



Name: _____ Form: _____

Science Group: _____ Science Teacher: _____

GCSE to A-Level Chemistry: Summer Transition Booklet

These tasks and notes will help you get up to speed in your Chemistry A-Level!

Use your GCSE resources, the internet, or a chemistry textbook to help you as you go through these.

Good textbooks/websites you can use are:

The course text: A-Level Salters Advanced Chemistry for OCR, Oxford University Press, 2015 (ISBN: 978-0-19-833290-9)

Recommended text: Calculations in AS/A Level Chemistry, Jim Clark, Pearson Education Limited, 2000 (ISBN: 978-0-582-41127-2)

Recommended website: <http://www.chemguide.co.uk>

Essential Purchase!

CGP Revision Guide, OCR B (Salters) Chemistry A-Level: Complete Revision and Practice (ISBN: 978-1-78294-303-7)

We will provide you with a physical and a digital copy of the course book, so no need to buy one.

We will also have copies of the maths for A-level chemistry textbook available to borrow.

Glossary

Molecule	A substance made of more than one atom chemically bonded together (can be atoms of the same type!)
Reactant	The chemical we start with in a reaction.
Reagent	The chemical we add to start a reaction.
Isotope	A version of an element with a different relative atomic mass.
Relative atomic mass (A_r)	The mass of an atom of an element relative to $1/12^{\text{th}}$ of the mass of an atom of carbon-12. A weighted average of the common isotopes.
Relative formula mass (M_r)	The mass of a compound relative to $1/12^{\text{th}}$ of the mass of an atom of carbon-12.
Avogadro's number (N_A)	6.022×10^{23} objects. Typically used to compare amounts of substance with different relative masses.
Moles equation	$n \text{ (moles)} = m \text{ (g)} / M_r \text{ (g mol}^{-1}\text{)}$
Solution equation	$c \text{ (mol dm}^{-3}\text{)} = n \text{ (moles)} \times V \text{ (dm}^3\text{)}$
Molar ratio	The large numbers in a balanced chemical equation. $2 \text{ H}_2 + \text{ O}_2 \rightarrow 2 \text{ H}_2\text{O}$ The molar ratio in this equation is 2 : 1 : 2
Strong acid / alkali	Dissociates completely in water to give H^+ or OH^- ions respectively.
Weak acid / alkali	Partially dissociates in water to give H^+ or OH^- ions respectively.
Concentrated acid / alkali	A lot of acid / alkali dissolved in a small volume of water.
Dilute acid / alkali	Little acid / alkali dissolved in a large volume of water.
Reduction	Gaining electrons or losing oxygen
Oxidation	Losing electrons or gaining oxygen

The Basics: Structure and formulae

Elements and their structures

Monatomic	Simple molecular (simple covalent)	Ionic	Metallic	Giant Covalent
Helium Neon Argon Krypton Xenon Radon	Hydrogen Nitrogen Oxygen Fluorine Chlorine Bromine Iodine Phosphorous Sulfur Etc...	You can't have an ionic element!	The chemical formula is just the symbol... Magnesium Iron Sodium Etc...	The chemical formula is just the symbol... Carbon as diamond Carbon as graphite Silicon Etc...

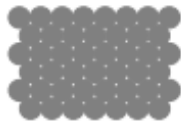


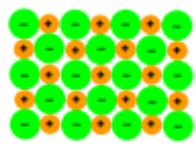




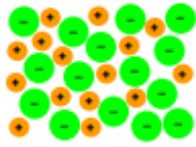
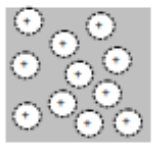


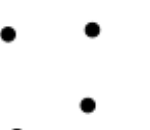
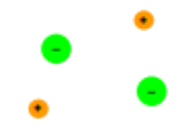

Compounds and their structures

Monatomic	Simple molecular (simple covalent)	Ionic	Metallic	Giant Covalent
You can't have a monatomic compound!	Some common molecular compounds: carbon dioxide carbon monoxide nitrogen monoxide nitrogen dioxide sulfur dioxide sulfur trioxide ammonia methane hydrogen sulfide Etc...	You have to work these out ionic formulas using the charges on the ions involved... You MUST be able to do this confidently straight away at A-level	There are no metallic compounds!	Silicon dioxide

Ions

Positive ions		Negative ions	
Simple ions	Complex ions	Simple ions	Complex ions
Group 1 ions are 1+ (e.g. lithium) Group 2 ions are 2+ (e.g. calcium) Group 3 ions are 3+ (e.g. aluminium)	Ammonium NH_4^+	Group 6 ions are 2- (e.g. <u>oxide</u>) Group 7 ions are 1- (e.g. <u>chloride</u>)	Nitrate NO_3^- Sulfate SO_4^{2-} Carbonate CO_3^{2-} Hydrogencarbonate HCO_3^- Hydroxide OH^- Phosphate PO_4^{3-} Hydride H^-

Structure types and properties

	Monatomic	Simple molecular	Giant covalent	Ionic	Metallic
Substances	Group 0 elements	Elements: H ₂ O ₂ N ₂ F ₂ Cl ₂ Br ₂ I ₂ S ₈ P ₄ Compounds: non-metal with non-metal	Elements: Si, diamond, graphite Compounds: SiO ₂	Compounds: metal with non-metal	Elements: metals
What the structure is	Individual atoms with very weak forces between them	Individual molecules with weak forces between them (atoms within molecules are joined by covalent bonds)	Lattice structure in which all atoms are joined to others by covalent bonds	Lattice structure of positive and negatively charged ions (ions are held together by attraction between the + and - ions (this +/- attraction is known as an ionic bond, though it is just an electrostatic attractive force))	Lattice structure of metal ions with outer shell electrons free to move through the structure
The formula	Just the symbol e.g. Ar	e.g. H ₂ O each molecule contains 1 O and 2H atoms	e.g. SiO ₂ ratio of Si:O atoms is 1:2 through the structure	e.g. MgCl ₂ ratio of Mg ²⁺ :Cl ⁻ ions is 1:2 through the structure	Just the symbol e.g. Fe
Melting and boiling points	VERY LOW Very weak forces between atoms	LOW Weak forces between the molecules (Note – the atoms within the molecules are held together by strong covalent bonds, but these DO NOT break when molecules melt/boil)	VERY HIGH Need to break many strong covalent bonds	HIGH Strong electrostatic attraction between positive and negative ions	HIGH Strong electrostatic attraction between positive metal ions and delocalised negative electrons
Conductivity	DO NOT CONDUCT No charged particles that can move – atoms are neutral	DO NOT CONDUCT No charged particles that can move – molecules are neutral	DO NOT CONDUCT No charged particles that can move – electrons are NOT delocalised EXCEPT GRAPHITE Delocalised electrons move between layers	CONDUCT (molten / dissolved) Ions can move DO NOT CONDUCT (as solids) Ions cannot move	CONDUCT Outer shell electrons are delocalised
Solubility in water	INSOLUBLE	INSOLUBLE (usually)	INSOLUBLE	SOLUBLE (usually)	INSOLUBLE (but some react with water)
Solid					
Liquid					
Gas					

TASK 1: Writing Formulae**Formulae of ionic compounds**

Remember – the **charges of the ions** in an ionic formula must add up to the **overall charge** (usually 0) on the compound.

e.g. Sodium oxide (Na^+ and O^{2-}), two sodium ions are required to balance the charge on the oxide ion. So the formula would be Na_2O

- | | | | |
|----------------------------|-------|------------------------|-------|
| 1) silver bromide | ..... | 2) sodium carbonate | ..... |
| 3) potassium oxide | ..... | 4) iron (III) oxide | ..... |
| 5) chromium (III) chloride | ..... | 6) calcium hydroxide | ..... |
| 7) aluminium nitrate | ..... | 8) sodium sulfate | ..... |
| 9) lead (II) oxide | ..... | 10) sodium phosphate | ..... |
| 11) zinc hydrogencarbonate | ..... | 12) ammonium sulfate | ..... |
| 13) gallium hydroxide | ..... | 14) strontium selenide | ..... |
| 15) radium sulfate | ..... | 16) sodium nitride | ..... |

Writing formulae – mixed practice!

