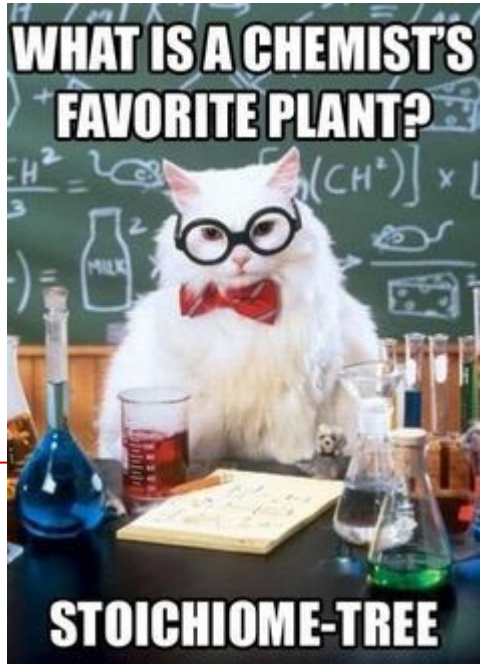
Stoichiometry



Learning Goal

To perform calculations based on chemical equations using mass-mass and solution stoichiometry.

Starter Question

If we had 5.0 grams of Magnesium which burns in oxygen, how many grams of MgO should we produce?

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

Mole Ratio	2	:	1	:	2

DID YOU GET IT? GUESS WHAT!? YOU KIND OF JUST DID STOICHIOMETRY!!

Quantities in a reaction

- If we have a balanced equation that tells us the relative proportions of all our reactants and products,
- From data about just one reactant or product we can work out the quantities of others

e.g. $2H_2(g) + O_2(g) \rightarrow 2H_20(l)$

Whenever this reaction takes place you need twice as much Hydrogen as oxygen

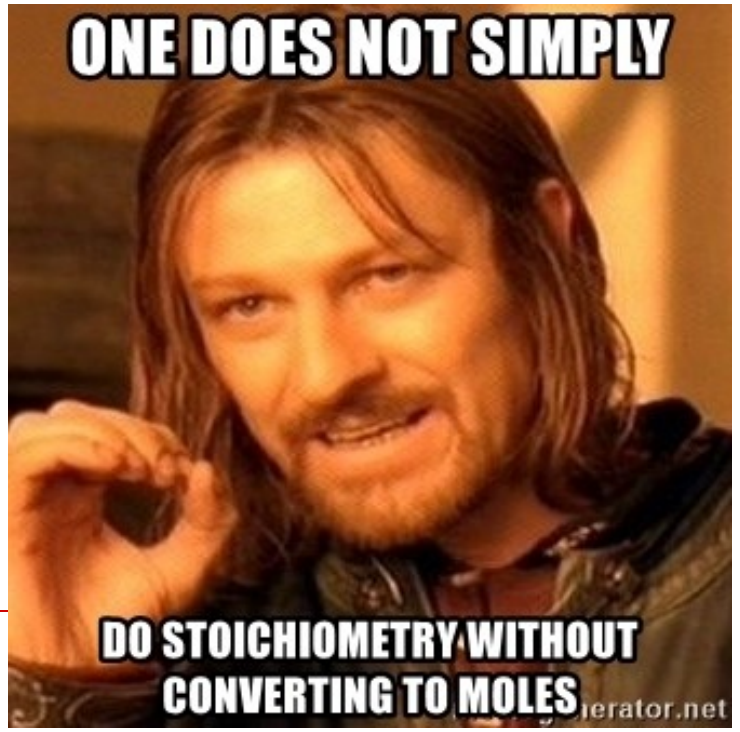
The amount of water produced is the same as the amount of hydrogen used (in Mole)

Mole – Mole stoichiometry

- The simplest kind
- Working out the number of Mole of one substance from the number of mole of another in the same reaction

1. Write the balanced equation
2. Use the mole ratio to work out

the number of moles of your desired substance.



Example

- How many moles of Hydrochloric acid will be made from reacting 3 moles of hydrogen with excess chlorine?

