

**Simple Step-by-Step  
Guides to Solving  
Chemistry Problems**

## Stoichiometry

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# Stoichiometry

## 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.



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

\* 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  $\text{cm}^3$ ,  $M_r$  in  $\text{g mol}^{-1}$

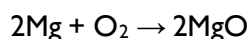
The Moles Calculating Frame is highly flexible. By changing the parameters in the left-hand column, it can be used to solve all chemical equation based problems involving solids and gases, including:

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:



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 <sub>2</sub>	→	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 <sub>2</sub>	→	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 <sub>2</sub>	→	2MgO
Reaction Coefficients	2		1		1
Mass Balance	48		32		80
Mass	2				?
No. of moles	$2/24 = 0.083$				0.083

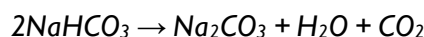
**Step 4:** Since we now know the  $M_r$  and the number of moles of the unknown (MgO), its mass can be calculated ie **mass:  $m=n \times M_r$**

	2Mg	+	O <sub>2</sub>	→	2MgO
Reaction Coefficients	2		1		1
$M_r$	24		32		40
Mass Balance	48		32		80
Mass	2				$0.083 \times 40 = 3.33$
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 to the following equation:



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 <sub>3</sub>	→	Na <sub>2</sub> CO <sub>3</sub>	+	H <sub>2</sub> O	+	CO <sub>2</sub>
Reaction Coefficients	2		1		1		1
$M_r$	84		106		18		44
Mass Balance	168		106		18		44
Mass		168		168			
No. of moles							

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

	2NaHCO <sub>3</sub>	→	Na <sub>2</sub> CO <sub>3</sub>	+	H <sub>2</sub> O	+	CO <sub>2</sub>
Reaction Coefficients	2		1		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<sub>2</sub>CO<sub>3</sub> - 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<sub>3</sub> produce one (1) mole of Na<sub>2</sub>CO<sub>3</sub>:

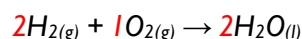
	2NaHCO <sub>3</sub>	→	Na <sub>2</sub> CO <sub>3</sub>	+	H <sub>2</sub> O	+	CO <sub>2</sub>
Reaction Coefficients	2		1		1		1
$M_r$	84		106		18		44
Mass Balance	168		106		18		44
Mass	?		10.6				
No. of moles	$2 \times 0.1 = 0.2$		$10.6/106 = 0.1$				

**Step 4:** Since we now know the  $M_r$  and the number of moles of the unknown ( $\text{NaHCO}_3$ ), its mass can be calculated ie **mass:  $m = n \times M_r$**

	$2\text{NaHCO}_3$	$\rightarrow$	$\text{Na}_2\text{CO}_3$	+	$\text{H}_2\text{O}$	+	$\text{CO}_2$
Reaction Coefficients	2		1		1		1
$M_r$	84		106		18		44
Mass Balance	168		106		18		44
Mass	$0.2 \times 84 =$ <b>16.8</b>		10.6				
No. of moles	$2 \times 0.1 = 0.2$		$10.6/106 = 0.1$				

Answer: **16.8 g**

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



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

	$2\text{H}_2$	+	$\text{O}_2$	$\rightarrow$	$2\text{H}_2\text{O}$
$A_r/M_r$	2		32		18
Mass Balance	4		32		$2 \times 18 = 36$
		36			
Reaction Coefficients	2		1		1
	8		$8/2 = 4$		8

Thus 1 mole  $\text{H}_2\text{O}$  is produced from 0.5 mole of  $\text{O}_2$

Therefore, 8 moles are  $\text{H}_2\text{O}$  are produced from  $0.5 \times 8 = 4$  moles

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

**Answer**

	$2\text{H}_2$	+	$\text{O}_2$	$\rightarrow$	$2\text{H}_2\text{O}$
$A_r/M_r$	2		32		18
Mass Balance	4		32		$2 \times 18 = 36$
		36			
Reaction Coefficients	2		1		1
Mass (g)	100				$50 \times 18 = 900$
Number of Moles	$100/2 = 50$				