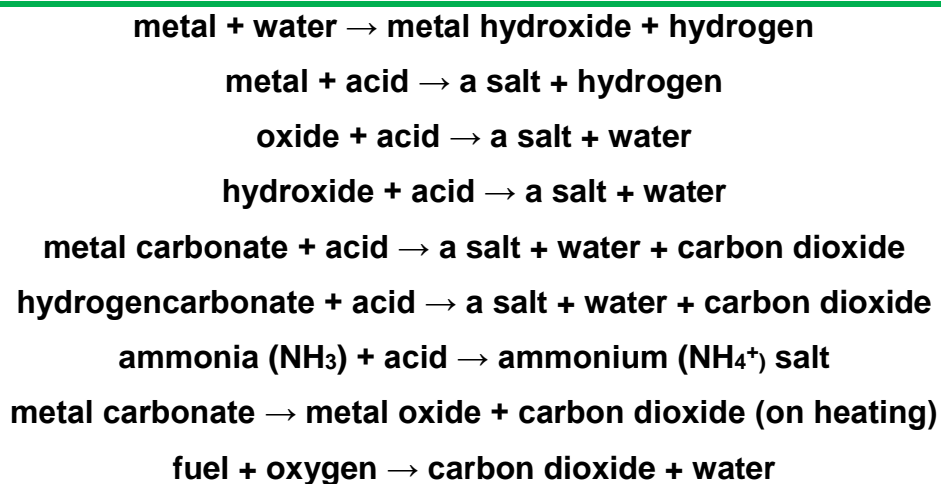
- | | | | |
|----------------------------|-------|---------------------------|-------|
| 1. lead (IV) oxide | ..... | 21. copper | ..... |
| 2. sodium | ..... | 22. ammonium chloride | ..... |
| 3. ammonia | ..... | 23. sulfur | ..... |
| 4. sulfuric acid | ..... | 24. neon | ..... |
| 5. silicon dioxide | ..... | 25. silicon | ..... |
| 6. barium hydroxide | ..... | 26. tin (IV) chloride | ..... |
| 7. silver nitrate | ..... | 27. iodine | ..... |
| 8. nickel | ..... | 28. hydrogen sulfide | ..... |
| 9. titanium (IV) oxide | ..... | 29. lead | ..... |
| 10. strontium sulfate | ..... | 30. lithium | ..... |
| 11. silver carbonate | ..... | 31. gold | ..... |
| 12. platinum (II) fluoride | ..... | 32. nitric acid | ..... |
| 13. ammonia | ..... | 33. silicon (IV) hydride | ..... |
| 14. phosphorus | ..... | 34. calcium phosphate | ..... |
| 15. vanadium (V) oxide | ..... | 35. diamond | ..... |
| 16. barium hydroxide | ..... | 36. cobalt (II) hydroxide | ..... |
| 17. hydrochloric acid | ..... | 37. ammonia | ..... |
| 18. silicon | ..... | 38. fluorine | ..... |
| 19. rubidium | ..... | 39. germanium (IV) oxide | ..... |
| 20. magnesium astatide | ..... | 40. nitrogen monoxide | ..... |

The Basics: Chemical Equations

There are several general equations you have learnt at GCSE.

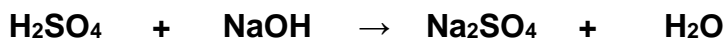
You will need to be VERY familiar with these and recognise when you can use them.

There are also some new ones you need to know:



You also must be comfortable with balancing chemical equations. Below is a worked example of how to balance a simple equation.

Step 1: Count the number of atoms on each side....



Number of atoms on each side

3	H	2
1	S	1
5	O	5
1	Na	2

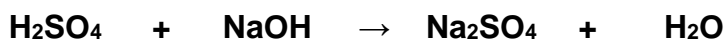
I like to write out the atoms in each chemical formula to make them easier to count!

I like to record how many atoms there are on each side of the arrow in a table

Step 2: Add a 'box' of atoms to try and get the same number of each atom on both sides of the arrow.

I need more hydrogen on the right hand side of my equation... the only thing I can add to get more hydrogen is another box of water.

Let's see what that does...



I added this

Number of atoms on each side

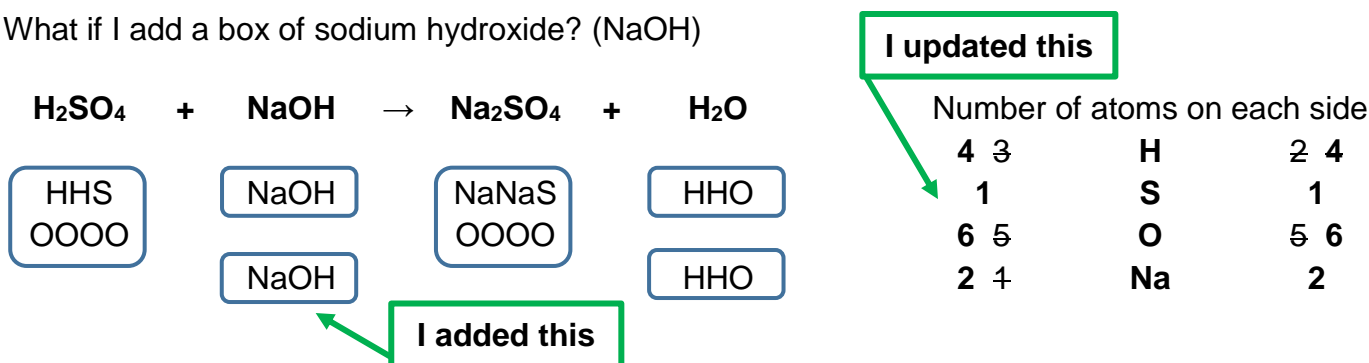
3	H	2 4
1	S	1
5	O	5 6
1	Na	2

I updated this

Step 3: Keep adding boxes of atoms until you get the same number of each atom on both sides of the arrow.

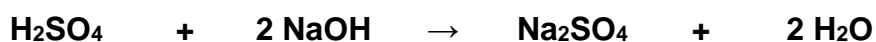
So that didn't quite fix everything. Now I need one more hydrogen, one more oxygen, and one more sodium...

What if I add a box of sodium hydroxide? (NaOH)



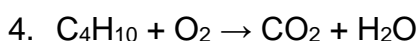
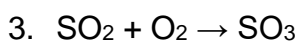
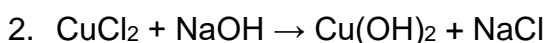
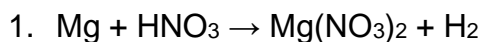
That worked! Everything is balanced now... so how do I finish off the equation?

Step 4: Count up the boxes, and write how many of each you needed in front of their chemical formula.



