2.4 REACTING VOLUMES AND MASSES

Learning outcomes

Candidates should be able to:

1. perform calculations, including the use of the mole concept, involving:
   (a) reacting masses (from formulae and equations), including percentage yield calculations
   (b) volumes of gases (e.g. in the burning of hydrocarbons)
   (c) volumes and concentrations of solutions
   (d) limiting reagent and excess reagent
   (e) deduce stoichiometric relationships from calculations such as those in 2.4.1 (a)–(d)

(When performing calculations, candidates' answers should reflect the number of significant figures given or asked for in the question. When rounding up or down, candidates should ensure that significant figures are neither lost unnecessarily nor used beyond what is justified (see also Mathematical requirements section).)

Stoichiometry: the mole ratio of reactants and products shown in the balanced equation.

Very important

- **When you are writing an answer to a calculation, the answer should be to the same number of significant figures as the least number of significant figures in the data.**
- **Do not round numbers to the correct number of significant figures until the end of a calculation or you risk introducing errors.**
- **If you are asked to write appropriate number of significant figures, take 3 or 4 significant figures after rounding off at last.**

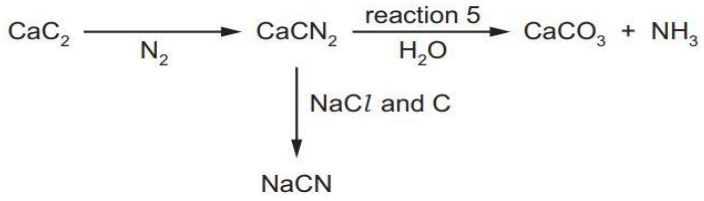
Reacting masses

1. Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?
   A aluminium B magnesium C phosphorus D sodium
2. If 1 mole of hexane combusts in an excess of oxygen, how many moles of products are formed?
   A 11 **B** 12 **C** 13 **D** 14
3. Mixture R consists of one mole of C_3H_6 and one mole of C_4H_6.
   What is the minimum number of moles of oxygen molecules needed for the complete combustion of mixture R?
   A 6.5 **B** 7 **C** 10 **D** 20

1. What mass of magnesium oxide is formed on burning 2.00g of magnesium? (ans = 3.33 g) [2]
2. Calculate how much sodium hydroxide is needed to make 5.00g of sodium sulphate. [1]
   $NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$ (ans= 0.704 mole or 2.815g)
3. Calculate how much water is formed when 10g of sulfuric acid reacts with sodium hydroxide. (ans = 0.204 moles or 3.67 g) [1]

4. Strontium metal can be extracted from strontium oxide, SrO, by reduction with aluminium. One of the possible reactions is shown.
   $6SrO + 2Al \rightarrow 3Sr + Sr_3Al_2O_6$
   What is the maximum mass of strontium metal that can be produced from the reduction of 100 g of strontium oxide using this reaction?
   A 41.3 g **B** 42.3 g **C** 84.6 g **D** 169.2 g

4. The flowchart shows some reactions of CaC_2.



Reaction 5 can be used to prepare NH_3.
$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$
Calculate the minimum mass, in tonnes, of calcium cyanamide, $CaCN_2$, that is required to produce 1.50×10^6 tonnes of NH_3.
Show your working.
1 tonne = 1.00×10^6g (ans = 3.53 x 10^6 tonnes) [2]

5. An ore of manganese contains 4% by mass of MnO_2 and no other manganese compound.
Which mass of manganese would be obtained from 1 tonne of this ore?
A 25.3 kg **B** 40.0 kg **C** 63.3 kg **D** 632 kg
6. A copper ore contains 3.00% of copper carbonate, $CuCO_3$, by mass.
Which mass of copper would be obtained from 1 tonne of the ore?
A 1.91 kg **B** 3.71 kg **C** 15.4 kg **D** 58.4 kg
7. Calcium oxide and magnesium sulfide each react with acid.
$CaO(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l)$
$MgS(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2S(g)$
A mixture of these two compounds, X, reacts with exactly 0.125 mol of dilute hydrochloric acid.
The amount of hydrogen sulfide formed is 0.0250 mol.
What was the mass of calcium oxide in mixture X?
A 1.4 g **B** 2.1 g **C** 2.8 g **D** 4.2 g
8. 2.0 g of ammonium nitrate, NH_4NO_3, decomposes to give 0.90 g of water and a single gas. What is the identity of the gas?
A NO **B** NO_2 **C** N_2O **D** N_2
9. Originally, chemists thought indium oxide had the formula InO. By experiment, they showed that 4.8 g of indium combined with 1.0 g of oxygen to produce 5.8 g of indium oxide. The Ar of oxygen was known to be 16.
Which value for the Ar of indium is calculated using these data?
A 38 **B** 77 **C** 115 **D** 154
10. Zinc reacts with concentrated nitric acid, giving three products only: zinc nitrate, an oxide of nitrogen and water.
3.0 moles of zinc react with 8.0 moles of nitric acid. Zinc nitrate contains Zn^{2+} ions.
What could be the formula for the oxide of nitrogen?
A N_2O B NO C N_2O_3 D NO_2
11. X is an impure sample of a Group 2 metal carbonate, MCO_3. X contains 57% by mass of MCO_3.
The impurities in X do not react with hydrochloric acid.
7.4 g of X is reacted with an excess of dilute hydrochloric acid.
0.050 mol of the Group 2 metal chloride is produced.
What is the identity of the Group 2 metal?
A Mg B Ca C Sr D Ba