Number of moles of  $\text{H}_2$  in 100 g =  $\text{mass}/M_r = 100/2 = 50$

According to the reaction coefficients 2moles of  $\text{H}_2$  produce 2 moles  $\text{H}_2\text{O}$

Therefore, 50 moles of  $\text{H}_2$  will produce 50 moles  $\text{H}_2\text{O}$

Mass of 50 moles of  $\text{H}_2\text{O}$  = number of moles  $\times M_r = 50 \times 18 = 900\text{g}$

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

**Answer**

	$2\text{H}_2$	+	$\text{O}_2$	$\rightarrow$	$2\text{H}_2\text{O}$
Reaction Coefficients	2		1		2
$A_r/M_r$	2		32		18
Mass Balance	4		32		$2 \times 18 = 36$
		36			
Mass (g)	$0.25 \times 2 = 0.5$		4		

Number of Moles	$2 \times 0.125 = 0.25$	$4/32 = 0.125$
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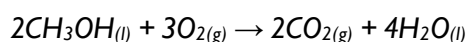
Number of moles in 4 g  $O_2 = \text{mass}/M_r = 4/32 = 0.125$

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  $2 \times 0.125 = 0.25$  moles  $H_2$

Mass of 0.25 moles  $H_2 = \text{mass} \times M_r = 0.25 \times 2 = \mathbf{0.5g}$

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



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

**Answer**

	$2CH_3OH$	+	$3O_2$	$\rightarrow$	$2CO_2$	+	$4H_2O$
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  $H_2O$

Therefore, 0.17 moles  $CH_3OH$  will produce  $2 \times 0.17 = 0.34$  moles  $H_2O$

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

**Answer**

	$2CH_3OH$	+	$3O_2$	$\rightarrow$	$2CO_2$	+	$4H_2O$
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		$3/2 \times 2.78 =$ <b>4.17</b>				

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  $CH_3OH$  requires  $3/2 \times 2.78 = 4.17$  moles  $O_2$

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

**Answer**

	$2CH_3OH$	+	$3O_2$	$\rightarrow$	$2CO_2$	+	$4H_2O$
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		<b>1.25</b>		2.50

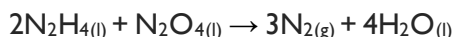
The reaction coefficients tell us that 2 moles  $CO_2$  are produced from the combustion of 2 moles  $CH_3OH$

Thus 1 mole  $CO_2$  is produced from the combustion of 1 mole of  $CH_3OH$

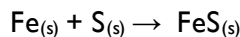
Therefore, 1.25  $CO_2$  are produced from the combustion of 1.25 moles  $CH_3OH$

## Practice Problems

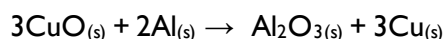
- a. Determine the number of moles of  $\text{N}_2\text{O}_4$  needed to react completely with 3.62 moles of  $\text{N}_2\text{H}_4$  for the reaction:



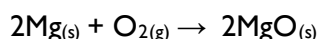
- b. What mass of iron (II) sulfide can be formed from 14.0 g of sulphur?



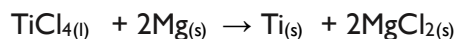
- c. What mass of aluminum will be needed to react with 10 g of  $\text{CuO}$ , and what mass of  $\text{Al}_2\text{O}_3$  will be produced?



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



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

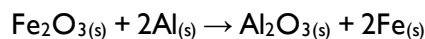


What mass of titanium could theoretically be obtained from 37.98 kg of titanium(IV) chloride?

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

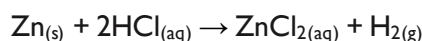


- g. The Thermite Reaction below forms the basis of thermite welding often used to join rail tracks.

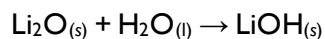


What mass of aluminium is required to produce 7g of iron?

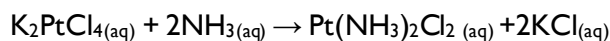
- h. What mass of zinc chloride would be formed by reacting 10 g of zinc with dilute hydrochloric acid?