TASK 2: Basic Chemical Equations

Balance the following equations:



5. sodium + oxygen → sodium oxide

6. aluminium + chlorine → aluminium chloride

7. calcium + hydrochloric acid → calcium chloride + hydrogen

8. ammonia + sulfuric acid → ammonium sulfate

9. burning aluminium

10. burning hexane (C₆H₁₄)

11. burning ethanol (CH₃CH₂OH)

12. reaction of lithium with water

13. reaction of calcium carbonate with nitric acid

14. thermal decomposition of lithium carbonate

15. reaction of ammonia with nitric acid

16. reaction of potassium oxide with sulfuric acid

17. reaction of calcium hydroxide with hydrochloric acid

18. reaction of zinc with phosphoric acid

19. reaction of sodium hydrogencarbonate with sulfuric acid

20. reaction of potassium hydroxide with sulfuric acid

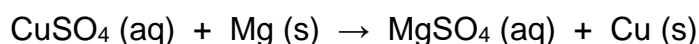
Ionic equations

When an ionic substance dissolves in water, the positive and negative ions separate and become hydrated (they interact with water molecules rather than each other). For example, a solution of sodium chloride could also be described as a mixture of hydrated sodium ions and hydrated chloride ions in water.

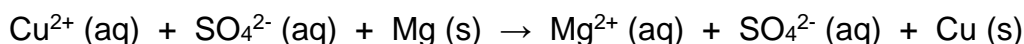
In reactions involving ionic compounds dissolved in water, some of the ions may not be involved in the reaction. These are called spectator ions. For such reactions, we can write an ionic equation that only shows the species that are involved in the reaction.

For example:

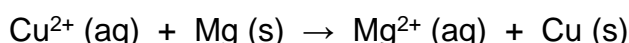
Copper sulfate will react with magnesium to produce copper metal and magnesium sulfate. The full chemical equation is shown below.



We can split the ionic compounds into their ions as they are dissolved in water...



Then we can remove the spectator ions...

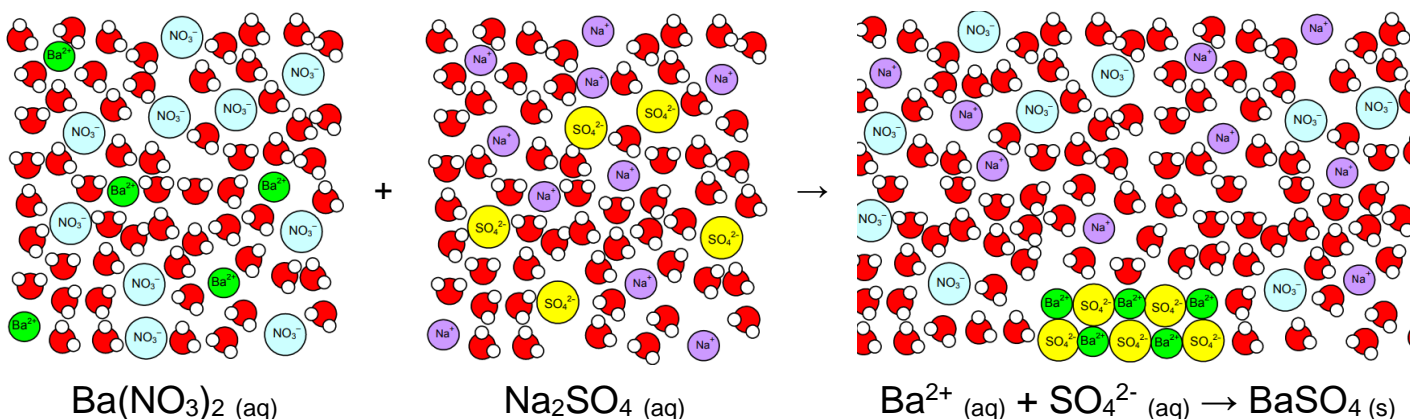


Some common ionic equations are the neutralisation reactions of acids:

acid + hydroxide	$\text{H}^+ (\text{aq}) + \text{OH}^- (\text{aq}) \rightarrow \text{H}_2\text{O} (\text{l})$
acid + carbonate	$2 \text{H}^+ (\text{aq}) + \text{CO}_3^{2-} (\text{aq}) \rightarrow \text{H}_2\text{O} (\text{l}) + \text{CO}_2 (\text{g})$
acid + hydrogencarbonate	$\text{H}^+ (\text{aq}) + \text{HCO}_3^- (\text{aq}) \rightarrow \text{H}_2\text{O} (\text{l}) + \text{CO}_2 (\text{g})$
acid + ammonia	$\text{H}^+ (\text{aq}) + \text{NH}_3 (\text{aq}) \rightarrow \text{NH}_4^+ (\text{aq})$

Precipitation reactions:

When ions react in water, sometimes the product is insoluble. We call these **precipitation reactions**.



The Basics: Moles!

KEY POINT:

- $6.022 \times 10^{23} = 1$ mole. This is **Avogadro's Number**.
- Therefore, one mole of hamburgers would be 6.022×10^{23} (602,200,000,000,000,000,000) hamburgers.

Calculations using moles

There is an equation which can tell us how many moles of atoms we have if we know what atoms they are, and their relative atomic mass.

The equation is:

$$\text{Moles (moles)} \longrightarrow n = \frac{m}{M_r}$$

Mass (grams) ←

← Relative formula mass (g/mole)

Mole calculations of this sort are always carried out in grams.

Therefore you have to know some conversions.

$$1 \text{ mg} = 0.001 \text{ g} \quad 1 \text{ g} = 1 \text{ g} \quad 1 \text{ kg} = 1000 \text{ g} \quad 1 \text{ ton} = 1\,000\,000 \text{ g}$$

TASK 4: Basic moles calculations

1. How many moles are there in each of the following?

a. 72.0 g of Mg

b. 4.00 kg of CuO

c. 39.0 g of Al(OH)₃

d. 1.00 ton of NaCl

e. 20.0 mg of $\text{Cu}(\text{NO}_3)_2$

2. What is the mass of each of the following?

a. 5.00 moles of Cl_2

b. 0.200 moles of Al_2O_3

c. 0.0100 moles of Ag

d. 0.00200 moles of $(\text{NH}_4)_2\text{SO}_4$

e. 0.300 moles of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

3. This question is about carbon dioxide

a. Calculate the number of moles of CO_2 molecules in 11.0 g of carbon dioxide.

b. Calculate the number of moles of C atoms in 11.0 g of carbon dioxide.

c. Calculate the number of moles of O atoms in 11.0 g of carbon dioxide.

4. This question is about aluminium oxide.
- Calculate the number of moles of Al_2O_3 in 5.10 g of Al_2O_3 .
 - Calculate the number of moles of Al^{3+} ions in 5.10 g of Al_2O_3 .
 - Calculate the number of moles of O^{2-} ions in 5.10 g of Al_2O_3 .
5. An experiment was carried out to find the Mr of vitamin C (ascorbic acid). It was found that 1.00 g contains 0.00568 moles of Vitamin C molecules. Calculate the Mr of vitamin C.
6. Use the following data to calculate the mass of the particles shown.
- Mass of proton = 1.6726×10^{-24} g
Mass of electron = 9.1094×10^{-28} g
Mass of neutron = 1.6749×10^{-24} g
Avogadro constant = $6.022 \times 10^{23} \text{ mol}^{-1}$
- Calculate the mass of a ^1H atom.
 - Calculate the mass of an $^1\text{H}^+$ ion.
 - Calculate the mass of one mole of ^3H atoms.

Reacting Mass Calculations

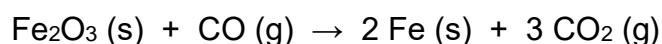
You can use balanced chemical equations to predict what mass of chemicals (or volume of gases) react or are produced in a chemical reaction. This is called a reacting mass calculation.

