Moles & Stoichiometry: Theory Questions

Question 1

(e) Ammonia is used to make fertilisers such as ammonium phosphate, $(NH_4)_3PO_4$.
Calculate the percentage by mass of nitrogen in ammonium phosphate.

[2]

w/14/qp22

(e) Hydrogen cyanide, HCN, is manufactured by reacting methane with ammonia and oxygen.

$$2CH_4 + 2NH_3 + 3O_2 \rightarrow 2HCN + 6H_2O$$

(i) Calculate the mass of hydrogen cyanide that can be formed from 500 g of methane if the percentage yield of hydrogen cyanide is 65%.

mass = ...g [2]

(ii) Hydrogen cyanide reacts with calcium hydroxide to form calcium cyanide and water.
The formula of the cyanide ion is CN^-.

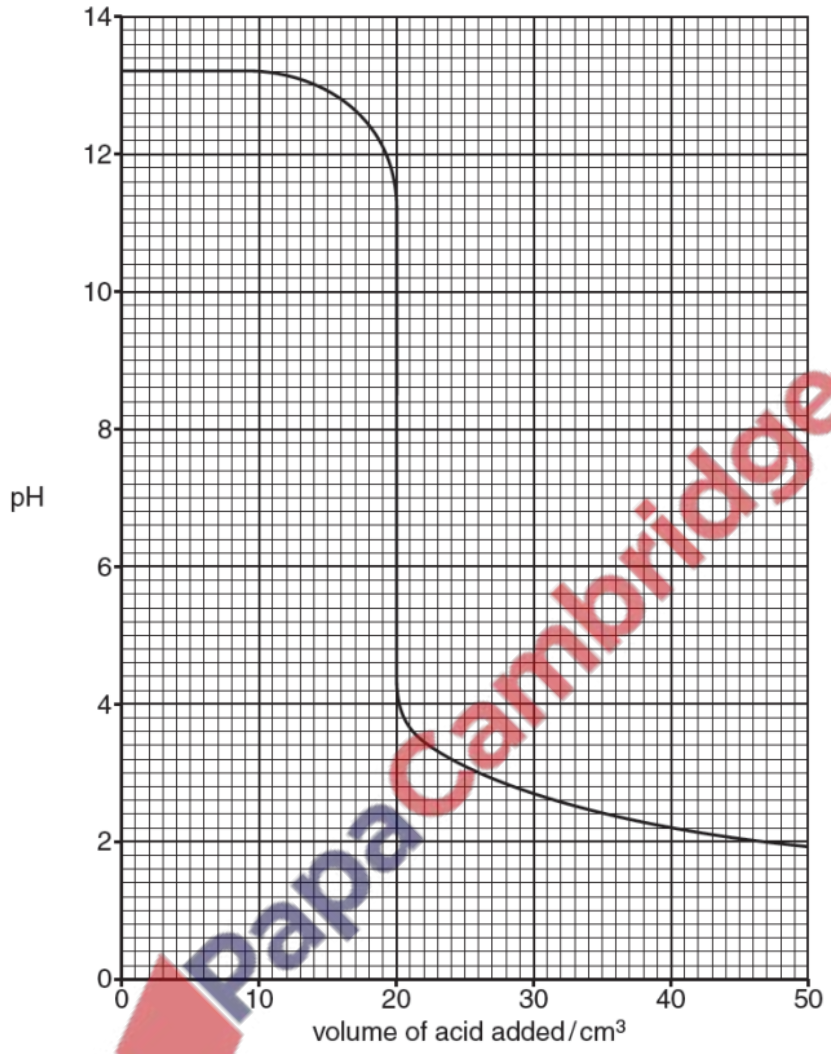
Construct the equation for this reaction.

.....[1]

w/14/qp22

Question 3

(b) The graph below shows how the pH changes when aqueous sulfuric acid is added slowly to 45.0 cm^3 of 0.150 mol/dm^3 sodium hydroxide until the acid is in excess.



(i) What volume of acid has been added when the pH is 7?

.....[1]

(ii) Use your answer to part **(i)** to calculate the concentration, in mol/dm^3, of the sulfuric acid.

concentration = ... mol/dm^3 [3]

w/14/qp22

Question 4

(b) Magnesium chloride, $MgCl_2$, is present in seawater at a concentration of 1.26 g/dm^3.

(i) Write the formulae for the ions present in magnesium chloride.