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

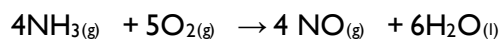


j. Cisplatin is an anti-cancer agent prepared as follows:



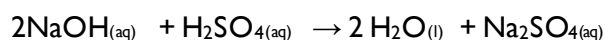
How many grams of cisplatin can be obtained from 10.0 g of  $\text{K}_2\text{PtCl}_4$ ?

k. Ammonia ( $\text{NH}_3$ ) combusts in air to produce nitrogen dioxide and water according to the following equation:



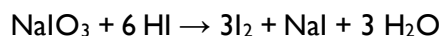
How many moles and how many grams of oxygen ( $\text{O}_2$ ) are needed to react with 56.8 grams of ammonia by this reaction?

l. Using the following equation:



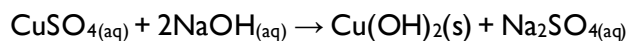
How many grams of sodium sulfate will be formed if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid?

m. Using the following equation:



Calculate the number of moles and the number of grams of iodine ( $\text{I}_2$ ) that can be made this way from 8.2 grams of  $\text{NaIO}_3$ .

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



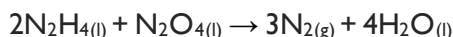
What mass of sodium hydroxide would be needed to convert 15.95 g of copper sulphate to copper hydroxide and what mass of copper hydroxide would be produced?

**Answers are given on the next page.**



## Practice Problem Answers

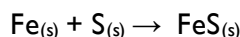
- a. Determine the number of moles of  $\text{N}_2\text{O}_4$  needed to react completely with 3.62 moles of  $\text{N}_2\text{H}_4$  for the reaction:



**Answer:**

The balanced chemical equation tells us that 2 moles of  $\text{N}_2\text{H}_4$  react with 1 mole  $\text{N}_2\text{O}_4$ . Thus 3.62 moles of  $\text{N}_2\text{H}_4$  will require  $3.62/2 = \mathbf{1.81 \text{ moles of } \text{N}_2\text{O}_4}$

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



**Answer:**

	$\text{Fe}(\text{s})$	+	$\text{S}(\text{s})$	$\rightarrow$	$\text{FeS}(\text{s})$
Reaction Coefficients	1		1		1
A <sub>r</sub> /M <sub>r</sub>	56		32		88
Mass Balance		88			88
Mass	$0.438 \times 56 = 24.5\text{g}$		14		$0.438 \times 88 = \mathbf{38.5}$
No. of moles	0.438		$14/32 = 0.438$		

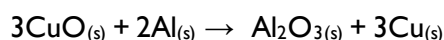
Number of moles in 14g of S =  $14/32 = 0.438$

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  $\times$  M<sub>r</sub> =  $0.438 \times 88 = \mathbf{38.5\text{g}}$

- c. What mass of aluminum will be needed to react with 10 g of  $\text{CuO}$ , and what mass of  $\text{Al}_2\text{O}_3$  will be produced?



**Answer:**

	$3\text{CuO}$	+	$2\text{Al}$	$\rightarrow$	$\text{Al}_2\text{O}_3$	+	$3\text{Cu}$
Reaction Coefficients	3		2		1		3
A <sub>r</sub> /M <sub>r</sub>	79.5		27		102		63.5
Mass Balance	238.5		54		102		190.5
Mass	10		292.5		$0.042 \times 102 = \mathbf{4.28}$		292.5
No. of moles	$10/79.5 = 0.126$				$0.126/3 = 0.042$		

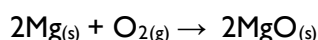
Number of moles in 10 g of  $\text{CuO} = 10/79.5 = 0.126$

According to the reaction coefficients, 3 moles of  $\text{CuO}$  produce 1 mole of  $\text{Al}_2\text{O}_3$ .