They look like this:

What mass of iron is produced when 32.0 kg of iron (III) oxide is heated with CO?

Step 1: Balanced chemical equation

We need a balanced chemical equation to answer these, so here it is...



Step 2: What do we know?

Produce a table with number of moles, mass and Mr in it for each chemical mentioned in the question...populate it from the question.

	Fe₂O₃	Fe
n		
m	32 000 g	?
Mr		

Step 3: Fill in the Mr / Ar values

$$\text{Ar} (\text{Fe}) = 55.8 \text{ g mol}^{-1}$$

$$\text{Mr} (\text{Fe}_2\text{O}_3) = (55.8 \times 2) + (16.0 \times 3)$$

$$\text{Mr} (\text{Fe}_2\text{O}_3) = 159.6 \text{ g mol}^{-1}$$

	Fe₂O₃	Fe
n		
m	32 000 g	?
Mr	159.6 g mol ⁻¹	55.8 g mol ⁻¹

Step 4: Calculate moles

$$n (\text{Fe}_2\text{O}_3) = 32\,000 \text{ g} / 159.6 \text{ g mol}^{-1}$$

$$n (\text{Fe}_2\text{O}_3) = 200.5 \text{ moles}$$

	Fe₂O₃	Fe
n	200.5 moles	
m	32 000 g	?
Mr	159.6 g mol ⁻¹	55.8 g mol ⁻¹

Step 5: Use the balanced equation and mole ratios to work out moles of product

$$\text{Ratio of Fe}_2\text{O}_3 : \text{Fe is } 1 : 2$$

$$\text{Therefore, } n (\text{Fe}) = n (\text{Fe}_2\text{O}_3) \times 2$$

$$n (\text{Fe}) = 200.5 \times 2 = 401.0 \text{ moles}$$

	Fe₂O₃	Fe
n	200.5 moles	401.0 moles
m	32 000 g	?
Mr	159.6 g mol ⁻¹	55.8 g mol ⁻¹

Step 6: Calculate the mass

$$m(\text{Fe}) = n \times M_r$$

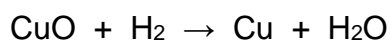
$$m(\text{Fe}) = 401.0 \times 55.8 \text{ g}$$

$$m(\text{Fe}) = 22\,375.8 \text{ g (22\,400 to 3 sig fig)}$$

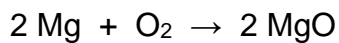
	Fe₂O₃	Fe
n	200.5 moles	401.0 moles
m	32 000 g	22 400 g
Mr	159.6 g mol ⁻¹	55.8 g mol ⁻¹

TASK 5: Reacting mass calculations

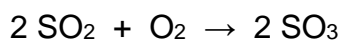
1. What mass of hydrogen is needed to react with 40.0 g of copper oxide?



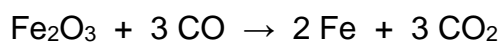
2. What mass of oxygen reacts with 192 g of magnesium?



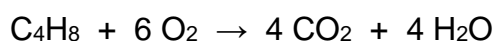
3. What mass of sulfur trioxide is formed from 96.0 g of sulfur dioxide?



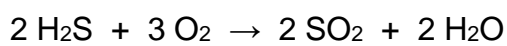
4. What mass of carbon monoxide is needed to react with 480 kg of iron oxide?



5. What mass of carbon dioxide is produced when 5.60 g of butene is burnt.

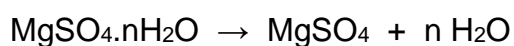


6. What mass of oxygen is needed to react with 8.50 g of hydrogen sulphide (H₂S)?



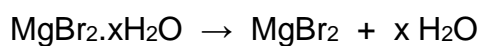
7. 4.92 g of hydrated magnesium sulphate crystals (MgSO₄.nH₂O) gave 2.40 g of anhydrous magnesium sulphate on heating to constant mass.

Work out the formula mass of the hydrated magnesium sulphate and so the value of n.



8. In an experiment to find the value of x in the compound $\text{MgBr}_2 \cdot x\text{H}_2\text{O}$, 7.30 g of the compound on heating to constant mass gave 4.60 g of the anhydrous salt MgBr_2 .

Find the value of x .

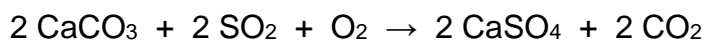


9. What mass of glucose must be fermented to give 5.00 kg of ethanol?

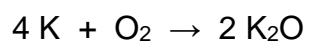


10. The pollutant sulfur dioxide can be removed from the air by reaction with calcium carbonate in the presence of oxygen.

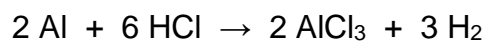
What mass of calcium carbonate is needed to remove 1.000 ton of sulfur dioxide?



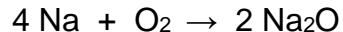
11. What mass of potassium oxide is formed when 7.80 mg of potassium is burned in oxygen?



12. What mass of hydrogen is produced when 10.0 g of aluminium reacts with excess hydrochloric acid?



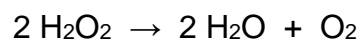
13. What mass of sodium reacts with 40.0 g of oxygen?



14. What mass of nitrogen is produced when 2.00 tons of ammonia gas decomposes?



15. What mass of oxygen is produced when 136 g of hydrogen peroxide molecules decompose?



16. What mass of lead (II) oxide is produced when 0.400 moles of lead (II) nitrate decomposes?



Calculations using moles in solutions

KEY POINT:

The equation for moles in solutions is slightly different. It uses concentration, volume and moles

The equation is:

$$\text{Concentration (mol dm}^{-3}\text{)} \longrightarrow c = \frac{n}{V}$$

← Moles (moles)
 ← volume (dm³)

Mole calculations of this sort are always carried out in decimetres cubed (dm³), and moles per decimetre cubed (mol dm⁻³).

Therefore you have to know some conversions.

$$1 \text{ mL} = 1 \text{ cm}^3$$

$$1 \text{ cm}^3 = 1 \text{ cm}^3$$

$$1 \text{ dm}^3 = 1000 \text{ cm}^3$$

$$1 \text{ L} = 1 \text{ dm}^3$$

TASK 6: Solution calculations

1. Calculate the number of moles in the following.
 - a. 2 dm³ of 0.05 mol dm⁻³ HCl
 - b. 50 litres of 5 mol dm⁻³ H₂SO₄
 - c. 10 cm³ of 0.25 mol dm⁻³ KOH

2. Calculate the concentration of the following in mol dm⁻³
 - a. 0.400 moles of HCl in 2.00 litres of solution

 - b. 12.5 moles of H₂SO₄ in 5.00 dm³ of solution

c. 1.05 g of NaOH in 500 cm³ of solution

3. Calculate the volume of each solution that contains the following number of moles.

a. 0.00500 moles of NaOH from 0.100 mol dm⁻³ solution

b. 1.00×10^{-5} moles of HCl from 0.0100 mol dm⁻³ solution

Titration Calculations

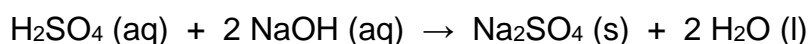
Titration calculations are the liquid equivalent of a reacting mass calculation... they rely on a volume of acid or alkali being measured really accurately, and a reaction being stopped exactly when the solution is neutral...

They look like this:

25.0 cm³ of 0.020 mol dm⁻³ sulfuric acid neutralises 18.6 cm³ of sodium hydroxide solution. Find the concentration of the sodium hydroxide solution in mol dm⁻³.