.....[1]

(ii) Calculate the concentration of chloride ions, in mol/dm^3, arising from the magnesium chloride in seawater.

concentration = ... mol/dm^3 [1]

(iii) Aqueous silver nitrate is added to a small sample of seawater.
Describe what you would observe.

.....[1]

w/14/qp22

Question 5

(c) Sulfuric acid is used to make superphosphate fertilisers. A mixture of the fertiliser and calcium sulfate is formed. This mixture is used by farmers.

$$Ca_3(PO_4)_2 + 2H_2SO_4 \rightarrow \underset{\text{calcium superphosphate}}{Ca(H_2PO_4)_2} + 2CaSO_4$$

(i) Calculate the percentage by mass of calcium sulfate in the mixture of calcium superphosphate and calcium sulfate.
(The relative formula mass of calcium superphosphate is 234.)

w/14/qp21 ..... % [2]

Question 6

(e) The compound used to make the monomer of the silicone fluid has the following composition by mass.

C = 18.6 g, Cl = 55.0 g, H = 4.65 g, Si = 21.7 g

Deduce the empirical formula of this compound.

w/14/qp21 empirical formula .....[2]

Question 7

A5 A student titrates 20.0 cm^3 of a metal hydroxide, $M(OH)_2$, of concentration 0.060 mol/dm^3 with a strong acid of concentration 0.050 mol/dm^3.
It requires 24.0 cm^3 of acid to neutralise the metal hydroxide.

(a) (i) Calculate the number of moles of acid in 24.0 cm^3 of the acid.

..... moles [1]

(ii) Calculate the number of moles of OH^- ions in 20.0 cm^3 of the metal hydroxide.

..... moles [1]

(iii) Deduce whether the acid used is more likely to be hydrochloric acid or sulfuric acid.
Explain your answer.

.....

.....[1]

w/14/qp21

Question 8

(d) A student titrated 10.0 cm^3 of aqueous calcium hydroxide with hydrochloric acid.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

It required 4.00 cm^3 of 0.0100 mol/dm^3 hydrochloric acid to neutralise 10.0 cm^3 of aqueous calcium hydroxide.

Calculate the concentration of the calcium hydroxide.

w/13/qp22

..... mol/ dm^3 [3]

Question 9

(d) Ethanol can be manufactured by the catalytic addition of steam to ethene.

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

If the reactants are not recycled, only 5% of the ethene is converted to ethanol.

Calculate the mass of ethanol formed from 0.4 tonnes of ethene when only 5% of the ethene is converted to ethanol.
[1 tonne is 1 000 000 grams]

mass of ethanol ..... tonnes [3]

w/13/qp22

Question 10

(c) Magnesium reacts with carbon to form the compound magnesium carbide.

Calculate the percentage by mass of magnesium in magnesium carbide, MgC_2.

[2]

w/13/qp22

B9 **(a)** Define the term *relative atomic mass*.

.....

..... [1]

(b) The relative atomic mass of magnesium can be determined in the laboratory by finding the volume of hydrogen given off when magnesium reacts with hydrochloric acid.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

0.036 g of magnesium reacts at room temperature and pressure with excess hydrochloric acid to produce 36 cm^3 of hydrogen.
1 mole of any gas at room temperature and pressure occupies 24 dm^3.
Show by calculation that the relative atomic mass of magnesium is 24.

[3]

(c) Magnesium reacts with oxygen in the air to form magnesium oxide.

$$2Mg + O_2 \longrightarrow 2MgO$$

(i) If the yield of the reaction is 75% calculate the mass of magnesium oxide formed when 12 kg of magnesium burns in excess air.

[2]

(ii) Magnesium nitride is also formed when magnesium burns in air.
Magnesium nitride is an ionic compound.
Deduce the formula for magnesium nitride.

w/12/qp21 ..... [1]

(c) Sulfuric acid is formed from sulfur trioxide in two stages.
Firstly, the sulfur trioxide, SO_3, is absorbed in concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

The oleum is then mixed with water to form sulfuric acid.
Construct an equation for this reaction.

[1]

(d) Aqueous sulfuric acid is titrated with aqueous sodium hydroxide.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

It requires 28.0 cm^3 of 0.100 mol/dm^3 aqueous sodium hydroxide to neutralise 9.50 cm^3 of sulfuric acid.
Calculate the concentration, in mol/dm^3, of the aqueous sulfuric acid.
Give your answer to 3 significant figures.

concentration of the aqueous sulfuric acid ..... mol/dm^3 [3]

Question 13

(c) Ammonium nitrate, NH_4NO_3, and ammonium sulfate, $(NH_4)_2SO_4$, are commonly used in fertilisers.