Percentage yield

5. 22.43 g of copper(II) hydroxide reacts with hydrochloric acid to form 23.63 g copper(II) chloride.
Complete the following Table to calculate the percentage yield of this reaction.

Relative formula mass of copper (II) hydroxide	
Moles copper (II) hydroxide	
Relative formula mass of copper (II) chloride	
Theoretical yield of copper (II) chloride	
Percentage yield of copper (II) chloride	(ans = 6.37%)

6. For the balanced equation shown below, if the reaction of 20.7 grams of $CaCO_3$ produces 6.81 grams of CaO, what is the percent yield?
$CaCO_3 \rightarrow CaO + CO_2$ (ans = 58.74%)

7. For the equation shown below, if the reaction of 0.112 grams of H_2 produces 0.745 grams of H_2O, what is the percent yield?
   $Fe_3O_4 + H_2 \rightarrow Fe + H_2O$ (ans = 73.91 %)
8. For the balanced equation shown below, if the reaction of 77.0 grams of $CaCN_2$ produces 27.1 grams of NH_3, what is the percent yield?
   $CaCN_2 + 3\ H_2O \rightarrow CaCO_3 + 2\ NH_3$ (ans = 50%)
9. For the balanced equation shown below, if the reaction of 40.8 grams of $C_6H_6O_3$ produces a 39.0% yield, how many grams of H_2O would be produced?
   $C_6H_6O_3 + 6\ O_2 \rightarrow 6\ CO_2 + 3\ H_2O$ (ans = 6.81)

Solutions and Concentrations

Concentration: the amount of solute (in moles) dissolved in a stated volume of solution (usually 1 dm^3)

$$C = n/V$$

10. Calculate the concentration, in mol dm^{-3}, of the following solutions:
    i) a solution of sodium hydroxide, NaOH, containing 2.0 g of sodium hydroxide in 50 cm^3 of solution. (ans= 1)
    ii) a solution of Ethanoic acid, CH_3COOH, containing 12.0 g of Ethanoic acid in 250 cm^3 of solution. (ans = 0.8 mol dm^{-3})

11. Calculate the number of moles of solute dissolved in each of the following:
    i. 40 cm^3 of aqueous nitric acid of concentration 0.2 $moldm^{-3}$. (ans = 0.008)
    ii. 50 cm^3 of calcium hydroxide solution of concentration 0.01 $moldm^{-3}$. (ans = 0.005)

12. 0.4 moles of aluminium sulfate, $Al_2(SO_4)_3$, are dissolved in water and the volume of the solution was made up to 500 cm^3. Which one of these statements is correct?
    A. The solution contains a total of 2 moles of ions.
    B. The concentration of aluminium ions is 0.8 mol dm^{-3}.
    C. The concentration of sulfate ions in solution is 1.2 mol dm^{-3}.
    D. The solution contains a total of 4 moles of ions.