Step 1: Balanced chemical equation

We need a balanced chemical equation to answer these, so here it is...



Step 2: What do we know?

Produce a table with number of moles, concentration and volume in it for each chemical mentioned in the question...populate it from the question.

	H₂SO₄	NaOH
n		
c	0.020 mol dm ⁻³	?
V	25 cm ³ or 0.025 dm ³	18.6 cm ³ or 0.0186 dm ³

Step 3: Calculate moles

$$n (\text{H}_2\text{SO}_4) = c \times V$$

$$n (\text{H}_2\text{SO}_4) = 0.020 \text{ mol dm}^{-3} \times 0.025 \text{ dm}^3$$

$$n (\text{H}_2\text{SO}_4) = 5 \times 10^{-4} \text{ moles}$$

	H₂SO₄	NaOH
n	5 x 10 ⁻⁴ moles	
c	0.020 mol dm ⁻³	?
V	0.025 dm ³	0.0186 dm ³

Step 5: Use the balanced equation and **mole ratios** to work out moles of product

Ratio of H₂SO₄ : NaOH is 1 : 2

Therefore, n (NaOH) = n (H₂SO₄) x 2

$$n (\text{NaOH}) = 5 \times 10^{-4} \times 2 = 1 \times 10^{-3} \text{ moles}$$

	H₂SO₄	NaOH
n	5 x 10 ⁻⁴ moles	1 x 10 ⁻³ moles
c	0.020 mol dm ⁻³	?
V	0.025 dm ³	0.0186 dm ³

Step 6: Calculate the concentration

$$c(\text{NaOH}) = n / V$$

$$c(\text{NaOH}) = 1 \times 10^{-3} \text{ moles} / 0.0186 \text{ dm}^3$$

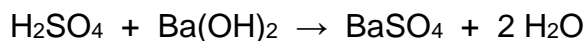
$$c(\text{NaOH}) = 0.05376\dots \text{ mol dm}^{-3}$$

(0.0538 mol dm⁻³ to 3 sig fig)

	H₂SO₄	NaOH
n	5 x 10 ⁻⁴ moles	1 x 10 ⁻³ moles
c	0.020 mol dm ⁻³	0.0538 mol dm⁻³
v	0.025 dm ³	0.0186 dm ³

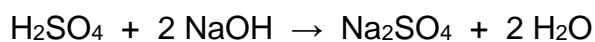
TASK 7: Titration Calculations

1. 25.0 cm³ of 0.020 mol dm⁻³ sulfuric acid neutralises 18.6 cm³ of barium hydroxide solution.



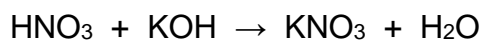
Find the concentration of the barium hydroxide solution in mol dm⁻³

2. 25.0 cm³ of a solution of sodium hydroxide required 18.8 cm³ of 0.0500 mol dm⁻³ H₂SO₄.

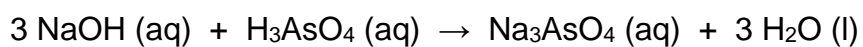


Find the concentration of the sodium hydroxide solution in mol dm⁻³

3. Calculate the volume of 0.05 mol dm^{-3} KOH is required to neutralise 25.0 cm^3 of $0.0150 \text{ mol dm}^{-3}$ HNO_3 .



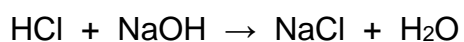
4. 25.0 cm^3 of arsenic acid, H_3AsO_4 , required 37.5 cm^3 of $0.100 \text{ mol dm}^{-3}$ sodium hydroxide for neutralisation.



Find the concentration of the acid in mol dm^{-3}

5. A 250 cm³ solution of NaOH was prepared. 25.0 cm³ of this solution required 28.2 cm³ of 0.100 mol dm⁻³ HCl for neutralisation.

Calculate what mass of NaOH was dissolved to make up the original 250 cm³ solution.



6. What volume of 5.00 mol dm⁻³ HCl is required to neutralise 20.0 kg of CaCO₃?



7. 3.88 g of a monoprotic acid was dissolved in water and the solution made up to 250 cm³. 25.0 cm³ of this solution was titrated with 0.095 mol dm⁻³ NaOH solution, requiring 46.5 cm³. Calculate the relative molecular mass of the acid.

A-Level exam questions

These are A-level past paper questions based around GCSE knowledge, or using the skills from this booklet.

Have a go!

1. A solid substance has a high melting point and does not conduct electricity.

Which type of structure does this substance have?

- | | |
|-------------------------------|--------------------------|
| Ionic lattice | <input type="checkbox"/> |
| Metallic lattice | <input type="checkbox"/> |
| Simple molecular | <input type="checkbox"/> |
| Structure resembling graphite | <input type="checkbox"/> |

(Total 1 mark)

2. Chlorine-35 is an isotope of chlorine.

Which of these statements is correct about an atom of chlorine-35?

- | | |
|---------------------------------|--------------------------|
| It has 35 electrons | <input type="checkbox"/> |
| It has 35 neutrons | <input type="checkbox"/> |
| It has 35 protons | <input type="checkbox"/> |
| It has 35 protons plus neutrons | <input type="checkbox"/> |

(Total 1 mark)

3. On a periodic table the number 39.1 is shown for potassium, K.

What is this number?

- | | |
|-----------------------|--------------------------|
| Atomic number | <input type="checkbox"/> |
| Mass number | <input type="checkbox"/> |
| Relative atomic mass | <input type="checkbox"/> |
| Relative formula mass | <input type="checkbox"/> |

(Total 1 mark)

4. Which row is correct for the properties of the solids shown?

	Solid	Melting point	Electrical conductivity	
A	Graphite	High	Poor	<input type="checkbox"/>
B	Iodine	High	Poor	<input type="checkbox"/>
C	Iron	Low	Good	<input type="checkbox"/>
D	Sodium chloride	High	Poor	<input type="checkbox"/>

(Total 1 mark)

5. An isotope of an element has a mass number of 25.

What is correct for an atom of this isotope?

- | | |
|---|--------------------------|
| It has 12 neutrons | <input type="checkbox"/> |
| It has 25 electrons | <input type="checkbox"/> |
| It has 25 protons | <input type="checkbox"/> |
| The sum of its protons and neutrons is 25 | <input type="checkbox"/> |

(Total 1 mark)

6. SiO₂ has a giant covalent structure.

What is correct for SiO₂?

- | | |
|---|--------------------------|
| It consists of SiO ₂ molecules joined by strong intermolecular bonds | <input type="checkbox"/> |
| It does not conduct electricity when molten | <input type="checkbox"/> |
| It has a low melting point | <input type="checkbox"/> |
| It is easily soluble in water | <input type="checkbox"/> |

(Total 1 mark)

7. Which feature of the structure of the atom was deduced from the Geiger and Marsden experiment?

- | | |
|--|--------------------------|
| Atoms consist of electrons, protons and neutrons | <input type="checkbox"/> |
| The nucleus is small and dense | <input type="checkbox"/> |
| Electrons exist in energy levels/shells | <input type="checkbox"/> |
| Electrons exist in atomic orbitals | <input type="checkbox"/> |

(Total 1 mark)

8. What mass of Na₂CO₃ is needed to make up 250 cm³ of a 0.100 mol dm⁻³ solution?

(Na = 23, C = 12, O = 16)

- | | |
|--------|--------------------------|
| 2.65 g | <input type="checkbox"/> |
| 3.57 g | <input type="checkbox"/> |
| 10.6 g | <input type="checkbox"/> |
| 26.5 g | <input type="checkbox"/> |

(Total 1 mark)

9. A student has 50 cm³ of a 0.25 mol dm⁻³ solution.

What volume of water (in cm³) should the student add to get a 0.10 mol dm⁻³ solution?