(i) Calculate the percentage of nitrogen by mass in ammonium nitrate.

[3]

w/12/qp22

Question 14

(c) Chlorine reacts with cold dilute sodium hydroxide to form sodium chlorate(I), NaC*l*O, sodium chloride and water.
Construct an equation for this reaction.

[1]

(d) The concentration of sodium chlorate(I) in a solution can be found by reacting sodium chlorate(I) with excess acidified potassium iodide and then titrating the iodine liberated with aqueous sodium thiosulfate, $Na_2S_2O_3$.

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$

A solution of sodium thiosulfate contains 12.4 g of sodium thiosulfate, $Na_2S_2O_3.5H_2O$, in 1.00 dm^3 of solution.

(i) Calculate the concentration of the sodium thiosulfate solution in mol / dm^3.

concentration = ... mol / dm^3 [1]

(ii) 23.6 cm^3 of this sodium thiosulfate solution reacts with exactly 12.5 cm^3 of aqueous iodine.
Calculate the concentration, in mol / dm^3, of the aqueous iodine.

[3]

(b) Nickel carbonyl has the formula $Ni(CO)_x$.
The relative molecular mass of nickel carbonyl is 171.
Calculate the value of x.

value of x = ...[1]

Question 15

(iii) The composition by mass of ethanal is C 54.5%, H 9.1%, O 36.4%.
Calculate the empirical formula of ethanal.

[2]

w/12/qp22

Question 16

(c) Carboxylic acid **X** contains 55.8% carbon, 7.0% hydrogen and 37.2% oxygen.

(i) Calculate the empirical formula of **X**.

[2]

(ii) A molecule of carboxylic acid **X** contains four carbon atoms. What is its molecular formula?

..... [1]

(iii) Carboxylic acid **X** is an unsaturated compound.
Give a test for an unsaturated compound.

test .....

observation ..... [2]

w/11/qp22 [Total: 10]

Question 17

(ii) A student reacts 3.0 g of magnesium with 2.5 mol / dm^3 sulfuric acid.
Calculate the minimum volume of sulfuric acid that reacts with all the magnesium.

[2]

Question 18

(ii) Another compound of bromine and fluorine is bromine(V) fluoride, BrF_5.
Calculate the percentage of bromine by mass in bromine(V) fluoride.

[2]

w/11/qp22

Question 19

(d) A student ignites a mixture of 15 cm^3 of propane and 100 cm^3 of oxygen. The oxygen is in excess. All measurements of volume are taken at room temperature and pressure.

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

Calculate

the volume of carbon dioxide formed,

..... cm^3 [1]

the volume of unreacted oxygen remaining.

.....cm^3 [1]

(e) Explain why the **incomplete** combustion of an alkane in an enclosed space is hazardous.

.....

..... [2]

w/11/qp22

Question 20

B9 Hydrogen fluoride, hydrogen chloride and hydrogen iodide are all acidic gases.

(a) A student makes hydrogen chloride by reacting sodium chloride with excess concentrated sulfuric acid at room temperature and pressure.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

(i) Calculate the maximum volume of hydrogen chloride that can be made from 0.2 moles of sodium chloride at room temperature and pressure.

[1]

(ii) Draw a 'dot-and-cross' diagram for hydrogen chloride.
Show only the outer electrons.

[1]

w/11/qp21

Question 21

(b) The student uses 25.0 cm^3 of 1.60 mol/dm^3 sodium hydroxide to prepare the crystals.

$$2NaOH(aq) + H_2SO_4(aq) + 8H_2O(l) \longrightarrow Na_2SO_4.10H_2O(s)$$

Calculate the maximum mass of hydrated sodium sulfate crystals that can be formed.

[4]

(c) When hydrated sodium sulfate crystals are heated gently, water is given off.

Describe a chemical test for water.

test .....

observation ..... [2]

w/11/qp21

Question 22

B9 Methanol, CH_3OH, is manufactured from carbon dioxide and hydrogen.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \quad \Delta H = -49\,kJ/mol$$

(c) In the reaction when 3.0 moles of hydrogen react, 49 kJ of heat energy is released.

