Simple Step-by-Step Guides to Solving Chemistry Problems

Stoichiometry

Nigel Freestone
www.chemtextbook.com

Stiochiometry

Introducing the 'Mole Calculating Frame

The '*Mole Calculating Frame*', which is both intuitive and easy to use, provides a simple approach to understanding and solving most mole-based problems.

$$dAX_3 + eZ_2 \longrightarrow pAZ + qZX_2$$

Balanced Equation	dAX_3	+	eZ_2	$\longrightarrow$	pAZ	+	qZX_2
Reaction Coefficients	d		e		p		q
Ar or Mr	$M_r[AX_3]$		$M_r[Z_2]$		$M_r[AZ]$		$M_r[ZX_2]$
Mass Balance*	d x $M_r[AX_3]$		e x $M_r[Z_2]$		p x $M_r[AZ]$		q x $M_r[ZX_2]$
Mass (g)	= No. of moles AX_3 x $M_r[AX_3]$		= No. of moles Z_2 x $M_r[Z_2]$		= No. of moles AZ x $M_r[AZ]$		= No. of moles ZX_2 x $M_r[ZX_2]$
No. of Moles	= Mass of $AX_3/M_r[AX_3]$		= Mass of $Z_2/M_r[Z_2]$		= Mass of $AZ/M_r[AZ]$		= Mass of $ZX_2/M_r[ZX_2]$
No. of Moles (gases only)	= Vol. $(AX_3)/V_m$		= Vol. $(Z_2)/V_m$		= Vol. $(AZ)/V_m$		= Vol. $(ZX_2)/V_m$
Volume (gases only)	= No. of moles AX_3 x Vm		= No. of moles Z_2 x Vm		= No. of moles AZ x Vm		= No. of moles ZX_2 x Vm

* Mass Balance: $(d \times M_r[AX_3]) + (e \times M_r[Z_2]) = (p \times M_r[AZ]) + (q \times M_r[ZX_2])$

Note: All the items in red are known or can be readily obtained from the balanced equation and relative atomic masses. In calculations additional information will be provided from which all the remaining values can be determined, using the equations provided in the boxes.

How to use the Mole Calculating Frame

Step 1: construct a frame around the balanced chemical equation;

Step 2: list the parameters – i.e. reaction coefficients, molar mass, mass, number of moles etc - in the left-hand column;

Step 3: insert all known information. Remember you will always be able to determine A_r, M_r, reaction coefficients and undertake a mass balance;

Step 4: use question mark(s) to identify the parameters you need to calculate to solve the problem;

Step 5: identify which gaps in the framework you can calculate using the known or given information.

Units: mass in grams (g), volume in litres (L) or cm^3, M_r in g mol^{-1}

The Moles Calculating Frame is highly flexible. By changing the parameters in the left-hand column, it can be used to solve all chemical equation based problems involving solids and gases, including:

Grams of Reactant to Grams of Product
Moles of Reactant to Moles of Product
Moles of Reactant to Grams of Product
Grams of Reactant to Moles of Product

Example 1: Magnesium metal (Mg) burns with a bright white flame to produce magnesium oxide (MgO). How much MgO could be produced from 2 g of Mg?

Answer

Step 1: write a balanced equation for the reaction:

$$2Mg + O_2 \rightarrow 2MgO$$

Fill in the M_r of all species and undertake a mass balance {reactants mass = (48 + 32) = products mass (80)} to both ensure that you have a balanced chemical equation and check that you have calculated the M_r values correctly.