2.5

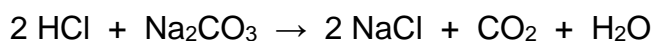
20

75

125

(Total 1 mark)

10. Hydrochloric acid reacts with sodium carbonate as shown in the equation.



20 cm³ of 2.0 mol dm⁻³ Na₂CO₃ are added to 20 cm³ 2.0 mol dm⁻³ HCl.

What mass of CO₂ (in g) is produced?

0.88

1.76

22

1760

(Total 1 mark)

11. Which statement about a lattice of sodium chloride is correct?

The ions are the same size

The attraction between two sodium ions is greater than the repulsion between two chloride ions

Each sodium ion is surrounded by six chloride ions

There are more sodium ions than chloride ions

(Total 1 mark)

ANSWERS TO TASKS

TASK 1 –Writing formulae

Ionic formulae

1. AgBr
2. Na₂CO₃
3. K₂O
4. Fe₂O₃
5. CrCl₃
6. Ca(OH)₂
7. Al(NO₃)₃
8. Na₂SO₄
9. PbO
10. Na₃PO₄
11. Zn(HCO₃)₂
12. (NH₄)₂SO₄
13. Ga(OH)₃
14. SrSe
15. RaSO₄
16. Na₃N

Mixed practice

- | | |
|-------------------------------------|---|
| 1. PbO ₂ | 21. Cu |
| 2. Na | 22. NH ₄ Cl |
| 3. NH ₃ | 23. S ₈ |
| 4. H ₂ SO ₄ | 24. Ne |
| 5. SiO ₂ | 25. Si |
| 6. Ba(OH) ₂ | 26. SnCl ₄ |
| 7. AgNO ₃ | 27. I ₂ |
| 8. Ni | 28. H ₂ S |
| 9. TiO ₂ | 29. Pb |
| 10. SrSO ₄ | 30. Li |
| 11. Ag ₂ CO ₃ | 31. Au |
| 12. PtF ₂ | 32. HNO ₃ |
| 13. NH ₃ | 33. SiH ₄ |
| 14. P ₄ | 34. C |
| 15. V ₂ O ₅ | 35. Co(OH) ₂ |
| 16. Ba(OH) ₂ | 36. NH ₃ |
| 17. HCl | 37. F ₂ |
| 18. Si | 38. Ca ₃ (PO ₄) ₂ |
| 19. Rb | 39. GeO ₂ |
| 20. MgAt ₂ | 40. NO |

TASK 2 – Balancing chemical equations

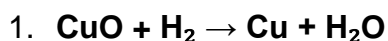
- $\text{Mg} + 2 \text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2$
- $\text{CuCl}_2 + 2 \text{NaOH} \rightarrow \text{Cu}(\text{OH})_2 + 2 \text{NaCl}$
- $2 \text{SO}_2 + \text{O}_2 \rightarrow 2 \text{SO}_3$
- $\text{C}_4\text{H}_{10} + 6\frac{1}{2} \text{O}_2 \rightarrow 4 \text{CO}_2 + 5 \text{H}_2\text{O}$ or $2 \text{C}_4\text{H}_{10} + 13 \text{O}_2 \rightarrow 8 \text{CO}_2 + 10 \text{H}_2\text{O}$
- $4 \text{Na} + \text{O}_2 \rightarrow 2 \text{Na}_2\text{O}$
- $2 \text{Al} + 3 \text{Cl}_2 \rightarrow 2 \text{AlCl}_3$
- $\text{Ca} + 2 \text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2$
- $2 \text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$
- $4 \text{Al} + 3 \text{O}_2 \rightarrow 2 \text{Al}_2\text{O}_3$
- $\text{C}_6\text{H}_{14} + 9\frac{1}{2} \text{O}_2 \rightarrow 6 \text{CO}_2 + 7 \text{H}_2\text{O}$ or $2 \text{C}_6\text{H}_{14} + 19 \text{O}_2 \rightarrow 12 \text{CO}_2 + 14 \text{H}_2\text{O}$
- $\text{CH}_3\text{CH}_2\text{OH} + 3\frac{1}{2} \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O}$
- $2 \text{Li} + 2 \text{H}_2\text{O} \rightarrow 2 \text{LiOH} + \text{H}_2$
- $\text{CaCO}_3 + 2 \text{HNO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O} + \text{CO}_2$
- $\text{Li}_2\text{CO}_3 \rightarrow \text{Li}_2\text{O} + \text{CO}_2$
- $\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3$
- $\text{K}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$
- $\text{Ca}(\text{OH})_2 + 2 \text{HCl} \rightarrow \text{CaCl}_2 + 2 \text{H}_2\text{O}$
- $3 \text{Zn} + 2 \text{H}_3\text{PO}_4 \rightarrow \text{Zn}_3(\text{PO}_4)_2 + 3 \text{H}_2$
- $2 \text{NaHCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{H}_2\text{O} + 2 \text{CO}_2$
- $2 \text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2 \text{H}_2\text{O}$

TASK 3 – Ionic equations

- $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$
- $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$
- $2 \text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{H}_2\text{O} + \text{CO}_2$
- $\text{Ca}^{2+} + 2 \text{OH}^- \rightarrow \text{Ca}(\text{OH})_2$
- $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$
- $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$
- $\text{Ca}^{2+} + \text{SO}_4^{2-} \rightarrow \text{CaSO}_4$
- $\text{Pb}^{2+} + 2 \text{Cl}^- \rightarrow \text{PbCl}_2$
- $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$

TASK 4 – Basic moles calculations

- | | | | | | |
|----|-------------------------------|-------------------------------|------------|-----------|-------------|
| 1. | a. 2.96 | b. 50.3 | c. 0.500 | d. 17100 | e. 0.000107 |
| 2. | a. 355 g | b. 20.4 g | c. 1.08 g | d. 1.08 g | e. 85.8 g |
| 3. | a. 0.250 | b. 0.250 | c. 0.500 | | |
| 4. | a. 0.0500 | b. 0.100 | c. 0.150 | | |
| 5. | 176 | | | | |
| 6. | a. 1.6735×10^{-24} g | b. 1.6726×10^{-24} g | c. 3.025 g | | |