Therefore, the number of moles of  $\text{Al}_2\text{O}_3$  produced from 0.126 moles of  $\text{CuO} = 0.126/3 = 0.042$

Mass of 0.042 moles of  $\text{Al}_2\text{O}_3 =$  number of moles  $\times$  M<sub>r</sub> =  $0.042 \times 102 = \mathbf{4.28 \text{ g}}$

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



**Answer:**

	$2\text{Mg}(\text{s})$	+	$\text{O}_2(\text{g})$	$\rightarrow$	$2\text{MgO}(\text{s})$
Reaction Coefficients	2		1		2
A <sub>r</sub> /M <sub>r</sub>	24		32		40
Mass Balance	48		32		80
		80			

Mass	250	$15.6 \times 40 = 625 \text{ g}$
No. of moles	$250/32 = 7.8$	$2 \times 7.8 = 15.6$

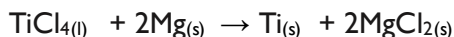
Number of moles  $\text{O}_2$  in 250g =  $250/32 = 7.8$

According to the reaction coefficients, one mole of  $\text{O}_2$  produces 2 moles of  $\text{MgO}$

Therefore, the number of moles of  $\text{MgO}$  produced from 7.8 moles  $\text{O}_2 = 7.8 \times 2 = 15.6$

Mass of 15.6 moles  $\text{MgO} = \text{number of moles} \times M_r = 15.6 \times 40 = 625 \text{ g}$

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



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

Answer:

	$\text{TiCl}_4$	+	$2\text{Mg}$	$\rightarrow$	$\text{Ti}$	+	$2\text{MgCl}_2$
Reaction Coefficients							
$A_r / M_r$	190		24		48		95
Mass Balance	190		48		48		190
			138				138
Mass (g)	37980				$199.9 \times 48 = 9595$		
No. of moles	$37980/190 = 199.9$				200		

Number of moles  $\text{TiCl}_4$  in 37.98 kg =  $37980/190 = 199.9$

According to the reaction coefficients, 1 mole of  $\text{TiCl}_4$  generates 1 mole  $\text{Ti}$

Therefore, the number of moles of  $\text{Ti}$  generated from 199.9 moles  $\text{TiCl}_4 = 199.9$  moles

Mass of 200 moles of  $\text{Ti} = \text{number of moles} \times M_r = 199.9 \times 48 = 9595 \text{ g} = 9.595 \text{ kg}$

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



Answer:

	$2\text{KHCO}_3$	$\rightarrow$	$\text{K}_2\text{CO}_3$	+	$\text{H}_2\text{O}$	+	$\text{CO}_2$
Reaction Coefficients	2		1		1		1
$M_r$	100				18		44
Mass Balance	200		138		18		44
			200		200		
Mass (g)	$1.45 \times 100 = 145$		100				
No. of moles	$0.725 \times 2 = 1.45$		$100/138 = 0.725$				

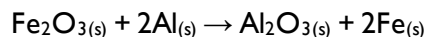
Number of moles of  $\text{K}_2\text{CO}_3$  in 100g =  $100/138 = 0.725$

According to the reaction coefficients 1 mole  $\text{K}_2\text{CO}_3$  is produced from 2 moles of  $\text{KHCO}_3$

Therefore 0.725 moles of  $\text{K}_2\text{CO}_3$  would be generated from  $0.725 \times 2 = 1.45$  moles of  $\text{KHCO}_3$

Mass of 1.45 moles of  $\text{KHCO}_3 = \text{number of moles} \times M_r = 1.45 \times 100 = 145 \text{ g}$

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



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

Answer:

	$\text{Fe}_2\text{O}_3$	+	$2\text{Al}$	$\rightarrow$	$\text{Al}_2\text{O}_3$	+	$2\text{Fe}$
Reaction Coefficients	1		2		1		2

A <sub>r</sub> /M <sub>r</sub>	160		27		102		56
Mass Balance	160	214	54		102	214	112
Mass (g)			0.125 × 27 = <b>3.375</b>				<b>7</b>
No. of moles			0.125				7/56 = 0.125

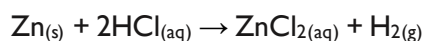
Number of moles Fe in 7 g = 7/56 = 0.125

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 × M<sub>r</sub> = 0.125 × 27 = **3.375 g**

