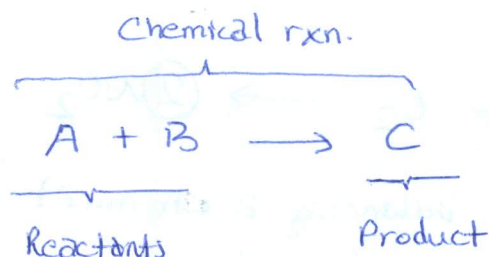


A chemical rxn. is a process in which one set of substances, called reactants, is converted to a new set of substances, called products.



→ Evidences that showing the occurrence of a reaction

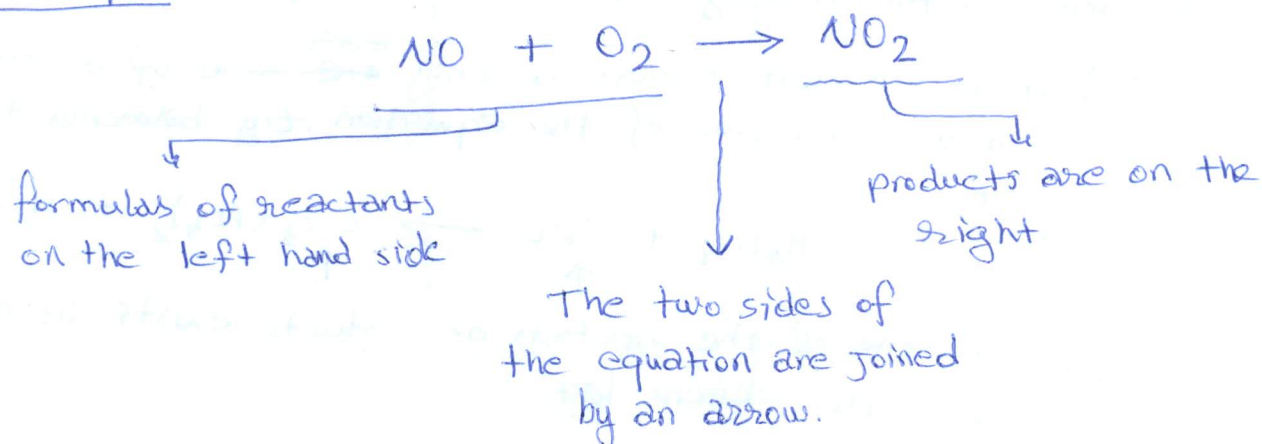
- Color change
- Formation of a solid within a clear solution
- Evolution of a gas
- Evolution or absorption of heat.

Although such observations are significant to show that a rxn. has occurred, a detailed ~~analysis~~ chemical analysis is required to obtain a conclusive evidence.

→ Chemical equations are used to represent chemical rxn.s

How do we write chemical equations?

Example



Since atoms are neither created nor destroyed in any kind of rxn., a chemical equation must have an equinumber of atoms on each side of the arrow.

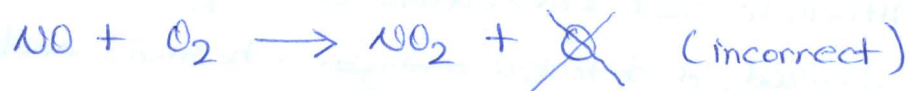
When a reaction meets this condition, it is said to be balanced.



\* The coefficients balancing a chemical equation are called as stoichiometric coefficients.

## Guidelines to Balance a Chemical Equation

- ① An equation can be balanced only by adjusting the coefficients of formulas.
- ② The equation must include only the reactants and products



- ③ Never balance an equation by changing a formula.



→ Some useful strategies for balancing equations

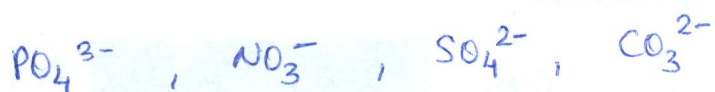
- 2) If an element occurs in only ~~one~~ <sup>each</sup> side of a one compound on each side of the equation, try balancing this element first.