13. In this question it should be assumed that $(NH_4)_2CO_3.H_2O(s)$ dissolves in water without causing an increase in volume.
    Which mass of $(NH_4)_2CO_3.H_2O(s)$ should be added to 800cm^3 of water to form a 0.100 mol dm^{-3} solution of NH_4^+ ions?
    A 4.56 g **B** 7.13 g **C** 9.12 g **D** 14.3 g

14. Sample X is added to water and made up to a total volume of 200 cm^3. This gives a solution of 0.100 mol dm^{-3} HCl. What is X?
    A 10 cm^3 of 1.00 mol dm^{-3} HCl
    B 30 cm^3 of 0.90 mol dm^{-3} HCl
    C 50 cm^3 of 0.40 mol dm^{-3}HCl
    D 100 cm^3 of 0.30 mol dm^{-3} HCl

12. 25.0 cm^3 of a solution of sodium hydroxide is exactly neutralised by 15.10 cm^3 of sulfuric acid of concentration 0.200 mol dm^{-3}.
    $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
    Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution. (ans = 0.2416)

13. The equation for the reaction of strontium hydroxide with hydrochloric acid is shown below.
    $Sr(OH)_2 + 2\ HCl \rightarrow SrCl_2 + 2\ H_2O$
    25.0 cm^3 of a solution of strontium hydroxide was exactly neutralised by 15.00 cm^3 of 0.100 mol dm^{-3} hydrochloric acid. Calculate the concentration, in mol dm^{-3}, of the strontium hydroxide solution. (ans = 0.03)

14. $NaBiO_3$ can be used to determine the concentration of $Mn^{2+}(aq)$. The ionic equation for the reaction is shown in equation 2.

equation 2: $2Mn^{2+} + 5BiO_3^- + 14H^+ \rightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$

A student uses the following procedure in an experiment.

- Add 100.0 cm^3 of a saturated solution of $Mn^{2+}(aq)$ to a volumetric flask.
- Add distilled water to the flask to make a 1.00 dm^3 diluted solution.
- Titrate a 25.00 cm^3 sample of the diluted solution with 0.100 mol dm^{-3} $NaBiO_3(aq)$.

The 25.00 cm^3 sample of the diluted solution of $Mn^{2+}(aq)$ reacts completely with exactly 21.50 cm^3 of 0.100 mol dm^{-3} $NaBiO_3(aq)$.

Calculate the concentration, in mol dm^{-3}, of $Mn^{2+}(aq)$ in the saturated solution.

Show your working.

concentration of $Mn^{2+}(aq)$ in the saturated solution =…….(ans: 0.344)…… mol dm^{-3} [3]

15. A student is provided with a sample of hydrated copper(II) sulfate, $CuSO4 \cdot xH_2O$, and is asked to determine the value of x.

The student dissolves a sample of the hydrated copper(II) sulfate in water and adds it to an excess of aqueous potassium iodide to make a total volume of 250.0 cm^3 of solution.

$2CuSO_4 + 4KI \rightarrow 2CuI + I_2 + K_2SO_4$

The amount of iodine produced during this reaction is found by titrating a sample of this solution with sodium thiosulfate solution.

25.0 cm^3 of the iodine-containing solution requires 20.0 cm^3 of 0.10 mol dm^{-3} sodium thiosulfate solution.

$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

(i) Calculate the amount, in mol, of copper(II) sulfate present in the original sample of hydrated copper(II) sulfate.

Show your working.

amount of copper(II) sulfate = ...(ans = 0.002)..... mol [2]

(ii) A total of 7.98 g of CuSO4 is present in 10.68 g of CuSO4•xH2O.

Complete each row of the table to calculate the value of x, where x is an integer. [Mr: CuSO4,159.6] [3]

amount of CuSO4 in 10.68 g of CuSO4•xH2O	..... mol
amount of H2O in 10.68 g of CuSO4•xH2O	..... mol
value of x	x = ...

15. Sodium hydroxide neutralises acid.

$H^+ + OH^- \rightarrow H_2O$

In a 11 000 dm^3 sample of an aqueous solution, the concentration of acid, $[H^+]$, is 1.26×10^{-3} mol dm^{-3}.

Which mass of solid sodium hydroxide neutralises the acid?

A 0.0214 g B 0.0504 g C 236 g D 554 g

16. Which mixture will react to form exactly one mole of water?

	volume 2.00 mol dm^{-3} H_2SO_4 / cm^3	volume 1.00 mol dm^{-3} NaOH / cm^3
A	250	500
B	250	1000
C	500	500
D	500	1000

17. A piece of rock has a mass of 2.00 g. It contains calcium carbonate, but no other basic substances.

It neutralises exactly 36.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid.

What is the percentage by mass of calcium carbonate in the 2.00 g piece of rock?

A 22.5% **B** 45.0% **C** 72.0% **D** 90.1%

18. A washing powder contains sodium hydrogencarbonate, $NaHCO_3$, as one of the ingredients.

In a titration, a solution containing 1.00 g of this washing powder requires 7.15 cm^3 of 0.100 mol dm^{-3} sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.

