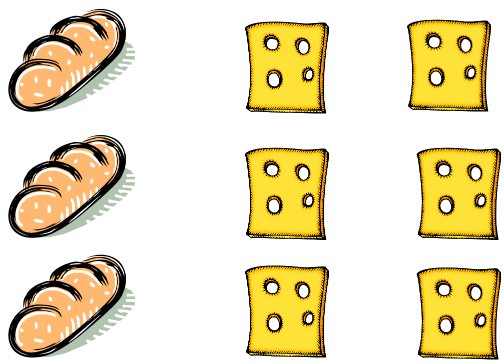
	C	H	Cl
Assuming 100g mass			
Amount (in mol)			
Divide by smallest no. of mol			
Simplest ratio			

The empirical formula of chloroform is:

[This format is to be STRCTLY followed in examinations]

Limiting Reactant

Imagine you have 3 pieces of bread and 6 slices of cheese. You want to make the greatest amount of sandwiches as possible, but each sandwich needs 1 piece of bread and 1.5 pieces of cheese to make. Regardless of how many pieces of cheese you have, the greatest amount of sandwiches you can make is still 3. Hence, the bread is said to be the limiting reactant.



Example:

Magnesium and oxygen react to form magnesium oxide.

$2Mg + O_2 \rightarrow 2MgO$ [A_r: O = 16, Mg = 24]

If 6.00 g of magnesium and 2.00g of oxygen are allowed to react, determine

[a] the limiting reactant;

Molar mass Mg:

Molar Mass of O_2:

No. of mol of Mg:

No. of mol of O_2:

From the equation, the mol ratio of Mg : O_2 is:

Therefore, if mol of Mg were to react, mol of O_2 is needed.

There is only mol of O_2, which is not enough for the reaction.

is the limited reactant.

[This format is to be STRCTLY followed in examinations]

[b] the reactant in excess and by how many mol;

From the reactant, 1 mol of oxygen produces 2 mol of magnesium oxide.

If mol of oxygen is used up, mol of Mg is needed.

Therefore Mg is in excess by mol.

[This format is to be STRCTLY followed in examinations]

[c] the mass of magnesium oxide formed.

The amount of product is determined by the amount of limiting reactant.

From the reaction, 1 mol of oxygen produces 2 mol of magnesium oxide.

Therefore mol of oxygen produces mol of magnesium oxide.

Molar mass of MgO = g mol^{-1}

Mass of MgO = g

Molar Volume of Gases

Avogadro's law states that equal volumes of all gases under the same conditions of temperature and pressure contain the same number of molecules.

Since equal volumes of all gases under the same conditions of temperature and pressure contain the same number of molecules, it follows that one mol of any gas under the same conditions must occupy the same volume. It has also been proven by experiment that one mole of any gas occupies 24 dm^3 at room temperature and pressure [standard atmospheric pressure]. 24 dm^3 is thus called the molar volume.

In addition, based on Avogadro's Law, a chemical equation gives the mole ratio as well as the volume ratio of the gaseous reactants and products.

For example:

$$3H_2\,(g) + N_2\,(g) \rightarrow 2NH_3\,(g)$$

3 mol : 1 mol : 2 mol

According to Avogadro's Law,

3 vol : 1 vol : 2 vol