1. $H_2(g) + Cl_2(g) \rightarrow 2HCl$

2. 1 mole of Hydrogen gives 2 moles of HCl

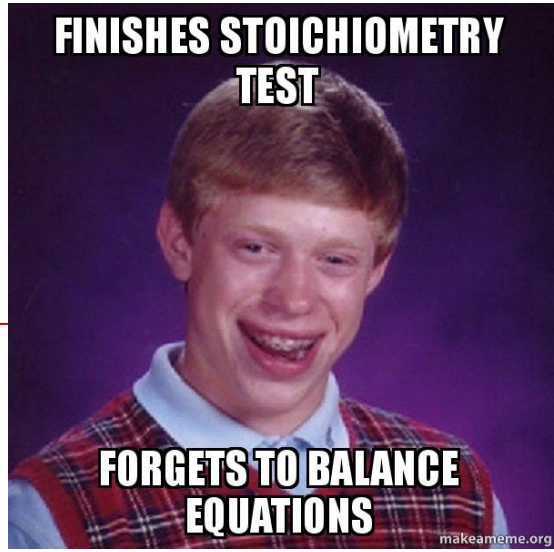
   So 3 moles of hydrogen give 6 moles HCl

   (3 x 2/1)

Mass-Mass stoichiometry

- When you know the mass of one substance in an equation you can calculate the mass of the other components
- You will need a balanced equation and the ability to calculate the amount in Mole.

Mass-Mass stoichiometry



1. Write the full balanced equation

2. Calculate the amount in mole of the substance with the known mass

3. Use the mole ratio in the equation to calculate the amount in mole of the substance needed.

4. Calculate the mass of the substance from its amount.

MOLE RATIO

In a chemical equation, the coefficients indicate the ratio of one substance in the reaction to another.

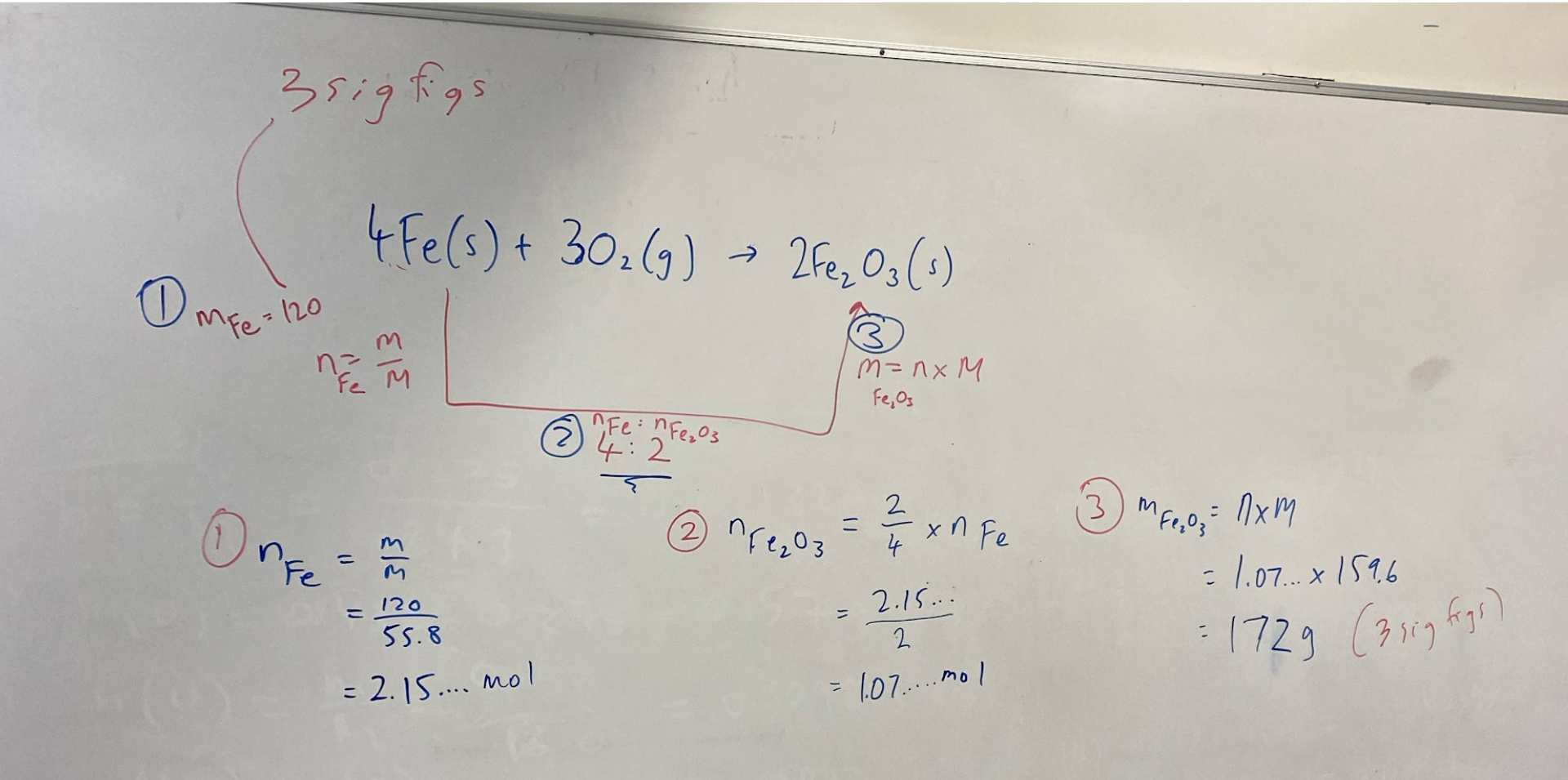
Finding the number of mole of a substance using coefficients:

$$n(\text{unknown}) = \frac{\textit{coefficient of unknown}}{\textit{coefficient of known}} \times n(\textit{known})$$

Example 1

What mass of Iron(IV) oxide is made when 120.0g of Iron rusts?

Iron rusts slowly when exposed to air and water.



Example

1. $Fe(s) + O_2(g) \rightarrow FeO_2(s)$

2. $n(Fe) = \frac{70.0g\ (m)}{55.8\ (M)} = 1.25$ (don't round yet on your calculator)

3. 1 mole Iron gives 1 moles Iron (IV) Oxide

So 1.25 Moles Iron gives 1.25 Moles (still don't round) Iron(VI) Oxide

4. $m(Fe) = 1.25(n) \times 87.8(M)$

   110g (3 sig figs)

Examples

1. Write a balanced equation for the combustion of methane.

2. Calculate the mass of magnesium oxide produced from burning 5.0g magnesium in excess oxygen.

Try it yourself

For the combustion of propane shown below:

$$C_3H_8\,(g) + 5O_2\,(g) \rightarrow 3CO_2\,(g) + 4H_2O\,(g)$$

How many moles of carbon dioxide are produced if 20 moles of oxygen are reacted?

Try it yourself

Question 2

Slaked lime is calcium hydroxide, which is made by reacting calcium oxide with water.

$$CaO\,(s) + H_2O\,(l) \rightarrow Ca(OH)_2\,(s)$$

Slaked lime is used to remove acidic gases from the waste fumes that are emitted from power stations. One of the gases is sulphur dioxide.

$$Ca(OH)_2\,(s) + SO_2\,(g) \rightarrow CaSO_3\,(s) + H_2O\,(l)$$

Calculate the mass (in grams) of sulphur dioxide that can be removed with an available supply of 100.0 kg of calcium oxide. [4]

Answer

m(CaO) = 100 000g

M(CaO) = 56.1 g/mol [1 mark]

n(CaO) = m / M

= 100 000 / 56.1

= 1782.53 mol [1 mark]

$n(SO_2) = n(CaO)$

= 1782.53 mol [1 mark]

$m(SO_2) = n \times M$

= 1782.53 x 64.1

= 114 260.25 g

= 1.143×10^5 g OR 114.3 kg [1 mark] (4 sig figs)

Learning Goal
To perform calculations based on chemical equations using mass-mass stoichiometry.

Complete the following

* Do the mass-mass stoichiometry worksheet.

LATER: Stoich in solutions

- In many cases reactions occur in solution.
- We can determine the amount in mol of a substance in a solution from its concentration and volume
- We can then use molar ratios to find the amount of any other substance in solution

Steps for stoich in solutions

1. Write the full balanced equation
2. Calculate the amount in mole of the substance with known concentration and volume.
3. Use the mole ratio in the equation to calculate the amount in mole of the substance needed.
4. You may then need to calculate the concentration of the final solution or the mass of a substance formed

Example 1

300ml of a 0.10M solution of Barium Chloride is mixed with excess Sodium sulphate solution. What is the mass of the precipitate formed.

Example

1. $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$

2. $n(BaCl_2) = c \times v$

$0.10\ (c) \times 0.30\ (V)$

$= 0.030$ mol

3.

1:1 mole ratio

So 0.03 mol Barium sulphate will be formed

4. $m(BaSO_4) = n \times M$

$0.030(n) \times 233.34(M)$

7.0g $BaSO_4$

Example 2

500ml of a 0.250M solution of HNO_3 reacts with excess H_2S solution according to the following reaction:

$$2HNO_3(aq) + 3H_2S(aq) \rightarrow 3S(s) + 4H_2O(l) + 2NO(g)$$

What mass of sulfer is formed?