	2Mg	+	O_2	→	2MgO
Reaction Coefficients	2		1		1
M_r	24		32		40
Mass Balance	48		32		80
Mass					
No. of moles					

Step 2: Fill in all the information you have been given in the question:

	2Mg	+	O_2	→	2MgO
Reaction Coefficients	2		1		1
M_r	24		32		40
Mass Balance	48		32		80
Mass	2				?
No. of moles					

Step 3: Work out the number of moles of any species for which you are given the mass (ie Mg - reactant), using $n=m/M_r$. Then use the reaction stoichiometry to determine the number of moles of the unknown, i.e. one (1) mole of Mg will produce one (1) mole MgO:

	$2Mg$	+	O_2	→	$2MgO$
Reaction Coefficients	2		1		1
Mass Balance	48		32		80
Mass	2				?
No. of moles	2/24 = 0.083				0.083

Step 4: Since we now know the M_r and the number of moles of the unknown (MgO), its mass can be calculated ie **mass: m=n x M_r**

	$2Mg$	+	O_2	→	$2MgO$
Reaction Coefficients	2		1		1
M_r	24		32		40
Mass Balance	48		32		80
Mass	2				0.083 x 49 = **3.33**
No. of moles	0.083				0.083

Once you are familiar with the process, you don't need a calculation frame, but keep your workings ordered and logical.

Answer: **3.33 g**

Example 2: Baking soda (sodium hydrogen carbonate) thermally degrades to produce sodium carbonate, water and carbon dioxide according the following equation:

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

What mass of sodium hydrogen carbonate is required to produce 10.6 g of sodium carbonate

Step 1: Fill in M_r values and undertake a mass balance:

	$2NaHCO_3$	→	Na_2CO_3	+	H_2O	+	CO_2
Reaction Coefficients	2		1		1		1
M_r	84		106		18		44
Mass Balance	168		106		18		44
		168		168			
Mass							
No. of moles							

Step 2: Fill in all the information you have been given in the question:

	$2NaHCO_3$	→	Na_2CO_3	+	H_2O	+	CO_2
Reaction Coefficients	2		1		1		
M_r	84		106		18		44
Mass Balance	168		106		18		44
Mass	?		10.6				
No. of moles							

Step 3: Work out the number of moles of any species for which you are given the mass (ie Na_2CO_3 - product), using n=m/M_r . Then use the reaction stoichiometry to determine the number of moles of the unknown, ie two (2) moles $NaHCO_3$ produce one (1) mole of Na_2CO_3:

	$2NaHCO_3$	→	Na_2CO_3	+	H_2O	+	CO_2
Reaction Coefficients	2		1		1		1
M_r	84		106		18		44
Mass Balance	168		106		18		44
Mass	?		10.6				
No. of moles	2 x 0.1 = 0.2		10.6/106 = 0.1				

Step 4: Since we now know the M_r and the number of moles of the unknown ($NaHCO_3$), its mass can be calculated ie **mass: m = n x M_r**

	$2NaHCO_3$	→	Na_2CO_3	+	H_2O	+	CO_2
Reaction Coeffients	2		1		1		1
M_r	84		106		18		44
Mass Balance	168		106		18		44
Mass	0.2 x 84 = **16.8**		10.6				
No. of moles	2 x 0.1 = 0.2		10.6/106 = 0.1				

Answer: **16.8 g**

Example 3: *Use the following equation to answer the questions below:*

$$2H_{2(g)} + 1O_{2(g)} \rightarrow 2H_2O_{(l)}$$

a) *How many moles of oxygen will need to be consumed to produce 8 moles of water?*

Answer

Construct a mole calculating frame around the balanced equation

	$2H_2$	+	O_2	→	$2H_2O$
A_r/M_r	2		32		18
Mass Balance	4		32		2 x 18 = 36
		36			
Reaction Coefficients	2		1		1
	8		8/2 = 4		8

Thus 1 mole H_2O is produced from 0.5 mole of O_2

Therefore, 8 moles are H_2O are produced from 0.5 x 8 = **4 moles**

b) *What mass of water will be produced from the combustion of 100g of hydrogen?*

Answer

	$2H_2$	+	O_2	→	$2H_2O$
A_r/M_r	2		32		18
Mass Balance	4		32		2 x 18 = 36
		36			
Reaction Coefficients	2		1		1
Mass (g)	100				50 x 18 = **900**
Number of Moles	100/2 = 50				