Calculate how much heat energy is released when 500 kg of hydrogen react.

heat energy = ... kJ [2]

w/12/qp22

Question 23

(c) A hydrogen-oxygen fuel cell uses 2000 dm^3 of hydrogen measured at room temperature and pressure.
Calculate the volume of oxygen, measured at room temperature and pressure, used by the fuel cell.
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

.....

.....

.....

volume of oxygen = ... dm^3 [2]

w/12/qp22

Question 24

A2 Small pieces of a silver coloured metal, **X**, were added to concentrated nitric acid. A brown gas, **Z**, and a colourless solution containing salt **Y** were formed.

Analysis of a 0.0914 mol sample of **Z** showed it contained 1.28 g of nitrogen and 2.93 g of oxygen.

The small sample of the colourless solution was diluted with water and then divided into two portions.

- To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess sodium hydroxide.
- To the other portion, aqueous ammonia was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess ammonia.

(a) (i) Name the white precipitate, **W**.

..... [1]

(ii) Construct the ionic equation, with state symbols, for the formation of **W**.

..... [2]

(b) Name **X** and **Y**.

X is .....

Y is ..... [2]

(c) (i) Calculate the relative formula mass, M_r, for gas **Z**.

M_r = ... [2]

(ii) Determine the molecular formula for **Z**.

molecular formula is ..... [2]

[Total: 9]

w/12/qp22

Question 25

B9 Hydrogen has many industrial uses. One possible way to manufacture hydrogen involves the reversible reaction between methane and steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +210\,kJ/mol$$

The reaction is carried out in the presence of a nickel catalyst. The conditions used are 30 atmospheres pressure and a temperature of 750 °C.

(d) In the reaction, 210 kJ of heat energy is used to form 3.0 moles of hydrogen.

Calculate how much heat energy is needed to make 1000 kg of hydrogen.

heat energy = ... kJ [2]

s/12/qp21

Question 26

(d) The overall reaction for the electrolysis of aqueous sodium hydroxide is shown below.

$$2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$$

This reaction is endothermic.

(i) Explain, in terms of the energy changes associated with bond breaking and bond forming, why the reaction is endothermic.

.....

.....

.....

..... [2]

(ii) Some submarines use this reaction to provide oxygen for the occupants to breathe.

Calculate the mass of water which must be electrolysed to make 2500 dm^3 of oxygen at room temperature and pressure.
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

mass of water = ... g [3]

s/12/qp21

Question 27

B6 Seawater contains many dissolved ions. The table shows the concentration of some of these ions in a typical sample of seawater.

ion	formula	concentration / g / dm^3
chloride	Cl^-	19.00
sodium	Na^+	10.56
sulfate	SO_4^{2-}	2.65
magnesium	Mg^{2+}	1.26
calcium	Ca^{2+}	0.40
potassium	K^+	0.38
hydrogencarbonate	HCO_3^-	0.14

(a) Suggest the formula of one salt dissolved in seawater.

..... [1]

(b) Calculate the concentration, in mol / dm^3, of sulfate ions in seawater.

.....

.....

..... [1]

(c) Excess aqueous silver nitrate is added to a 25.0 cm^3 sample of seawater.
What mass of silver chloride is precipitated in this reaction?

$$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$$

.....

.....

.....

.....

..... [3]

s/12/qp21

Question 28

(e) Molybdenum, atomic number 42, is manufactured by the displacement reaction between molybdenum(VI) oxide and aluminium.

$$MoO_3 + 2Al \longrightarrow Mo + Al_2O_3$$

Calculate the mass of aluminium needed to make 1 tonne of molybdenum.
[1 tonne is one million grams.]

mass of aluminium = ... [2]

s/12/qp21

Question 29

(e) Solid zinc chloride absorbs ammonia to form tetrammine zinc chloride, $Zn(NH_3)_4Cl_2$.

$$ZnCl_2 + 4NH_3 \longrightarrow Zn(NH_3)_4Cl_2$$

Calculate the maximum yield, in grams, of tetrammine zinc chloride formed when 3.4 g of zinc chloride reacts with excess ammonia.

[2]

w/10/qp22

Question 30

(e) An aqueous solution of calcium hydroxide was titrated with 0.0150 mol / dm^3 hydrochloric acid.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

It required 6.00 cm^3 of this aqueous hydrochloric acid to neutralise 20.0 cm^3 of the calcium hydroxide solution.
Calculate the concentration, in mol / dm^3, of the calcium hydroxide solution.

