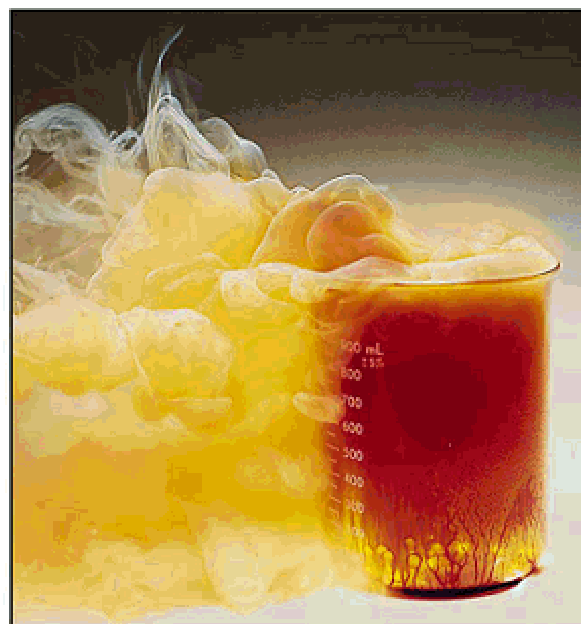
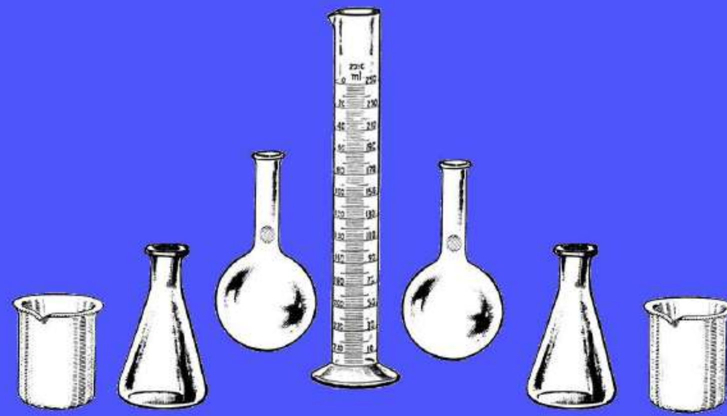
NOTES: 12.2 – Stoichiometric Calculations (moles, mass, volume)

STOICHIOMETRY

- the study of the quantitative aspects of chemical reactions.

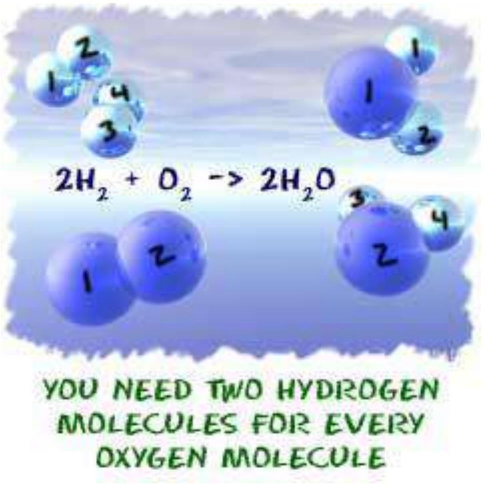




KEEP
CALM
STOICHIOMETRY
IS
EASY

Stoichiometry

- recall: **STOICHIOMETRY** = the calculation of quantities in chemical reactions using balanced equations



Mole-Mole Ratios:

- we've already covered how a balanced equation can be interpreted in terms of:

  -**particles** (molecules, atoms, form. units)

  and

  -**moles**

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

$4Al$ + $3O_2$ → $2Al_2O_3$

4 atoms Al react with
3 molecules O_2 to produce
2 form. units Al_2O_3

OR

4 mol Al react with
3 mol O_2 to produce
2 mol Al_2O_3

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

Example: How many moles of aluminum are needed to form 3.7 mol Al_2O_3?

$$\frac{3.7 \text{ mol } Al_2O_3}{} \times \frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3}$$

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

Example: How many moles of aluminum are needed to form 3.7 mol Al_2O_3?

$$\frac{3.7 \text{ mol } Al_2O_3}{} \times \frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3}$$

<u>7.4 mol Al</u>

Other Calculations:

- when we actually measure out chemicals in the lab, we can't measure MOLES, but we can measure MASS (grams)

- also, recall that can define a mole in terms of:

  mass (grams) – molar mass

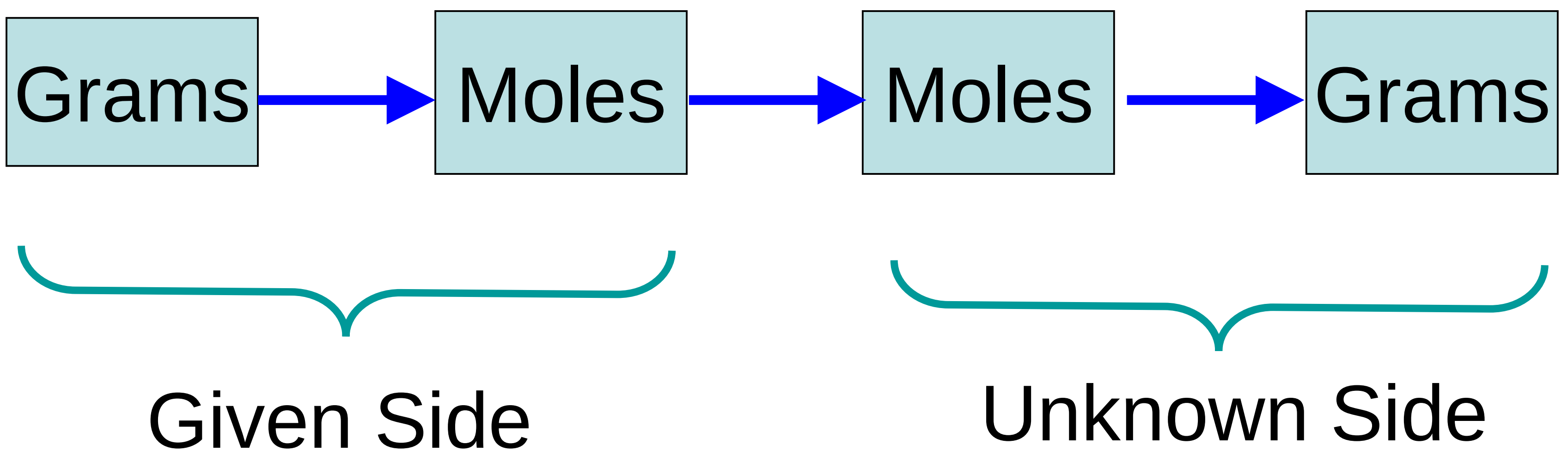
  volume (liters) – molar volume (22.4 L)

  # of particles – Avogadro's # (6.02×10^{23})

Example #1:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

5.0 g Zn will react with hydrochloric acid to produce how much zinc chloride?



Write down the given. Include units.

5.0 g Zn

change to moles, as before (using molar mass)…

$$5.0\,g\left(\frac{1\,mole\,Zn}{65.4\,g\,Zn}\right)$$

Next, use the mole ratio from the balanced equation…

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

$$5.0\,g\left(\frac{1\,mole\,Zn}{65.4\,g\,Zn}\right)\left(\frac{1\,mole\,ZnCl_2}{1\,mole\,Zn}\right)$$

This gets us to moles of $ZnCl_2$

Now, change moles of $ZnCl_2$ to grams. As before.

$$5.0\,g\left(\frac{1 mole\, Zn}{65.4\, g\, Zn}\right)\left(\frac{1 mole\, ZnCl_2}{1 mole\, Zn}\right)\left(\frac{136 g\, ZnCl_2}{1 mole\, ZnCl_2}\right)$$

Check that the units cancel…

Now, solve the equation…

$$5.0\,g\left(\frac{1\,mole\,Zn}{65.4\,g\,Zn}\right)\left(\frac{1\,mole\,ZnCl_2}{1\,mole\,Zn}\right)\left(\frac{136\,g\,ZnCl_2}{1\,mole\,ZnCl_2}\right)$$

= **10.4 g $ZnCl_2$**

Example #2:

CH_4 + $2O_2$ → CO_2 + $2H_2O$

What volume (at STP) of water vapor will be produced when 10.0 g of CH_4 are burned?

$$10.0\,g\,CH_4\left(\frac{1\,mole\,CH_4}{16\,g\,CH_4}\right)$$

This gets us to moles CH_4

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$$10.0\,g\,CH_4\left(\frac{1\,mole\,CH_4}{16\,g\,CH_4}\right)\left(\frac{2\,moles\,H_2O}{1\,mole\,CH_4}\right)$$

This represents moles H_2O…now convert to volume (liters of water) using molar volume

Solve the equation….

$$10.0\,g\,CH_4\left(\frac{1\,mole\,CH_4}{16\,g\,CH_4}\right)\left(\frac{2\,moles\,H_2O}{1\,mole\,CH_4}\right)\left(\frac{22.4\,liters\,H_2O}{1\,mole\,H_2O}\right)$$

= **28.0 L H_2O**

more practice problems!!

1) What mass of CO is required to react with 146 grams of iron (III) oxide?

$$Fe_2O_3 \quad + \quad 3CO \rightarrow \quad 2Fe \quad + \quad 3CO_2$$

$$\frac{146\ g\ Fe_2O_3}{} \times \frac{1\ mol\ Fe_2O_3}{159.6\ g\ Fe_2O_3} \times \frac{3\ mol\ CO}{1\ mol\ Fe_2O_3} \times \frac{28\ g\ CO}{1\ mol\ CO} =$$

$$76.8\ g\ CO$$

2) What mass of iron (III) oxide is required to produce 8.65 grams of carbon dioxide?

$$Fe_2O_3 \quad + \quad 3CO \rightarrow 2Fe \quad + \quad 3CO_2$$

$$\frac{8.65\,g\,CO_2}{} \times \frac{1\,mol\,CO_2}{44\,g\,CO_2} \times \frac{1\,mol\,Fe_2O_3}{3\,mol\,CO_2} \times \frac{159.6\,g\,Fe_2O_3}{1\,mol\,Fe_2O_3} =$$

$$10.5\,g\,Fe_2O_3$$

3) What volume of NO_2 gas will be produced when 105.5 L of O_2 gas react with excess NO? (assume STP)

$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

$$\frac{105.5\,\text{L O}_2}{} \times \frac{1\,\text{mol O}_2}{22.4\,\text{L O}_2} \times \frac{2\,\text{mol NO}_2}{1\,\text{mol O}_2} \times \frac{22.4\,\text{L NO}_2}{1\,\text{mol NO}_2} =$$

$$211.0\,\text{L NO}_2$$