Number of moles of H_2 in 100 g = mass/M_r = 100/2 = 50

According to the reaction coefficients 2moles of H_2 produce 2 moles H_2O

Therefore, 50 moles of H_2 will produce 50 moles H_2O

Mass of 50 moles of H_2O = number of moles x Mr = 50 x 18 = **900g**

c) *What mass of hydrogen can be combusted by 4 g of oxygen gas?*

Answer

	$2H_2$	+	O_2	→	$2H_2O$
Reaction Coefficients	2		1		2
A_r/M_r	2		32		18
Mass Balance	4		32		2 x 18 = 36
		36			
Mass (g)	0.25 x 2 = **0.5**		4		

Number of Moles	2 x 0.125 = 0.25	4/32 = 0.125

Number of moles in 4 g O_2 = mass/Mr = 4/32 = 0.125
According to the reaction coefficients 2 moles of H_2 require 1 mole of O_2 for combustion
Therefore 0.125 moles of O_2 can combust 2x 0.125 = 0.25 moles H_2
Mass of 0.25 moles H_2 = mass x M_r = 0.25 x 2 = **0.5g**

Example 4: *Use the following equation to answer the questions below:*

$$2CH_3OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 4H_2O_{(l)}$$

a) How many moles of water will be produced from the combustion of 0.17 moles of CH_3OH?

Answer

	$2CH_3OH$	+	$3O_2$	→	$2CO_2$	+	$4H_2O$
Reaction Coefficients	2		3		2		4
M_r	32		32		44		18
Mass Balance	64		96		88		72
		160				160	

The reaction coefficients tell us that 2 moles CH_3OH produce 4 moles H_2O
Thus 1 mole CH_3OH produces 2 moles H2O
Therefore, 0.17 moles CH3OH will produce 2 x 0.17 = 0.34 moles H_2O

b) How many moles of O_2 are needed to burn 2.78 moles of CH_3OH?

Answer

	$2CH_3OH$	+	$3O_2$	→	$2CO_2$	+	$4H_2O$
Reaction Coefficients	2		3		2		4
M_r	32		32		44		18
Mass Balance	64		96		88		72
		160				160	
Number of Moles	2.78		3/2 x 2.78 = **4.17**				

The reaction coefficients tell us that 2 moles CH_3OH require 3 moles O_2 for combustion
Thus 1 mole CH_3OH requires 3/2 moles O_2 for combustion
Therefore, 2.78 moles CH3OH requires 3/2 x 2.78 = 4.17 moles O_2

c) How many moles of CO_2 are produced from the combustion of 1.25 moles of CH_3OH?

Answer

	$2CH_3OH$	+	$3O_2$	→	$2CO_2$	+	$4H_2O$
Reaction Coefficients							
M_r	32		32		44		18
Mass Balance	64		96		88		72
		160				160	
Reaction Coefficients	2		3		2		4
Number of Moles	1.25		1.875		**1.25**		2.50

The reaction coefficients tell us that 2 moles CO_2 are produced from the combustion of 2 moles CH_3OH
Thus 1 mole CO_2 is produced from the combustion of 1 mole of CH_3OH
Therefore, 1.25 CO_2 are produced from the combustion of 1.25 moles CH_3OH

Practice Problems

a. Determine the number of moles of N_2O_4 needed to react completely with 3.62 moles of N_2H_4 for the reaction:

$$2N_2H_{4(l)} + N_2O_{4(l)} \rightarrow 3N_{2(g)} + 4H_2O_{(l)}$$

b. What mass of iron (II) sulfide can be formed from 14.0 g of sulphur?

$$Fe_{(s)} + S_{(s)} \rightarrow FeS_{(s)}$$

c. What mass of aluminum will be needed to react with 10 g of CuO, and what mass of Al_2O_3 will be produced?

$$3CuO_{(s)} + 2Al_{(s)} \rightarrow Al_2O_{3(s)} + 3Cu_{(s)}$$

d. What mass of magnesium oxide is made when 250 g of oxygen reacts with excess magnesium?