What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

A 3.0% **B** 6.0% **C** 12.0% **D** 24.0%

19. A white powder is known to be a mixture of magnesium oxide and aluminium oxide.
100 cm^3 of 2 mol dm^{-3} NaOH(aq) is just enough to dissolve the aluminium oxide in *x* grams of the mixture.
The reaction is shown.
$Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2Al(OH)_4^-$
800 cm^3 of 2 mol dm^{-3} HCl (aq) is just enough to dissolve **all** of the oxide in *x* grams of the mixture.
The reactions are shown.
$Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$
$MgO + 2H^+ \rightarrow Mg^{2+} + H_2O$
How many moles of each oxide are present in *x* grams of the mixture?

	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

Acid-Base Titration - YouTube In The Lab: How to do a titration – properly.

Molar gas volume

the volume occupied by one mole of any gas at room temperature and pressure(r.t.p). **One mole of gas** occupies **24.0 dm^3 at r.t.p.**

n= volume at rtp(in dm^3)/24.0

20. What is the number of molecules in 500 cm^3 of oxygen at standard temperature and pressure?
a. 3.00×10^{23} b. 3.00×10^{26} c. 1.25×10^{21} d. 1.34×10^{22}

16. A method of silane production involves the reduction of silicon dioxide by aluminium and hydrogen gas.
$3SiO_2(s) + 6H_2(g) + 4Al(s) \rightarrow 3SiH_4(g) + 2Al_2O_3(s)$
What is the volume, in dm^3, of hydrogen gas required to produce 10 dm^3 of silane gas? (ans = 20 dm^3)

21. Sodium azide, NaN_3, decomposes as shown.
$2NaN_3 \rightarrow 2Na + 3N_2$
Which volume of nitrogen, measured at room temperature and pressure, will be produced by the decomposition of 150 g of sodium azide?
A 166 dm^3 **B** 83 dm^3 **C** 55 dm^3 **D** 37 dm^3

22. What is the volume of carbon dioxide produced when 14 g of ethene, C_2H_4, reacts with excess oxygen? (M_r ethene = 28)
$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$
a. 96.0 dm^3 b. 24.0 dm^3 c. 0.0467 dm^3 d. 12.0 dm^3

23. Methanethiol, CH_3SH, burns as shown.
$CH_3SH + 3\ O_2 \rightarrow CO_2 + SO_2 + 2\ H_2O$
A sample of 10 cm^3 of methanethiol gas was reacted with 60 cm^3 of oxygen. Both samples were measured at room conditions.
What would be the final volume of the resultant mixture of gases measured at room temperature?
A 20 cm^3 B 30 cm^3 C 50 cm^3 D 70 cm^3

24. A sample of propane, C_3H_8, with a mass of 9.61 g is completely combusted in an excess of oxygen under room conditions.
Which volume of carbon dioxide gas is produced?
A 4.89 dm^3 **B** 5.24 dm^3 **C** 14.7 dm^3 **D** 15.7 dm^3

25. What is the maximum volume of sulfur dioxide gas measured at room conditions produced from burning 100 dm^3 of diesel fuel containing 0.8346 g of sulfur?
A 291 cm^3 **B** 312 cm^3 **C** 582 cm^3 **D** 624 cm^3

26. What is the minimum mass of oxygen required to ensure the complete combustion of 12 dm^3 of propane measured under room conditions?
A 60 g **B** 80 g **C** 120 g **D** 160 g

27. Sodium peroxide, Na_2O_2, is used to absorb carbon dioxide from the atmosphere and release oxygen in closed environments such as space capsules and submarines.
$2Na_2O_2 + 2CO_2 \rightarrow 2Na_2CO_3 + O_2$
Which mass of sodium peroxide would be required to remove 2.4 dm^3 of carbon dioxide from the atmosphere at room temperature and pressure?
A 2.4 g *B* 3.9 g *C* 7.8 g *D* 15.6 g

28. An excess of zinc reacts with *x* cm^3 of 2.00 mol dm^{-3} hydrochloric acid.
The gas produced is dried and collected.
The gas occupies 1.534 dm^3 at 101 000 Pa and 293 K.
The gas produced behaves as an ideal gas.
What is the value of *x*?