TASK 5 – Reacting mass calculations

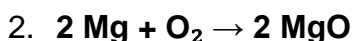
$$\text{Mr}(\text{CuO}) = 63.55 + 16.00 = 79.55 \text{ g/mol}$$

$$\text{Mr}(\text{H}_2) = 2.016 \text{ g/mol}$$

$$n(\text{CuO}) = 40.0/79.55 = 0.503 \text{ mol}$$

$$n(\text{CuO}) = n(\text{H}_2) \text{ therefore } n(\text{H}_2) = 0.503 \text{ mol}$$

$$m(\text{H}_2) = 0.503 \times 2.016 = \mathbf{1.01 \text{ g}}$$



$$\text{Mr}(\text{Mg}) = 24.31 \text{ g/mol}$$

$$\text{Mr}(\text{O}_2) = 32.00 \text{ g/mol}$$

$$n(\text{Mg}) = 192/24.31 = 7.898 \text{ mol}$$

$$n(\text{O}_2) = n(\text{Mg})/2 \text{ therefore } n(\text{O}_2) = 7.898/2 = 3.949 \text{ mol}$$

$$m(\text{O}_2) = 3.949 \times 32.00 = \mathbf{126 \text{ g}}$$



$$\text{Mr}(\text{SO}_2) = 64.06 \text{ g/mol}$$

$$\text{Mr}(\text{SO}_3) = 80.06 \text{ g/mol}$$

$$n(\text{SO}_2) = 96.0/64.06 = 1.499 \text{ mol}$$

$$n(\text{SO}_3) = n(\text{SO}_2) \text{ therefore } n(\text{SO}_3) = 1.499 \text{ mol}$$

$$m(\text{SO}_3) = 1.499 \times 80.06 \approx \mathbf{120.0 \text{ g}}$$



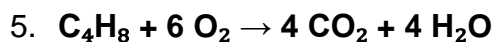
$$\text{Mr}(\text{Fe}_2\text{O}_3) = (2 \times 55.85) + (3 \times 16.00) = 159.7 \text{ g/mol}$$

$$\text{Mr}(\text{CO}) = 28.01 \text{ g/mol}$$

$$n(\text{Fe}_2\text{O}_3) = 480\,000 \text{ g} / 159.7 = 3005.6 \text{ mol}$$

$$n(\text{CO}) = 3 \times n(\text{Fe}_2\text{O}_3) \text{ therefore } n(\text{CO}) = 3 \times 3005.6 = 9016.9 \text{ mol}$$

$$m(\text{CO}) = 9016.9 \times 28.01 = \mathbf{253\,000 \text{ g or } 253 \text{ kg}}$$



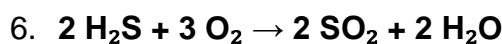
$$Mr(C_4H_8) = 56.104 \text{ g/mol}$$

$$Mr(CO_2) = 44.01 \text{ g/mol}$$

$$n(C_4H_8) = 5.60/56.104 = 0.0998 \text{ mol}$$

$$n(CO_2) = 4 \times n(C_4H_8) \text{ therefore } n(CO_2) = 4 \times 0.0998 = 0.399 \text{ mol}$$

$$m(CO_2) = 0.399 \times 44.01 = \mathbf{17.6 \text{ g}}$$



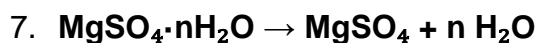
$$Mr(H_2S) = 34.076 \text{ g/mol}$$

$$Mr(O_2) = 32.00 \text{ g/mol}$$

$$n(H_2S) = 8.50/34.076 = 0.249 \text{ mol}$$

$$n(O_2) = (3/2)n(H_2S) \text{ therefore } n(O_2) = (3/2) \times 0.249 = 0.374 \text{ mol}$$

$$m(O_2) = 0.374 \times 32.00 = \mathbf{12.0 \text{ g}}$$



$$Mr(MgSO_4) = 120.37 \text{ g/mol}$$

$$Mr(H_2O) = 18.016 \text{ g/mol}$$

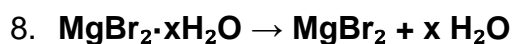
$$\text{Mass lost (H}_2\text{O)} = 4.92 - 2.40 = 2.52 \text{ g}$$

$$n(H_2O) = 2.52/18.016 = 0.1499 \text{ mol}$$

$$n(MgSO_4) = 2.40/120.37 = 0.01994 \text{ mol}$$

$$\mathbf{n = 0.1499/0.01994 \approx 7}$$

$$\text{Formula mass hydrated salt} = 120.37 + (7 \times 18.016) = \mathbf{246.48 \text{ g/mol}}$$



$$Mr(MgBr_2) = 184.118 \text{ g/mol}$$

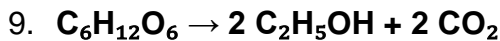
$$Mr(H_2O) = 18.016 \text{ g/mol}$$

$$\text{Mass lost (H}_2\text{O)} = 7.30 - 4.60 = 2.70 \text{ g}$$

$$n(H_2O) = 2.70/18.016 = 0.1499 \text{ mol}$$

$$n(MgBr_2) = 4.60/184.118 = 0.02498 \text{ mol}$$

$$\mathbf{x = 0.1499/0.02498 \approx 6}$$



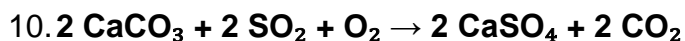
$$\text{Mr}(\text{ethanol}) = 46.068 \text{ g/mol}$$

$$\text{Mr}(\text{glucose}) = 180.156 \text{ g/mol}$$

$$m(\text{ethanol}) = 5.00 \text{ kg or } 5000 \text{ g therefore } n(\text{ethanol}) = 5000/46.068 = 108.5 \text{ mol}$$

$$n(\text{glucose}) = n(\text{ethanol})/2 \text{ therefore } n(\text{glucose}) = 108.5/2 = 54.23 \text{ mol}$$

$$m(\text{glucose}) = 54.23 \times 180.156 = \mathbf{9780 \text{ g or } 9.780 \text{ kg}}$$



(Assume 1.000 metric ton = 1000 kg)

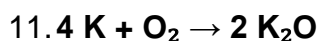
$$\text{Mr}(\text{SO}_2) = 64.06 \text{ g/mol}$$

$$\text{Mr}(\text{CaCO}_3) = 100.09 \text{ g/mol}$$

$$n(\text{SO}_2) = 1.000 \times 10^6 / 64.06 = 15,611 \text{ mol}$$

$$n(\text{CaCO}_3) = 15,611 \text{ mol}$$

$$m(\text{CaCO}_3) = 15,611 \times 100.09 = \mathbf{1.56 \times 10^3 \text{ kg } (\approx 1.56 \text{ t})}$$

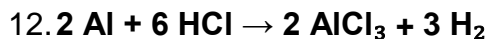


$$\text{Mr}(\text{K}_2\text{O}) = 94.20 \text{ g/mol}$$

$$m(\text{K}) = 7.80 \text{ mg} = 0.00780 \text{ g therefore } n(\text{K}) = 0.00780/39.10 = 1.995 \times 10^{-4} \text{ mol}$$

$$n(\text{K}_2\text{O}) = \frac{1}{2} n(\text{K}) = 9.98 \times 10^{-5} \text{ mol}$$

$$m = 9.98 \times 10^{-5} \times 94.20 = \mathbf{0.00940 \text{ g or } 9.40 \text{ mg}}$$



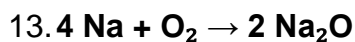
$$\text{Mr}(\text{Al}) = 26.98 \text{ g/mol}$$

$$\text{Mr}(\text{H}_2) = 2.016 \text{ g/mol}$$

$$n(\text{Al}) = 10.0/26.98 = 0.3706 \text{ mol}$$

$$n(\text{H}_2) = (3/2)n(\text{Al}) \text{ therefore } n(\text{H}_2) = (3/2) \times 0.3706 = 0.5559 \text{ mol}$$

$$m(\text{H}_2) = 0.5559 \times 2.016 = \mathbf{1.12 \text{ g}}$$

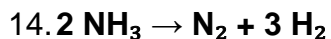


$$\text{Mr}(\text{O}_2) = 32.00 \text{ g/mol}$$

$$\text{Mr}(\text{Na}) = 22.99 \text{ g/mol}$$

$$n(\text{O}_2) = 40.0/32.00 = 1.250 \text{ mol} \rightarrow n(\text{Na}) = 4 \times 1.250 = 5.000 \text{ mol}$$

$$m(\text{Na}) = 5.000 \times 22.99 = \mathbf{115 \text{ g}}$$



(Assume metric tons)