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

e. Titanium(IV) chloride can be converted to titanium by reacting it with an excess of magnesium.

$$TiCl_{4(l)} + 2Mg_{(s)} \rightarrow Ti_{(s)} + 2MgCl_{2(s)}$$

What mass of titanium could theoretically be obtained from 37.98 kg of titanium(IV) chloride?

f. What mass of potassium hydrogen carbonate is needed to make 100 g of potassium carbonate on thermal decomposition?

$$2KHCO_{3\,(s)} \rightarrow K_2CO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$$

g. The Thermite Reaction below forms the basis of thermite welding often used to join rail tracks.

$$Fe_2O_{3(s)} + 2Al_{(s)} \rightarrow Al_2O_{3(s)} + 2Fe_{(s)}$$

What mass of aluminium is required to produce 7g of iron?

h. What mass of zinc chloride would be formed by reacting 10 g of zinc with dilute hydrochloric acid?

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

i. Lithium oxide is a drying agent used on the space shuttle. What mass of water could be removed by 65g of lithium oxide?

$$Li_2O_{(s)} + H_2O_{(l)} \rightarrow LiOH_{(s)}$$

j. Cisplatin is an anti-cancer agent prepared as follows:

$$K_2PtCl_{4(aq)} + 2NH_{3(aq)} \rightarrow Pt(NH_3)_2Cl_{2\ (aq)} + 2KCl_{(aq)}$$

How many grams of cisplatin can be obtained from 10.0 g of K_2PtCl_4?

k. Ammonia (NH_3) combusts in air to produce nitrogen dioxide and water according the following equation:

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4\ NO_{(g)} + 6H_2O_{(l)}$$

How many moles and how many grams of oxygen (O_2) are needed to react with 56.8 grams of ammonia by this reaction?

l. Using the following equation:

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow 2\ H_2O_{(l)} + Na_2SO_{4(aq)}$$

How many grams of sodium sulfate will be formed if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid?

m. Using the following equation:

$$NaIO_3 + 6\ HI \rightarrow 3I_2 + NaI + 3\ H_2O$$

Calculate the number of moles and the number of grams of iodine (I_2) that can be made this way from 8.2 grams of $NaIO_3$.

n. A solution of copper sulphate reacts with sodium hydroxide solution to produce a precipitate of copper hydroxide according to the following equation:

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Cu(OH)_2(s) + Na_2SO_{4(aq)}$$

What mass of sodium hydroxide would be needed to convert 15.95 g of copper sulphate to copper hydroxide and what mass of copper hydroxide would be produced?

Answers are given on the next page.

Practice Problem Answers

a. Determine the number of moles of N_2O_4 needed to react completely with 3.62 moles of N_2H_4 for the reaction:

$$2N_2H_{4(l)} + N_2O_{4(l)} \rightarrow 3N_{2(g)} + 4H_2O_{(l)}$$

Answer:

The balanced chemical equation tells us that 2 moles of $2N_2H_4$ react with 1 mole N_2O_4
Thus 3.62 moles of N_2H_4 will require 3.62/2 = **1.81 moles of N_2O_4**

b. What mass of iron (II) sulfide can be formed from 14.0 g of sulphur?

$$Fe_{(s)} + S_{(s)} \rightarrow FeS_{(s)}$$

Answer:

	$Fe_{(s)}$	+	$S_{(s)}$	→	$FeS_{(s)}$
Reaction Coefficients	1		1		1
A_r/Mr	56		32		88
Mass Balance		88			88
Mass	0.438 x 56 = 24.5g		14		0.438 x 88 =**38.5**
No. of moles	0.438		14/32 = 0.438		

Number of moles in 14g of S = 14/32 = 0.438
According to the reaction coefficients, 1 mole of Fe reacts with 1 mole of S
Therefore 0.438 moles of S can produce 0.438 moles of FeS
Mass of 0.438 moles of FeS = number of moles x M_r = 0.438 x 88 = **38.5g**

c. What mass of aluminum will be needed to react with 10 g of CuO, and what mass of Al_2O_3 will be produced?

$$3CuO_{(s)} + 2Al_{(s)} \rightarrow Al_2O_{3(s)} + 3Cu_{(s)}$$

Answer:

	3CuO	+	2Al	→	Al_2O_3	+	3Cu
Reaction Coefficients	3		2		1		3
A_r/ M_r	79.5		27		102		63.5
Mass Balance	238.5		54		102		190.5
		292.5				292.5	
Mass	10				0.042 x 102 = **4.28 g**		
No. of moles	10/79.5 = 0.126				0.126/3 = 0.042		

Number of moles in 10 g of CuO = 10/79.5 = 0.126
According to the reaction coefficients, 3 moles of CuO produce 1mole of Al_2O_3.
Therefore, the number of moles of Al_2O_3 produced from 0.126 moles of CuO = 0.126/3 = 0.042
Mass of 0.042 moles of Al_2O_3 = number of moles x M_r = 0.042 x 102 = **4.28 g**

d. What mass of magnesium oxide is made when 250 g of oxygen reacts with excess magnesium?

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

Answer:

	$2Mg_{(s)}$	+	$O_{2(g)}$	→	$2MgO_{(s)}$
Reaction Coefficients	2		1		2
A_r/Mr	24		32		40
Mass Balance	48		32		
		80			80

Mass	250	15.6 x 40 = **625g**
No. of moles	250/32 = 7.8	2 x 7.8 = 15.6

Number of moles O_2 in 250g = 250/32 = 7.8
According to the reaction coefficients, one mole of O_2 produces 2 moles of MgO
Therefore, the number of moles of MgO produced from 7.8 moles O_2 = 7.8 x 2 = 15.6
Mass of 15.6 moles MgO = number of moles x M_r = 15.6 x 40 = **625 g**

e. Titanium(IV) chloride can be converted to titanium by reacting it with an excess of magnesium.

$$TiCl_{4(l)} + 2Mg_{(s)} \rightarrow Ti_{(s)} + 2MgCl_{2(s)}$$

What mass of titanium could theoretically be obtained from 37.98 kg of titanium(IV) chloride?

Answer:

	TiCl	+	2Mg	→	Ti	+	$2MgCl_2$
Reaction Coefficients							
A_r/ M_r	190		24		48		95
Mass Balance	190		48		48		190
		138				138	
Mass (g)	37980				199.9 x 48 = **9595**		
No. of moles	37980/190 = 199.9				200		

Number of moles $TiCl_4$ in 37.48 kg = 37980/190 = 199.9
According to the reaction coefficients, 1 mole of $TiCl_4$ generates 1 mole Ti
Therefore, the number of moles of Ti generated from 199.9 moles $TiCl_4$ = 199.9 moles
Mass of 200 moles of Ti = number of moles x M_r = 199.9 x 48 = 9595 g = **9.595 kg**

f. What mass of potassium hydrogen carbonate is needed to make 100 g of potassium carbonate on thermal decomposition?

$$2KHCO_{3\ (s)} \rightarrow K_2CO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$$

Answer:

	$2KHCO_3$	→	K_2CO_3	+	H_2O	+	CO_2
Reaction Coefficients	2		1		1		1
M_r	100				18		44
Mass Balance	200		138		18		44
		200		200			
Mass (g)	1.45 x 100 = 145		100				
No. of moles	0.725 x 2 = **1.45**		100/138 = 0.725				

Number of moles of K_2CO_3 in 100g = 100/138 = 0.73
According to the reaction coefficients 1 mole K_2CO_3 is produced from 2 moles of $KHCO_3$
Therefore 0.725 moles of K_2CO_3 would be generated from 0.725 x2 = 1.46 moles of $KHCO_3$
Mass of 1.46 moles of $KHCO_3$ = number of moles x M_r = 1.45 x 100 = **145 g**

g. The Thermite Reaction below forms the basis of thermite welding often used to join rail tracks.

$$Fe_2O_{3(s)} + 2Al_{(s)} \rightarrow Al_2O_{3(s)} + 2Fe_{(s)}$$

What mass of aluminium is required to produce 7g of iron?