- b) When one of the reactants or products exists as a free element balance this element last.



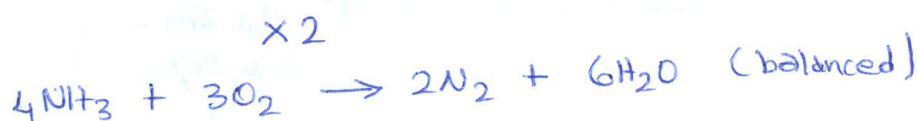
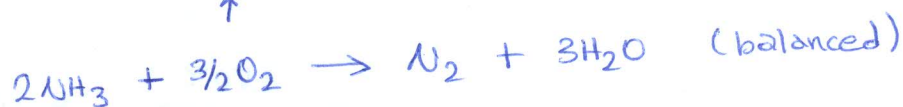
c) In some rxns, certain groups of atoms remain unchanged. (for example, polyatomic ions). In such cases balance this groups as a unit.



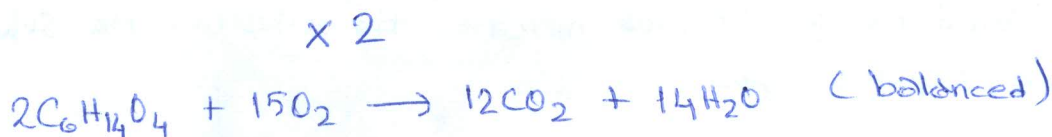
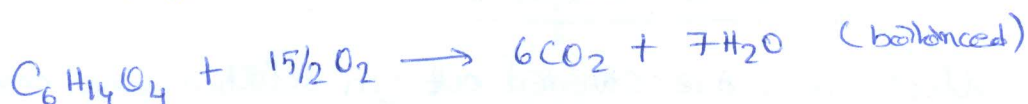
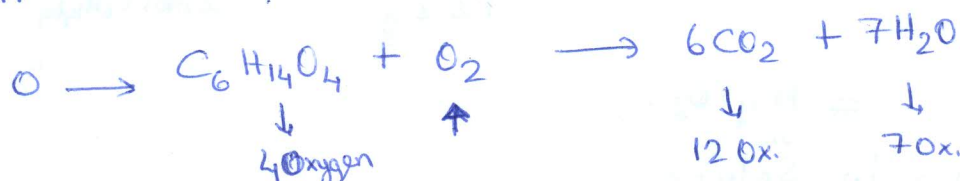
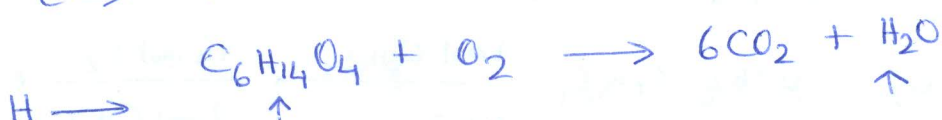
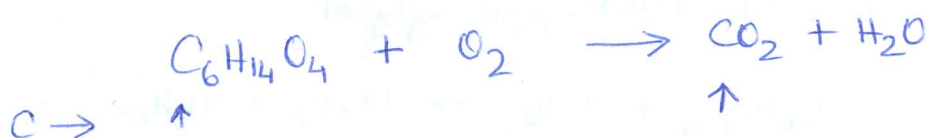
d) Coefficients can be integral or fractional numbers.

 $2, 3, 3/2, 1/2$ 

Example:



Example: Balance the chemical equation of the reaction of triethylene glycol an  $O_2$ .



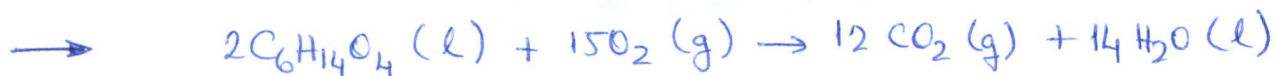


## States of Matter in Chemical Equations

Following symbols are used to show the physical form of reactants and products.

