Stoichiometry

Stoichiometry (greek): **Stoicheion** – element, **metry** – to measure

Balanced Chemical equation:

Skills –formula writing
–balancing equations

Tells –substances involved in the chemical rxn
–relationship between the # of particles of each substance

Ex. $N_{2\,(g)} + 3\ H_{2\,(g)} \rightarrow 2\ NH_{3\,(g)}$

1 molecule N_2 + 3 molecules of H_2 → 2 molecules of NH_3
Or… 1 mole N_2 + 3 moles of H_2 → 2 moles of NH_3

If we use 2 moles of N_2 we could make 4 moles of NH_3

Equation: $2\ \text{mol}\ N_2 \left(\frac{2\ \text{mol}\ NH_3}{1\ \text{mol}\ N_2}\right) = 4\ \text{mol}\ NH_3$

Ex. How many moles of oxygen gas are required to produce 5.0 moles of MgO when $Mg_{(s)}$ undergoes combustion?

$2\ Mg_{\,(s)} + O_{2\,(g)} \rightarrow 2MgO_{\,(s)}$

Ex. Aluminum metal will undergo combustion in $O_{2(g)}$ How many moles of aluminum oxide would be produced from 3.70 moles of aluminum?

$4\ Al_{\,(s)} + 3\ O_{2\,(g)} \rightarrow 2Al_2O_{3\,(s)}$

Ex. How many moles of ammonia are produced when you react 12 grams of hydrogen gas with an excess of nitrogen gas?

$N_{2\ (g)} + 3\ H_{2\ (g)} \rightarrow 2\ NH_{3\ (g)}$

Ex. How many grams of hydrogen gas are required to burn with 24.0 grams of oxygen when making water by combustion?

$2\ H_{2\ (g)} + O_{2\ (g)} \rightarrow 2\ H_2O_{\ (g)}$

Reactions involving a Limiting Reactant

When chemicals are mixed together in reactions there are two possibilities:

a) Stoichiometric quantities: exactly correct amounts used, so each reactant runs out at the same time (not too likely)

b) One or more reactants are in excess: more of one reactant then is required, the reaction will proceed until the limiting reactant is all used up

Steps to Follow

1) Write and balance the equation for the reaction
2) Convert known masses of substances into moles
3) Calculate the theoretical number of moles of a product that each of the reactants could form
4) Take the smaller amount to be your limiting reactant
5) Solve for final units (grams, concentration, etc…)

Ex. If 75.0g of mercury react with 50.0g of sulphur, how much HgS will be produced?

1) Hg + S → HgS

2)

3)

4) So mercury only gives 0.374 mol of product, to sulphurs 1.56 mol of product, and therefore mercury is the limiting reagent. Now you know that 0.374 mol of HgS will be produced

5) So just calculate the amount of HgS produced.

Ex. If 15.5g of aluminum react with 46.7g of chlorine how much aluminum chloride will be produced?

$2\ Al + 3\ Cl_2 \rightarrow 2\ AlCl_3$

So because Cl_2 produces less aluminum chloride it's the limiting reactant! And only 0.439 moles of $AlCl_3$ can be produced.

Ex. How many grams of solid aluminum oxide are produced if 270g of aluminum are combined with 256g of oxygen gas?

Aluminum is limiting so…

Amount of excess

How many liters of Oxygen are left over from the above question?

Moles of reactant – moles required for reaction = moles remaining (excess)

Percent Yield

Actual experimental results rarely follow theory (due to side reactions, and impurities, and experimental error etc…) percent yield is a measure of how efficient a particular chemical reaction is in practice.

$$\%\ \text{Yield} = \frac{\text{actual yield (usually given in question)}}{\text{theoretical yield (calculated)}} \times 100\%$$

Ex. If 4.0g of hydrogen gas are burned in excess oxygen and 32.0g of water are produced, what is the yield?

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

Percent Composition

Very similar to % yield, but is concerned with percentage of active ingredient in a sample; such as the % acetic acid in vinegar, or % of Al in bauxite ore.

Ex. Calculate the % composition of copper metal in covellite (CuS) if 37.0kg sample of covellite yields 22.2kg of copper?

$8\ CuS \rightarrow 8\ Cu + S_8$

Stoich problems with Solutions

Recall: $M = n/V$ and $n = M \times V$

Where M = molarity, n = number of moles, V = volume

Ex. 100.0 mL of 0.50 M $Pb(NO_3)_2$ are mixed with 100.0 mL of 0.50 M KI. How much PbI_2 is precipitated? (assume PbI_2 is totally insoluble)

$$Pb(NO_3)_{2(aq)} + 2\ KI_{(aq)} \rightarrow PbI_{2(s)} + 2\ KNO_{3(aq)}$$

Since KI produces less it's the limiting reactant…

Ex. How many grams of copper will react to completely replace the silver from 208 mL of a 0.100M solution of silver nitrate?

$$2\ AgNO_{3\ (aq)} + Cu_{(s)} \rightarrow 2\ Ag_{(s)} + Cu(NO_3)_{2\ (aq)}$$

Here, we can assume that silver is the limiting reactant because it asks how much copper is needed

Stoich problems with Gases

Recall: 1 mole of any gas at STP has a volume of 22.4L

Ex. 33.6 L of N_2 gas reacts with 44.8 L of H_2 gas. What volume of NH_3 will be produced at STP?

$N_{2\,(g)} + 3\ H_{2\,(g)} \rightarrow 2\ NH_{3\,(g)}$

Since H_2 produces less it's the limiting reactant…