Answer:

	Fe_2O_3	+	2Al	→	Al_2O_3	+	2Fe
Reaction Coefficients	1		2		1		2

A_r/ M_r	160		27		102		56
Mass Balance	160		54		102		112
		214				214	
Mass (g)			0.125 x 27 = **3.375**				7
No. of moles			0.125				7/56 = 0.125

Number of moles Fe in 7 g = 7/56 = 0.125
According to the reaction coefficients, 2 moles of Fe are generated from 2 moles of Al
Therefore the number of moles of Al required to produce 0.125 moles of Fe = 0.125
Mass of 0.125 moles of Al = number of moles x M_r = 0.125 x 27 = **3.375 g**

h. What mass of zinc chloride would be formed by reacting 10 g of zinc with dilute hydrochloric acid?

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

Answer:

	Zn	+	2HCl	→	$ZnCl_2$	+	H_2
Reaction Coefficients	1		2		1		1
A_r/ M_r	65		36.5		136		2
Mass Balance	65		73		136		2
		138				138	
Mass (g)	10				0.154 x 136 = **20.9**		
No. of moles	10/65 = 0.154				0.154		

Number of moles of Zn in 10 g = 10/65 = 0.154
According to the reaction coefficients, 1 mole of Zn produces 1 mole $ZnCl_2$
Therefore, the number of moles of $ZnCl_2$ generated from 0.154 moles of Zn = 0.154
Mass of 0.154 moles of $ZnCl_2$ = number of moles x M_r = 0.154 x 136 = **20.9 g**

i. Lithium oxide is a drying agent used on the space shuttle. What mass of water could be removed by 65g of lithium oxide?

$$Li_2O_{(s)} + H_2O_{(l)} \rightarrow 2LiOH_{(s)}$$

Answer:

	Li_2O	+	H_2O	→	2LiOH
Reaction Coefficients	1		1		2
A_r/Mr	30		18		24
Mass Balance	30		18		
		48			48
Mass (g)	65		2.17 x 18 = **39**		
No. of moles	65/30 = 2.17		2.17		

Number if moles in 65 g of Li_2O = 65/30 = 2.17
According to the reaction coefficients, 1 mole of Li_2O reacts with 1 mole of H_2
Therefore 2.17 moles Li_2O will react with 2.17 moles of H_2O
Mass of 2.2 moles of H_2O = number of moles x M_r = 2.17 x 18 = **39 g**

j. Cisplatin is an anti-cancer agent prepared as follows:

$$K_2PtCl_{4(aq)} + 2NH_{3(aq)} \rightarrow Pt(NH_3)_2Cl_{2\ (aq)} + 2KCl_{(aq)}$$

How many grams of cisplatin can be obtained from 10.0 g of K_2PtCl_4?

Answer:

	K_2PtCl_4	+	$2NH_3$	→	$Pt(NH_3)_2Cl_2$	+	2KCl

Reaction Coefficients	1		2	1		2
A_r/ M_r	415		17	300		74.5
Mass Balance	417		34	300		149
		449			449	
Mass (g)	10			**7.24**		
No. of moles	10/417 = 0.024			0.024		

Number of moles of K_2PtCl_4 in 10g = 10/417 = 0.024
According to the equation, one mole of K_2PtCl_4 generates one mole of $Pt(NH_3)_2Cl_2$
Therefore, 0.024 moles of K_2PtCl_4 generates 0.024 moles of $Pt(NH_3)_2Cl_2$
Mass of 0.024 moles of $Pt(NH_3)_2Cl_2$ = number of moles x M_r = 0.024 x 302 = **7.24 g**

k. Ammonia (NH_3) combusts in air to produce nitrogen dioxide and water according the following equation:

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4\ NO_{(g)} + 6H_2O_{(l)}$$

How many moles and how many grams of oxygen (O_2) are needed to react with 56.8 grams of ammonia by this reaction?