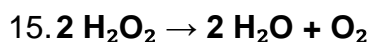
$$\text{Mr}(\text{NH}_3) = 17.034 \text{ g/mol}$$

$$\text{Mr}(\text{N}_2) = 28.02 \text{ g/mol}$$

$$m(\text{NH}_3) = 2.00 \text{ t} = 2.00 \times 10^6 \text{ g} \rightarrow n(\text{NH}_3) = 2.00 \times 10^6 / 17.034 = 117,444 \text{ mol}$$

$$n(\text{N}_2) = \frac{1}{2} \times 117,444 = 58,722 \text{ mol}$$

$$m(\text{N}_2) = 58,722 \times 28.02 = \mathbf{1.65 \times 10^3 \text{ kg}}$$



$$\text{Mr}(\text{H}_2\text{O}_2) = 34.016 \text{ g/mol}$$

$$\text{Mr}(\text{O}_2) = 32.00 \text{ g/mol}$$

$$n(\text{H}_2\text{O}_2) = 136/34.016 = 3.998 \text{ mol} \rightarrow n(\text{O}_2) = \frac{1}{2} \times 3.998 = 1.999 \text{ mol}$$

$$m(\text{O}_2) = 1.999 \times 32.00 = \mathbf{64.0 \text{ g}}$$



$$1:1 \text{ in moles: } n(\text{PbO}) = n[\text{Pb}(\text{NO}_3)_2] = 0.400 \text{ mol}$$

$$\text{Mr}(\text{PbO}) = 207.2 + 16.00 = 223.2 \text{ g/mol}$$

$$m = 0.400 \times 223.2 = \mathbf{89.3 \text{ g}}$$

TASK 6 - Solution Calculations

1a. 0.1 1b. 250 1c. 0.0025

2a. 0.2 mol dm⁻³, 7.3 g dm⁻³

2b. 2.5 mol dm⁻³, 245.3 g dm⁻³

2c. 0.0512 mol dm⁻³, 2.10 g dm⁻³

3a. 0.05 dm³ 3b. 0.001 dm³

TASK 7 – Titration Calculations

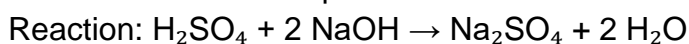
1. **25.0 cm³ of 0.0200 mol·dm⁻³ H₂SO₄ neutralises 18.6 cm³ of Ba(OH)₂.**



- moles H₂SO₄ = C × V = 0.0200 × (25.0/1000) = **0.0005000 mol**
- stoichiometry 1 : 1 → moles Ba(OH)₂ = 0.0005000 mol
- concentration Ba(OH)₂ = n / V = 0.0005000 / (18.6/1000) = **0.02688 mol·dm⁻³**

Answer: 0.0269 mol·dm⁻³ (to 3 s.f.)

2. **25.0 cm³ of NaOH required 18.8 cm³ of 0.0500 mol·dm⁻³ H₂SO₄.**



- moles H₂SO₄ = 0.0500 × (18.8/1000) = **0.0009400 mol**
- stoich 1 H₂SO₄ : 2 NaOH → moles NaOH = 2 × 0.0009400 = **0.001880 mol** (in 25.0 cm³)
- concentration NaOH = 0.001880 / (25.0/1000) = **0.0752 mol·dm⁻³**

Answer: 0.0752 mol·dm⁻³

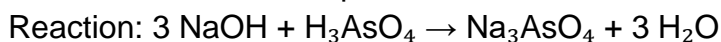
3. What volume of **0.050 mol·dm⁻³ KOH** is required to neutralise **25.0 cm³ of 0.0150 mol·dm⁻³ HNO₃**?



- moles HNO₃ = 0.0150 × (25.0/1000) = **0.0003750 mol**
- moles KOH required = 0.0003750 mol
- volume KOH = n / C = 0.0003750 / 0.0500 = 0.00750 dm³ = **7.50 cm³**

Answer: 7.50 cm³ KOH

4. **25.0 cm³ of H₃AsO₄ required 37.5 cm³ of 0.100 mol·dm⁻³ NaOH.**



- moles NaOH = 0.100 × (37.5/1000) = **0.003750 mol**
- stoich 3 NaOH : 1 H₃AsO₄ → moles H₃AsO₄ = 0.003750 / 3 = **0.001250 mol** (in 25.0 cm³)
- concentration acid = 0.001250 / (25.0/1000) = **0.0500 mol·dm⁻³**

Answer: 0.0500 mol·dm⁻³

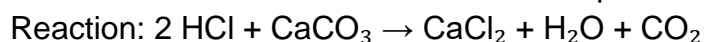
5. A **250 cm³** solution of NaOH was prepared. **25.0 cm³** of this solution required **28.2 cm³** of **0.100 mol·dm⁻³** HCl. Find the **mass of NaOH** dissolved to make the original 250 cm³.



- moles HCl used = $0.100 \times (28.2/1000) = \mathbf{0.00282 \text{ mol}}$ → moles NaOH in 25.0 cm³ = 0.00282 mol
- concentration of NaOH solution = $0.00282 / (25.0/1000) = \mathbf{0.1128 \text{ mol}\cdot\text{dm}^{-3}}$
- total moles in 250 cm³ = $0.1128 \times 0.250 = \mathbf{0.02820 \text{ mol}}$
- $M(\text{NaOH}) = 22.99 + 16.00 + 1.008 = \mathbf{39.998 \text{ g}\cdot\text{mol}^{-1}}$
- mass NaOH = $0.02820 \times 39.998 = \mathbf{1.13 \text{ g}}$

Answer: 1.13 g NaOH (to 3 s.f.)

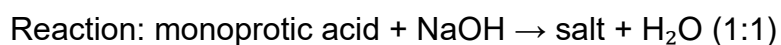
6. What volume of **5.00 mol·dm⁻³** HCl is required to neutralise **20.0 kg CaCO₃**?



- mass CaCO₃ = 20.0 kg = 20,000 g
- $M(\text{CaCO}_3) = 40.08 + 12.01 + 3 \times 16.00 = \mathbf{100.09 \text{ g}\cdot\text{mol}^{-1}}$
- moles CaCO₃ = $20000 / 100.09 = \mathbf{199.82 \text{ mol}}$
- stoich 2 HCl : 1 CaCO₃ → moles HCl = $2 \times 199.82 = \mathbf{399.64 \text{ mol}}$
- volume HCl = $n / C = 399.64 / 5.00 = \mathbf{79.93 \text{ dm}^3} = \mathbf{79.93 \text{ L}}$

Answer: 79.9 dm³ (≈ 79.9 L) of 5.00 mol·dm⁻³ HCl

7. **3.88 g** of a monoprotic acid was dissolved and made up to **250 cm³**. **25.0 cm³** of this solution required **46.5 cm³** of **0.0950 mol·dm⁻³** NaOH. Find the relative molecular mass (Mr) of the acid.



- moles NaOH used = $0.0950 \times (46.5/1000) = \mathbf{0.0044175 \text{ mol}}$ → moles acid in 25.0 cm³ = 0.0044175 mol
- concentration acid solution = $0.0044175 / (25.0/1000) = \mathbf{0.1767 \text{ mol}\cdot\text{dm}^{-3}}$
- total moles acid in 250 cm³ = $0.1767 \times 0.250 = \mathbf{0.044175 \text{ mol}}$
- $\text{Mr} = \text{mass} / \text{moles} = 3.88 / 0.044175 = \mathbf{87.8 \text{ g}\cdot\text{mol}^{-1}}$

Answer: Mr ≈ 87.8