AVOGADRO'S NUMBER AND THE MOLE

Avogadro's Number (N_A) = 6.022 x 10^{23} (to 4 sig figs) OR **6.02 x 10^{23}** (to 3 sig figs)

1 mole (abbreviated mol) = **6.022 x 10^{23} entities**
Similar to: 1 dozen = 12 entities:
1 dozen doughnuts = **12** doughnuts
1 mole of doughnuts = **6.022 x 10^{23}** doughnuts

How many eggs are in 3 dozen eggs? 12 x 3 = 36 eggs

How many eggs are in 3 moles of eggs? 3 x (6.02 x 10^{23} eggs/mol)

How many C atoms are in 3 moles of C atoms? 2 x 10^{24} carbon atoms

Atomic weights and molar masses:

— The mass of **1 C atom** (on average) is **12.01 amu**
— The mass of **1 mole of C atoms** is **12.01 g (or 12.01 g/mol)**

1 mole (6.022 x 10_{23}) is the amount of atoms of any element that has a mass in **grams** equal to the mass of ONE atom in **amu**.

The atomic masses reported for each element in the Periodic Table gives the **atomic weight** (or **molecular/formula weight for compounds**) **in amu** and the **molar mass in g/mol**.

Example: What is the molar mass for each of the following?
(Use the atomic masses reported for each in the Periodic Table.)

a. Mg: 24.31 g/mol
c. Ar: 39.95 g/mol
b. Si: 28.09 g/mol
d. Sn: 118.71 g/mol

MOLECULAR MASS (for molecules) **or FORMULA MASS** (for ionic compounds)

Molar mass (MM): Mass in grams of 1 mole of any element/compound
– To obtain, multiply the molar mass of each element by the number of each present, then add up all the constituent parts.

Example: Determine the molar mass of each of the following compounds:

a. **O_2**: 2 (molar mass of O) = 2 (16.00 g/mol) = **32.00 g/mol**

b. **H_3PO_4:** 96.99 g/mol

c. **$Al_2(SO_4)_3$**: 342.17 g/mol

Mole Calculations

Ex. 1 How many moles of Ne are in 50.0 g Ne?

$$50.0 \text{ g Ne} \left(\frac{1 \text{ mol Ne}}{20.18 \text{ g}}\right) = 2.48 \text{ g Ne}$$

Ex. 2 How many Ne atoms are in 50.0 g of Ne?

$$50.0 \text{ g Ne} \left(\frac{1 \text{ mol Ne}}{20.18 \text{ g}}\right)\left(\frac{6.02 \times 10^{23} \text{ atoms Ne}}{1 \text{ mol}}\right) = 1.49 \times 10^{24} \text{ Ne atoms}$$

Ex. 3 How many moles of CO_2 are in 25.0 g of CO_2?

$$25.0 \text{ g } CO_2 \left(\frac{1 \text{ mol } CO_2}{44.01 \text{ g}}\right) = 0.568 \text{ moles } CO_2$$

Ex. 4 How many CO_2 molecules are in 25.0g of CO_2?

$$25.0 \text{ g } CO_2 \left(\frac{1 \text{ mol } CO_2}{44.01 \text{ g}}\right)\left(\frac{6.02 \times 10^{23} \text{ molecules } CO_2}{1 \text{ mol } CO_2}\right) = 3.42 \times 10^{23} \text{ molecules } CO_2$$

Ex. 5 How many oxygen atoms are in 25.0 g of CO_2?

$$25.0 \text{ g } CO_2 \left(\frac{1 \text{ mol } CO_2}{44.01 \text{ g}}\right)\left(\frac{6.02 \times 10^{23} \text{ molecules } CO_2}{1 \text{ mol } CO_2}\right)\left(\frac{2 \text{ atoms of oxygen}}{1 \text{ molecule } CO_2}\right)$$

$$= 6.84 \times 10^{23} \text{ oxygen atoms}$$

Molar Volume: Volume occupied by 1 mole of any gas

Avogadro's Law: At the same temperature and pressure, equal volumes of gases contain the same number of molecules

Standard temperature and pressure (STP): T=0°C and P=1.00 atm

At STP, 1 mole of gas occupies 22.4L! **(3 sig figs)**

Molar Volume Calculations

Ex. 1 How many moles of He occupy a volume of 1.50 L at STP?

$$1.50 \text{ L He} \left(\frac{1 \text{ mol He}}{22.4 \text{ L}}\right) = 0.0670 \text{ moles He}$$

Ex. 2 What mass of SO_3 occupies a volume of 2.50 L at STP?

$$2.50 \text{ L } SO_3 \left(\frac{1 \text{ mol}}{22.4 \text{ L}}\right)\left(\frac{80.07 \text{ g } SO_3}{1 \text{ mol}}\right) = 8.94 \text{ g } SO_3$$

Ex. 3 What is the volume (in liters) occupied by 5.000 g of NH_3 at STP?

$$5.000 \text{ g } NH_3 \left(\frac{1 \text{ mol } NH_3}{17.04 \text{ g}}\right)\left(\frac{22.4 \text{ L}}{1 \text{ mol}}\right) = 6.57 \text{ L } NH_3$$

Ex. 4 How many Ne atoms are present in 50.0 L of Ne gas at STP?

$$50.0 \text{ L Ne} \left(\frac{1 \text{ mol}}{22.4 \text{ l}}\right)\left(\frac{6.02 \times 10^{23} \text{ atoms Ne}}{1 \text{ mol}}\right) = 1.34 \times 10^{24} \text{ Ne Atoms}$$