A 31.8 cm^3 **B** 34.7 cm^3 **C** 63.6 cm^3 **D** 69.4 cm^3

17. Potassium can form a superoxide $KO_2(s)$, which will react with $CO_2(g)$, to produce potassium carbonate, $K_2CO_3(s)$ and oxygen $O_2(g)$.
Calculate the volume, in dm^3, of carbon dioxide which will react with 5.00 g of the superoxide. Give your answer to 3 significant figures. (Ans = 0.840 dm^3)

18. 3 g of copper(II) carbonate reacts with hydrochloric acid at room temperature and pressure. One of the products is a gas.
Calculate the volume, in cm^3, of the gas produced. (ans = 583)

19. (i) The concentration of NaClO in bleach *S* is x gdm^{-3}.
NaClO reacts with $H_2O_2(aq)$ as shown.
$H_2O_2(aq) + NaClO(aq) \rightarrow H_2O(l) + NaCl(aq) + O_2(g)$
A 5.00cm^3 sample of *S* completely reacts with $H_2O_2(aq)$. The volume of $O_2(g)$ produced is 24.0cm^3 under room conditions.
Assume that only the NaClO in *S* reacts with $H_2O_2(aq)$.
Calculate x. Show your working. (ans = 14.9 g dm^{-3}) [3]
(ii) A sample of bleach **W** contains an unknown concentration of sodium chlorate(I).
10.0 cm^3 of **W** is diluted with distilled water to make a total volume of 100 cm^3 of bleach solution. 25.0 cm^3 of this diluted bleach solution is added to an excess of hydrogen peroxide and the volume of gas produced measured under room conditions.
The experiment is repeated and on average 25.0 cm^3 of diluted bleach solution produces 42.0 cm^3 of gas.
Calculate the concentration, in gdm^{-3}, of sodium chlorate(*I*) in **W**.
concentration of NaClO in **W** = ... gdm^{-3} (ans = 52.15) [3]

29. A volume of nitrogen gas, 2.00 dm^3 measured under standard conditions, was reacted with a large volume of hydrogen gas, to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.
What mass of ammonia was made?
a. 2.83 b. 1.42 c. 0.455 d. 0.213

30. 1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, under room conditions, to form an oxide which contains O^{2-} ions.
What could be the identity of this metallic element?
A calcium B magnesium C potassium D sodium

20. The nitric acid made in stage 3 can then be reacted with ammonia to form ammonium nitrate.
Stage 3 $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$
$NH_3 + HNO_3 \rightarrow NH_4NO_3$
Calculate the volume of nitrogen dioxide, measured at room temperature and pressure, required to make 40 tonnes of ammonium nitrate.
[1 tonne = 1000 kg]
Show your working. (ans = 3.6 x 10^7 dm^3) [3]

31. A mixture of 10 cm^3 of methane and 10 cm^3 of ethane was sparked with an excess of oxygen. After cooling, the residual gas was passed through aqueous potassium hydroxide.
All gas volumes were measured at the same temperature and pressure.
Which volume of gas was absorbed by the alkali?
A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 40 cm^3

32. A 0.216 g sample of aluminium carbide reacts with an excess of water to produce methane gas.
This is the only carbon-containing product formed in the reaction. This methane gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 produced at room temperature and pressure is 108 cm^3.
What is the formula of aluminium carbide?
A Al_2C_3 **B** Al_3C_2 **C** Al_3C_4 **D** Al_4C_3

Limiting reactant and excess reagent

Reactants, Products and Leftovers (colorado.edu)
↑ Simulations to visualize the concept of limiting reactant and excess reagent.

www.youtube.com/watch?v=MuzOmFhiE8o

21. 11.93 g of copper (II) oxide is reacted with 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.
i) Calculate the number of moles of copper (II) oxide and hydrochloric acid. 1
ii) Explain which chemical is the limiting reagent. 1

33. A 3.0 g sample of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HCl. The volume of CO_2 produced is 600 cm^3.
$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$ [Mr: Na_2CO_3, 106.0]
Which volume of CO_2 is produced if 1.0 g of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HCl under the same conditions?
A 600 cm^3 B 452 cm^3 C 226 cm^3 D 200 cm^3

22. The compound As_2S_3 is a common mineral.
When As_2S_3 is heated strongly in air, it forms a mixture of products, as shown.
$2As_2S_3(s) + 9O_2(g) \rightarrow As_4O_6(s) + 6SO_2(g)$
(i) A sample containing 0.198g As_2S_3 is placed in 0.100dm^3 of pure oxygen, an excess, in a reaction chamber connected to a gas syringe at room temperature.
The reactants are heated until no further change is observed. The products are then allowed to cool to room temperature.
Calculate the volume, in dm^3, of gas present at the end of the experiment.
The molar volume of gas is 24.0 dm^3mol^{-1} under these conditions. Assume that the pressure is constant throughout the experiment.
Show your working. [4]