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



**Answer:**

	Zn	+	2HCl	→	ZnCl <sub>2</sub>	+	H <sub>2</sub>
Reaction Coefficients	1		2		1		1
A <sub>r</sub> /M <sub>r</sub>	65		36.5		136		2
Mass Balance	65		73		136		2
Mass (g)	10	138			0.154 × 136 = <b>20.9</b>	138	
No. of moles	10/65 = 0.154				0.154		

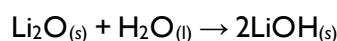
Number of moles of Zn in 10 g = 10/65 = 0.154

According to the reaction coefficients, 1 mole of Zn produces 1 mole ZnCl<sub>2</sub>

Therefore, the number of moles of ZnCl<sub>2</sub> generated from 0.154 moles of Zn = 0.154

Mass of 0.154 moles of ZnCl<sub>2</sub> = number of moles × M<sub>r</sub> = 0.154 × 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?



**Answer:**

	Li <sub>2</sub> O	+	H <sub>2</sub> O	→	2LiOH
Reaction Coefficients	1		1		2
A <sub>r</sub> /M <sub>r</sub>	30		18		24
Mass Balance	30		18		48
Mass (g)	65	48	2.17 × 18 = <b>39</b>		48
No. of moles	65/30 = 2.17		2.17		

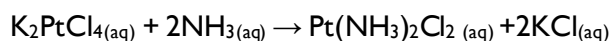
Number of moles in 65 g of Li<sub>2</sub>O = 65/30 = 2.17

According to the reaction coefficients, 1 mole of Li<sub>2</sub>O reacts with 1 mole of H<sub>2</sub>O

Therefore 2.17 moles Li<sub>2</sub>O will react with 2.17 moles of H<sub>2</sub>O

Mass of 2.2 moles of H<sub>2</sub>O = number of moles × M<sub>r</sub> = 2.17 × 18 = **39 g**

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



How many grams of cisplatin can be obtained from 10.0 g of K<sub>2</sub>PtCl<sub>4</sub>?

**Answer:**

K <sub>2</sub> PtCl <sub>4</sub>	+	2NH <sub>3</sub>	→	Pt(NH <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>	+	2KCl
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Reaction Coefficients	1		2		1		2
A <sub>r</sub> / M <sub>r</sub>	415		17		300		74.5
Mass Balance	417		34	449	300		149
Mass (g)	10				7.24	449	
No. of moles	10/417 = 0.024				0.024		

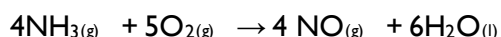
Number of moles of K<sub>2</sub>PtCl<sub>4</sub> in 10g = 10/417 = 0.024

According to the equation, one mole of K<sub>2</sub>PtCl<sub>4</sub> generates one mole of Pt(NH<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub>

Therefore, 0.024 moles of K<sub>2</sub>PtCl<sub>4</sub> generates 0.024 moles of Pt(NH<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub>

Mass of 0.024 moles of Pt(NH<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub> = number of moles × M<sub>r</sub> = 0.024 × 302 = **7.24 g**

k. Ammonia (NH<sub>3</sub>) combusts in air to produce nitrogen dioxide and water according to the following equation:



How many moles and how many grams of oxygen (O<sub>2</sub>) are needed to react with 56.8 grams of ammonia by this reaction?

**Answer:**

	4NH <sub>3</sub>	+	5O <sub>2</sub>	→	4NO	+	6H <sub>2</sub> O
Reaction Coefficients	4		5		4		6
A <sub>r</sub> / M <sub>r</sub>	17		32		30		18
Mass Balance	68		160		120	228	108
Mass (g)	56.8	228	4.18 × 32 = 133.6				
No. of moles	56.8/17 = 3.34		5/4 × 3.34 = 4.176				

Number of moles of NH<sub>3</sub> in 56.8 g = 56.8/17 = 3.34

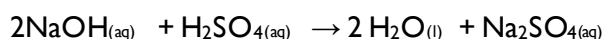
According to the reaction coefficients 4 moles of NH<sub>3</sub> requires 5 moles of O<sub>2</sub>

Thus, each mole of NH<sub>3</sub> requires 5/4 moles of O<sub>2</sub>

Therefore, 3.34 moles of NH<sub>3</sub> requires 5/4 × 3.34 moles = 4.18 moles O<sub>2</sub>