Answer:

	$4NH_3$	+	$5O_2$	→	$4NO$	+	$6H_2O$
Reaction Coefficients	4		5		4		6
A_r/ M	17		32		30		18
Mass Balance	68		160		120		108
		228				228	
Mass (g)	56.8		4.18 x 32 = **133.6**				
No. of moles	56.8/17 = 3.34		5/4 x 3.34 = 4.176				

Number of moles of NH_3 in 56.8 g = 56.8/17 = 3.34
According to the reaction coefficients 4 moles of NH_3 requires 5 moles of O_2
Thus, each mole of NH_3 requires 5/4 moles of O_2
Therefore, 3.34 moles of NH_3 requires 5/4 x 3.34 moles = 4.18 moles O_2
Mass of 4.18 moles O_2 = number of moles x M_r = 4.18 x 32 = **133.6 g**

l. Using the following equation:

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow 2\ H_2O_{(l)} + Na_2SO_{4(aq)}$$

How many grams of sodium sulfate will be formed if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid?

Answer:

	$2NaOH$	+	H_2SO_4	→	$2H_2O$	+	Na_2SO_4
Reaction Coefficients	2		1		2		1
A_r/ M_r	40		98		18		142
Mass Balance	80		98		36		142
		178				178	
Mass	200						2.5 x 142 = **355**
No. of moles	200/40=5		2.5		5		2.5

Number of moles in 200g of NaOH = mass/M_r = 200/40 = 5
According to the reaction coefficients, 2 moles of NaOH produce 1 mole Na_2SO_4
Therefore, 5 moles of NaOH will produce 5 x 0.5 = 2.5 moles of Na_2SO_4
Mass of 2.5 moles of Na_2SO_4 = number of moles x M_r = 2.5 x 141 = **355 g**

m. Using the following equation:

$NaIO_3 + 6\,HI \rightarrow 3I_2 + NaI + 3\,H_2O$

Calculate the number of moles and the number of grams of iodine (I_2) that can be made this way from 8.2 grams of $NaIO_3$.

Answer:

	$NaIO_3$	+	6HI	→	$3I_2$	+	4NO	+	$3H_2O$
Reaction Coefficients	1		6		3		4		3
A_r/ M_r	198		128		254		30		18
Mass Balance	198		768		762		120		54
		966				966			
Mass	8.2				0.124 x 254 = **31.5**				
No. of moles	8.2/198 = 0.0414				0.124				

Number of moles in 8.2 g of $NaIO_3$ = mass/M_r = 8.2/198 = 0.0414
According to the reaction coefficients, 1 mole of $NaIO_3$ produces 3 moles I_2
Therefore, 0.0414 moles of $NaIO_3$ will produce 3 x 0.0414 = 0.124 moles of I_2
Mass of 0.124 moles of I_2 = number of moles x M_r = 0.124 x 254 = **31.6 g**

n. A solution of copper sulphate reacts with sodium hydroxide solution to produce a precipitate of copper hydroxide according to the following equation:

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Cu(OH)_2(s) + Na_2SO_{4(aq)}$$

What mass of sodium hydroxide would be needed to convert 15.95 g of copper sulphate to copper hydroxide and what mass of copper hydroxide would be produced?

Answer:

	$CuSO_4$	+	2NaOH	→	Cu(OH)	+	Na_2SO_4
Reaction Coefficients	1		2		1		1
A_r/ M_r	159.5		40		97.5		142
Mass Balance	159.5		80		97.5		142
		239.5				239.5	
Mass (g)	15.95		0.2 x 40 = **8**		0.1 x 97.5 = **9.75**		14.2
No. of moles	159.5/159.5 = 0.1		0.2		0.1		0.1

Number of moles in 15.95 g of $CuSO_4$ = mass/M_r = 15.95/159.5 = 0.1
According to the reaction coefficients, 1 mole of $CuSO_4$ reacts with 2 moles of NaOH to produce 1 mole of $Cu(OH)_2$
Therefore, 0.1 moles $CuSO_4$ reacts with 0.2 moles of NaOH to produce 0.1 mole of $Cu(OH)_2$
Mass of 0.2 moles NaOH = number of moles x M_r = 0.2 x 40 = **8 g**
Mass of 0.1 moles $Cu(OH)_2$ = number of moles x M_r = 0.1 x 97.5 = **9.75 g**