23. The reaction of nitrous oxide gas, N_2O (g), with carbondisulfide vapour, CS_2 (g), is an example of a chemical luminescence reaction producing a flame with a bright blue light.
$2N_2O\ (g) + CS_2\ (g) \rightarrow 2S(s) + 2N_2(g) + CO_2(g)$
The brightness of the light produced was a reason why this reaction was once used in low-light photography.
A measuring cylinder containing 100 cm^3 of nitrous oxide is used in a demonstration of the reaction between nitrous oxide and carbon disulfide.
i) Calculate the number of moles of nitrous oxide in the measuring cylinder. 1
ii) Calculate the minimum number of carbon disulfide molecules required to react with the nitrous oxide at room temperature. 2
In a second demonstration, 10.8 dm^3 of nitrous oxide is reacted with 5.6 dm^3 of carbon disulfide vapour.
i) Explain which reagent is in excess. Show your working. 2
ii) Calculate the maximum mass of sulfur that will be produced from this demonstration. 1

34. A 3.7 g sample of copper(II) carbonate is added to 25cm^3 of 2.0 moldm^{-3} hydrochloric acid.
Which volume of gas is produced at room conditions?
A 0.60 dm^3 B 0.72 dm^3 C 1.20 dm^3 D 2.40 dm^3

35. Crystals of copper(II) nitrate are prepared by adding an excess of malachite to nitric acid.
The formula of malachite is $Cu(OH)_2 \bullet CuCO_3$. (Mr = 221.0)
12.0 g of malachite is added to 30.0 cm^3 of 1.50 mol dm^{-3} nitric acid.
Which mass of malachite is left unreacted when the reaction is complete?

A 2.05 g B 2.49 g C 7.03 g D 9.51 g

36. Methane and steam react to produce hydrogen.
$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$
0.80 g of methane and 1.35 g of steam react. One of the reactants is used up.
Which volume of hydrogen, measured at room conditions, will be produced?

A 1.80 dm^3 B 3.60 dm^3 C 4.80 dm^3 D 7.20 dm^3

Deducing stoichiometry from titration data

24. 25.0 cm^3 of a 0.0500 mol dm^{-3} solution of a metal hydroxide was titrated against a solution of 0.200 mol dm^{-3} hydrochloric acid. It required 12.50 cm^3 of hydrochloric acid to exactly neutralise the metal hydroxide. Deduce the stoichiometry of this reaction.

25. 20.0 cm^3 of a metal hydroxide of concentration 0.0600 mol dm^{-3} was titrated with 0.100 mol dm^{-3} hydrochloric acid. It required 24.00 cm^3 of hydrochloric acid to exactly neutralise the metal hydroxide.
    A. Calculate the number of moles of metal hydroxide used.
    B. Calculate the number of moles of hydrochloric acid used.
    C. What is the simplest mole ratio of metal hydroxide to hydrochloric acid?
    D. Write a balanced equation for this reaction using your answers to parts a, b and c to help you. Use the symbol M for the metal.

26. Compound X, an anhydrous Group 2 bromide, is dissolved in water and titrated against aqueous silver nitrate. A solution containing 0.250g of X requires 33.65cm^3 of 0.0500 moldm^{-3} $AgNO_3(aq)$ for complete reaction. Identify X.
Show your working. [3]

Gas Volumes and Stoichiometry

27. 50 cm^3 of a gaseous hydride of phosphorus, PH_n reacts with exactly 150 cm^3 of chlorine, Cl_2, to form liquid phosphorus trichloride and 150 cm^3 of hydrogen chloride gas, HCl.
    a. How many moles of chlorine react with 1 mole of the gaseous hydride?
    b. Deduce the formula of the phosphorus hydride.
    c. Write a balanced equation for the reaction.

37. The carbonate of an s-block element is reacted with an excess of hydrochloric acid.
0.833 g of the carbonate releases 200 cm^3 of gas, measured under room conditions.
What is the identity of the metal carbonate?
A Na_2CO_3 **B** K_2CO_3 **C** $MgCO_3$ **D** $CaCO_3$

*****This is not a complete note. It is to guide you. It is recommended to study the prescribed textbooks along with this material. *****