Mass of 4.18 moles O<sub>2</sub> = number of moles × M<sub>r</sub> = 4.18 × 32 = **133.6 g**

l. Using the following equation:



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 <sub>2</sub> SO <sub>4</sub>	→	2H <sub>2</sub> O	+	Na <sub>2</sub> SO <sub>4</sub>
Reaction Coefficients	2		1		2		1
A <sub>r</sub> / M <sub>r</sub>	40		98		18		142
Mass Balance	80		98		36	178	142
Mass	200						2.5 × 142 = 355
No. of moles	200/40=5		2.5		5		2.5

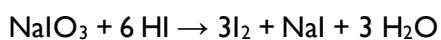
Number of moles in 200g of NaOH = mass/M<sub>r</sub> = 200/40 = 5

According to the reaction coefficients, 2 moles of NaOH produce 1 mole Na<sub>2</sub>SO<sub>4</sub>

Therefore, 5 moles of NaOH will produce 5 × 0.5 = 2.5 moles of Na<sub>2</sub>SO<sub>4</sub>

Mass of 2.5 moles of Na<sub>2</sub>SO<sub>4</sub> = number of moles × M<sub>r</sub> = 2.5 × 141 = **355 g**

m. Using the following equation:



Calculate the number of moles and the number of grams of iodine (I<sub>2</sub>) that can be made this way from 8.2 grams of NaIO<sub>3</sub>.

**Answer:**

	<b>NaIO<sub>3</sub></b>	+	<b>6HI</b>	→	<b>3I<sub>2</sub></b>	+	<b>4NO</b>	+	<b>3H<sub>2</sub>O</b>
Reaction Coefficients	1		6		3		4		3
A./ M <sub>r</sub>	198		128		254		30		18
Mass Balance	198		768		762		120		54
Mass	8.2	966			0.124 × 254 =	966			
					<b>31.5</b>				
No. of moles	8.2/198 = 0.0414				0.124				

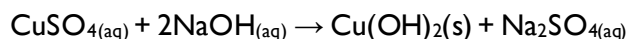
Number of moles in 8.2 g of NaIO<sub>3</sub> = mass/M<sub>r</sub> = 8.2/198 = 0.0414

According to the reaction coefficients, 1 mole of NaIO<sub>3</sub> produces 3 moles I<sub>2</sub>

Therefore, 0.0414 moles of NaIO<sub>3</sub> will produce 3 × 0.0414 = 0.124 moles of I<sub>2</sub>

Mass of 0.124 moles of I<sub>2</sub> = number of moles × M<sub>r</sub> = 0.124 × 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:



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:**

	<b>CuSO<sub>4</sub></b>	+	<b>2NaOH</b>	→	<b>Cu(OH)<sub>2</sub></b>	+	<b>Na<sub>2</sub>SO<sub>4</sub></b>
Reaction Coefficients	1		2		1		1
A./ M <sub>r</sub>	159.5		40		97.5		142
Mass Balance	159.5		80		97.5		142
Mass (g)	15.95	239.5	0.2 × 40 = <b>8</b>		0.1 × 97.5 = <b>9.75</b>	239.5	14.2
No. of moles	15.95/159.5 = 0.1		0.2		0.1		0.1

Number of moles in 15.95 g of CuSO<sub>4</sub> = mass/M<sub>r</sub> = 15.95/159.5 = 0.1

According to the reaction coefficients, 1 mole of CuSO<sub>4</sub> reacts with 2 moles of NaOH to produce 1 mole of Cu(OH)<sub>2</sub>

Therefore, 0.1 moles CuSO<sub>4</sub> reacts with 0.2 moles of NaOH to produce 0.1 mole of Cu(OH)<sub>2</sub>

Mass of 0.2 moles NaOH = number of moles × M<sub>r</sub> = 0.2 × 40 = **8 g**

Mass of 0.1 moles Cu(OH)<sub>2</sub> = number of moles × M<sub>r</sub> = 0.1 × 97.5 = **9.75 g**