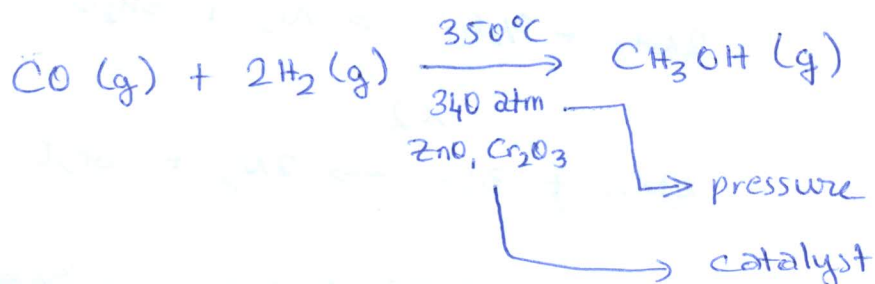
(g): Gas, (l): liquid, (s): solid

(aq.): aqueous (dissolved in water)



## Reaction Conditions

The rxn. conditions are often written above or below the arrow in an equation.



Example: what mass of O<sub>2</sub> is consumed in the complete combustion of 6.86 g of triethylene glycol.



$$\begin{aligned} ? \text{ g O}_2 &= 6.86 \text{ g C}_6\text{H}_{14}\text{O}_4 \times \frac{1 \text{ mol C}_6\text{H}_{14}\text{O}_4}{150.2 \text{ g}} \times \frac{15 \text{ mol O}_2}{2 \text{ mol C}_6\text{H}_{14}\text{O}_4} \times \frac{32 \text{ g O}_2}{1 \text{ mol O}_2} \\ &= 11 \text{ g O}_2. \end{aligned}$$

## Chemical Rxns In Solutions

Most rxns are carried out in solution. One component of a solution is called the solvent, which indicates whether the solution exists as a solid, liquid or gas.

- Molarity: The composition of a solution may be specified by giving its molarity, which is defined as the amount of solute, in moles, per liter of solution.

$$\text{molarity} = \frac{\text{amount of solute (in moles)}}{\text{volume of solution (in liters)}} = \frac{\text{mol}}{\text{L}}$$

$$M = \frac{n}{V}$$

Example: A solution is prepared by dissolving 25.0 mL ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) in enough water to produce a 250.0 mL solution. What is the molarity of ethanol? ( $d_{\text{ethanol}} = 0.789 \text{ g/mL}$ )

$$M = \frac{n}{V} \rightarrow \text{find } n \text{ of ethanol}$$

$$\begin{aligned} ? \text{ mol ethanol} &= 25.0 \text{ mL ethanol} \times \frac{0.789 \text{ g/mL eth.}}{1 \text{ mL eth.}} \times \frac{1 \text{ mol eth.}}{46.07 \text{ g eth.}} \\ &= 0.428 \text{ mol CH}_3\text{CH}_2\text{OH} \end{aligned}$$

$$M = \frac{0.428 \text{ mol ethanol}}{0.2500 \text{ L solvent}} = 1.71 \text{ M CH}_3\text{CH}_2\text{OH}$$

Example: What mass of  $\text{K}_2\text{CrO}_4$  is needed to prepare 250 mL of a 0.250 M  $\text{K}_2\text{CrO}_4$  solution in water.

$$\begin{aligned} ? \text{ g K}_2\text{CrO}_4 &= 0.2500 \text{ L soln} \times \frac{0.250 \text{ mol K}_2\text{CrO}_4}{1 \text{ L soln}} \times \frac{194.2 \text{ g K}_2\text{CrO}_4}{1 \text{ mol K}_2\text{CrO}_4} \\ &= 12.1 \text{ g K}_2\text{CrO}_4 \end{aligned}$$

$$M = \frac{n}{V} \Rightarrow n = M \cdot V$$

$$n \text{ K}_2\text{CrO}_4 \rightarrow m \text{ K}_2\text{CrO}_4$$

$$n = \frac{m}{m_w} \Rightarrow m = n \cdot m_w$$

## Solution Dilution

Dilution is used to prepare dilute solutions from so-called stock solutions that stored as highly concentrated solutions.