Example 2

1. $2HNO_3(aq) + 3H_2S(aq) \rightarrow 3S(s) + 4H_2O(l) + 2NO(g)$

2. $n(HNO_3) = c \times v$

   $0.250\ (c) \times 0.50\ (V)$

   $= 0.125$ mol

3.

   2:3 mole ratio

   $n(S) = \ \times n(HNO_3) = 1.5 \times 0.125 = 0.1875$ mol

4. $m(S) = n \times M$

0.1875×32

6.0g S

Limiting reagents

- In some calculations you will be given the mass or amount of 2 reactants
- You will have to determine which is the limiting reagent
- You then use the amount of limiting reagent **only** to do your stochiometric calculations.

Example 1

2g of Hydrogen and 8g of oxygen are reacted to make water. What is the final mass of water produced

Example 1

1. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

2. $n(H_2) = \frac{2(m)}{2(M)} = 1$ Mol Hydrogen

   $n(O_{2)} = 8(m)/ 32 = 0.25$ Mol Oxygen

3. You need 2 Mol Hydrogen for 1 Mol Oxygen

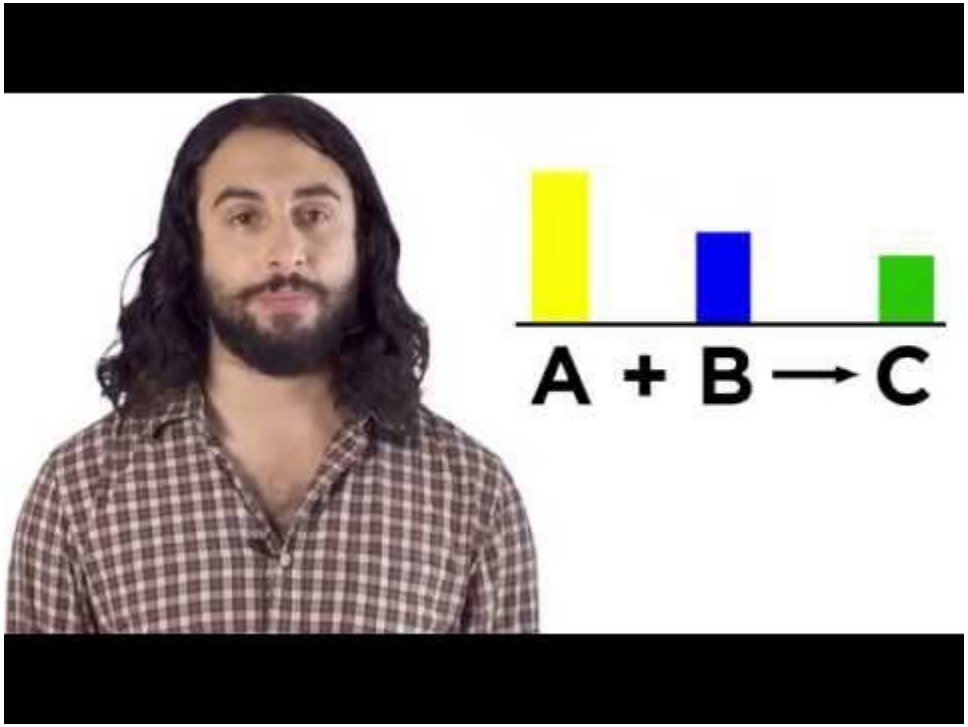
   So 1 Mol Hydrogen for 0.5 Mol Oxygen

   Hydrogen is in excess.

4. 1 Mol Oxygen gives 2 Mol water
   0.25mol O2 gives 0.5mol water

$m\ (H_2O) = 0.5(n) \times 18(M) = 9g$ water.

Professor Dave explains..



Example 2

50.0mL of 1.2M lead(II)nitrate solution is reacted with 75.0mL of 0.900M potassium chloride solution.

What mass of precipitate is obtained from this reaction?

Example 2

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

$n(Pb(NO_3)_2) = cV = 1.2M \times 0.0500L = 0.0600mol$

$n(KCl) = cV = 0.900M \times 0.0750L = 0.0675\ mol$

$n(KCl)$ needed for reaction is $= 2 \times n(Pb(NO_3)_2)$

Therefore, $n(KCl)$ is limiting, $n(Pb(NO_3)_2$ is in excess

USE LIMITING REAGENT: $n(KCl) = 0.0675mol$

$n(PbCl_2) : n(KCl)$

$1 : 2$

$n(PbCl_2) = 0.0675/2$

$= 0.0338mol$

$m = nM = 0.0338mol \times (207.2 + 2 \times 35.5)\ g/mol$