CHEMICAL QUANTITIES
The Mole

Mole - an amount of substance that represents 6.02×10^{23} representative particles of that substance.

Representative Particles - the smallest particle of a substance (atom, ion or formula unit, molecule) that has the same physical and chemical properties.

Amadeo Avogadro - gets credit for Avogadro's number
6.02×10^{23}

A mole of a diatomic element (N_2) - a molecular compound - contains 6.02×10^{23} molecules of nitrogen.

Diatomic elements: BrINClHOF

1 mol = 6.02×10^{23} atoms, ions, or molecules

Sample problems:
1. How many moles are contained in 1.20×10^{23} molecules CO_2?

$$1.20 \times 10^{24} \text{ molecules } CO_2 \times \frac{1 \text{ mol } CO_2}{6.02 \times 10^{23} \text{ molecules } CO_2} =$$

1.99 mol CO_2

More problems with Avogadro's number:

2. How many molecules are in .400 mol N_2O_5?

3. How many moles are contained in 4.50×10^{23} atoms of Ni?

4. How many moles is each of the following?
   A. 4.81×10^{24} atoms Cu
   B. 1.50×10^{23} molecules NH_3

MOLAR MASS: Refers to the mass of a substance in 1 mole. (gam, gmm, gfm)

1. gram atomic mass (gam) - number of g of an ELEMENT that is = to the atomic mass (mass # - rounded atomic mass)

ex. O gam is 16 g
1 mol Cr = _____ g?

2. gram molecular mass (gmm) - the mass of 1 mole of that MOLECULAR COMPOUND.

Ex. 1 mol of SO_3 = 80 g

S 1 X 32 = 32
O 3 X 16 = 48
80 g

3. gram formula mass (gfm) - the mass of 1 mole of an IONIC COMPOUND.

Ex. 1 mol KCl = 74 g

1 mol of ammonium dichromate = g ?

1 mol of aluminum sulfate = g ?

Mole-Mass conversion problems:

1. 10.0 mol Cr = _____ g Cr

$$10.0 \text{ mol Cr} \times \frac{52 \text{ g Cr}}{1 \text{ mol Cr}} = 520. \text{ g Cr}$$

2. 72.0 g Ar = _____ mol Ar

$$72.0 \text{ g Ar} \times \frac{1 \text{ mol Ar}}{40 \text{ g Ar}} = 1.80 \text{ mol Ar}$$

1 mol = _____g of a substance

According to Avogadro's Hypothesis, we can have another relationship between the mole and gas particles. However, the conditions of STP must be in effect:

STP - standard temperature (0^o C) and standard pressure at 1 atmosphere (atm). - sea level

MOLAR VOLUME - At STP, 1 mol of any gas occupies a molar volume of 22.4 L.

Sample problems: (Molar Volume conversions)

1. What is the volume at STP of a gas that has 5.40 mol O_2 ?

$$5.40 \text{ mol } O_2 \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = 121 \text{ L } O_2$$

2. Assuming STP, how many moles are in this volume of gas: 89.6 L SO_2 ?

$$89.6 \text{mol } SO_2 \times \frac{1 \text{ mol } SO_2}{22.4 \text{ L } SO_2} = 4.00 \text{ mol } SO_2$$

3. What is the density of He at STP?

D = m/v

D = 2 g / 22.4 L = .089 g/L of He

1 mol of a gas = 22.4 L (at STP)

MULTISTEP MOLE PROBLEMS
Use the MOLE ROAD for help

What is the mass in g of an atom of Ni?

More practice multistep problems:
1. Find the number of molecules in 60.0 g of NO_2.
2. Find the volume (L) of 3.24×10^{22} molecules of carbon dioxide.
3. Assuming STP, find the mass of 18.0 L of CH_4.
4. Find the mass of 1 molecule of aspirin, $C_9H_8O_4$.
5. Find the volume (L) of 835.00 g of SO_3 at STP.

Answers:
1. 7.85×10^{23} molecules NO_2
2. 1.20 L CO_2
3. 12.8 g CH_4
4. 3×10^{-22} g $C_9H_8O_4$
5. 234 L SO_3

PERCENT COMPOSITION: The % by mass of each element in a compound.
% mass = gam/gmm or gfm x 100

total composition = 100%

Sample problems:

A. Calculate the % composition of ethane, C_2H_6.

1. Find the gam of each element
2. Add the gam's together to get the gmm.
3. Gam/gmm x 100 = % of each element in the compound.

C $\frac{24}{30} \times 100 = 80\%$

H $\frac{6}{30} \times 100 = 20\%$

B. 29.0 g Ag combines completely with 4.30 g of S. What is the % Ag and % S in the compound?

29.0 g Ag + 4.30 g S = 33.3 g Ag_2S

2 chemical formula calculations:

1. Empirical formula - the lowest whole-number ratio of the elements in a compound. Ex. Pb_2S_4 =➔ PbS_2 lead (IV) sulfide

Ex. Calculate the empirical formula of the compound with the following % composition: 79.8% C 20.2 % H

1. erase % and replace with g. (because 1 mol = gam, gmm, gfm)
2. Find number of mol and divide the number of mol of each element by the lowest number.
3. The whole number = number of atoms of each element.

$$79.8 \text{ g C} \times \frac{1 \text{ mol C}}{12 \text{ g C}} = 6.65 \text{ mol C} / 6.65 = 1$$

$$20.2 \text{ g H} \times \frac{1 \text{ mol H}}{1 \text{ g H}} = 20.2 \text{ mol H} / 6.65 = 3$$

Answer: CH_3

2. Molecular Formula - It is determined by the gfm and the empirical formula (efm) of a compound. It will NOT be in the lowest ratio.

Ex. Glucose $C_6H_{12}O_6$

Sample problem: molecular formula
What is the molecular formula if CH_4N has a gfm of 60 g?

1 1. efm of CH_4N = 30 g
2 2. gfm/efm = 60/30 = 2 (multiply this by the number of atoms in CH_4N)
3 3. $C_2H_8N_2$ (molecular formula)