When a volume of solution is diluted, the amount of solute remains constant. So the mol of solute.

$$n_i = n_f$$

since

$$n_i = M_i \cdot V_i \quad \text{and} \quad n_f = M_f V_f$$

$$\boxed{M_i V_i = M_f V_f}$$

This equation is used to find final conc. of a diluted solution.

Example: What volume of 0.250 M NaOH must be diluted with water to obtain a 0.250 L of 0.0100 M NaOH.

$$M_i V_i = M_f V_f$$

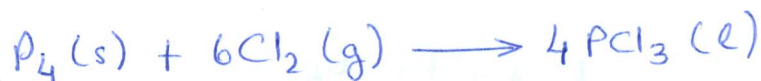
$$0.250 \times V_i = 0.010 \times 0.250$$

$$V_i = 0.01 \text{ L} = 10 \text{ mL soln}$$

## Determining the Limiting Reactant

The reactant that is completely consumed in a rxn. is called as the Limiting Reactant. The limiting reactant determines or limits the amounts of products formed.

Example:



What is the maximum mass of  $\text{PCl}_3$  that can be formed from 125g  $\text{P}_4$  and 323g  $\text{Cl}_2$ ?



$$? \text{ mol Cl}_2 = \frac{323 \text{ g Cl}_2}{70.91 \text{ g Cl}_2} \times \frac{1 \text{ mol Cl}_2}{1} = 4.56 \text{ mol Cl}_2$$

$$? \text{ P}_4 = 125 \text{ g P}_4 \times \frac{1 \text{ mol P}_4}{123.9 \text{ g P}_4} = 1.01 \text{ mol P}_4$$

$\frac{\text{P}_4}{\text{Cl}_2} = \frac{1}{6} \rightarrow$  Since there is less than 6 mol  $\text{Cl}_2$  per mole of  $\text{P}_4$ , chlorine ( $\text{Cl}_2$ ) is the limiting reactant.

\* If more than 6 mol  $\text{Cl}_2$  was available per mole of  $\text{P}_4$ ,  $\text{P}_4$  would have been the limiting reactant.

$$\begin{aligned} ? \text{ g PCl}_3 &= 4.56 \text{ mol Cl}_2 \times \frac{4 \text{ mol PCl}_3}{6 \text{ mol Cl}_2} \times \frac{137.3 \text{ g PCl}_3}{1 \text{ mol PCl}_3} \\ &= 417 \text{ g PCl}_3 \end{aligned}$$

What mass of  $\text{P}_4$  remains?



$$\begin{aligned} ? \text{ g P}_4 &= 417 \text{ g PCl}_3 \times \frac{1 \text{ mol PCl}_3}{137.3 \text{ g PCl}_3} \times \frac{1 \text{ mol P}_4}{4 \text{ mol PCl}_3} \times \frac{123.9 \text{ g P}_4}{1 \text{ mol P}_4} \\ &= 94.1 \text{ g P}_4 \end{aligned}$$

$$125 \text{ g P}_4 - 94.1 \text{ g P}_4 = 31 \text{ g P}_4 \text{ remaining.}$$

Theoretical Yield: The theoretical yield of a rxn., is the calculated quantity of product expected from given quantities of reactants.



Actual Yield: The quantity of product that is actually produced is called the actual yield.



Percent yield:

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

$$A + B \rightarrow C \quad \text{py} = \frac{8.5}{10} \times 100 = 85\%$$

Factors  
→ ~~Reasons~~ effecting the actual yield

a) Loss of product during purification

b)