[3]

w/10/qp22

Question 31

B9 Phosphine, PH_3, is a gas which has a smell of garlic. It is formed when white phosphorus is warmed with aqueous sodium hydroxide.

$$4P + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2$$

(a) Draw a 'dot-and-cross' diagram for phosphine.

Show only the outer electrons.

[1]

(b) **(i)** Calculate the maximum mass of phosphine formed when 1.86 g of phosphorus reacts with excess aqueous sodium hydroxide.

[2]

(ii) Calculate the volume of phosphine formed from 1.86 g of phosphorus at r.t.p.

[1]

(c) Phosphine decomposes into its elements on warming. Write an equation for this reaction.

.....[2]

w/10/qp21

Question 32

(b) Analysis of 21.25 g of gallic acid showed that it contained 10.50 g of carbon, 0.75 g of hydrogen and 10.00 g of oxygen.

Show that the empirical formula of gallic acid is $C_7H_6O_5$.

[3]

w/10/qp21

Question 33

(b) A solution of fumaric acid was titrated against aqueous sodium hydroxide.

$$HO_2CCH{=}CHCO_2H + 2NaOH \rightarrow NaO_2CCH{=}CHCO_2Na + 2H_2O$$

18.0 cm^3 of 0.200 mol/dm^3 sodium hydroxide were required to neutralise 60.0 cm^3 of fumaric acid solution.
Calculate the concentration, in mol/dm^3, of the fumaric acid solution.

.....

.....

.....

.....

.....

..... [3]

w/09/qp2

Question 34

(d) Methylamine is made by reacting methanol with excess ammonia under pressure in the presence of a catalyst.

$$CH_3OH + NH_3 \rightarrow CH_3NH_2 + H_2O$$

(i) Define the term *catalyst*.

.....[1]

(ii) Calculate the theoretical yield of methylamine that can be obtained from 240 kg of methanol.

[2]

w/08/qp2

Question 35

(d) A small amount of xenon is present in the air. Several compounds of xenon have been made in recent years.
A compound of xenon contained 9.825 g of xenon, 1.200 g of oxygen and 5.700 g of fluorine.
Determine the empirical formula of this compound.

[3]

w/08/qp2

Question 36

(c) Analysis of 10.0 g of carboxylic acid **X** shows that it contains 2.67 g carbon, 0.220 g hydrogen and 7.11 g oxygen.

(i) Deduce the empirical formula of **X**. [3]

(ii) The relative molecular mass of **X** is 90. Deduce the molecular formula of **X**. [1]

w/08/qp2

Question 37

(iii) 25.0 cm^3 of an aqueous solution of calcium hydroxide is exactly neutralised by 18.0 cm^3 of 0.040 mol/dm^3 hydrochloric acid.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

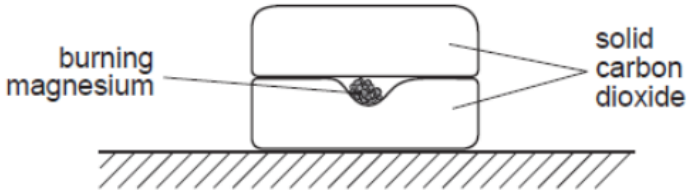
Calculate the concentration, in mol/dm^3, of the aqueous calcium hydroxide.

concentration = ...mol/dm^3 [3]

w/08/qp2

Question 38

A2 Several small pieces of magnesium are placed on a block of solid carbon dioxide. The solid carbon dioxide is at a temperature of -60 °C. The magnesium is ignited and another block of solid carbon dioxide is immediately placed on top.



A vigorous reaction is observed.

$$2Mg + CO_2 \rightarrow 2MgO + C$$

(a) Suggest what could be seen as the reaction proceeds to completion.

.....

..... [2]

(b) Why is another block of solid carbon dioxide placed above the burning magnesium?

..... [1]

(c) State **one** factor in the experiment which slows down the reaction.

..... [1]

(d) When 2 moles of magnesium react with one mole of carbon dioxide, 810 kJ of energy are released.
Calculate the energy released when 2.0 g of magnesium reacts completely with carbon dioxide.

[2]

(e) In a second experiment 6.0 g of magnesium and 4.4 g of carbon dioxide are used. Which solid, magnesium or carbon dioxide is in excess?
Show your working.

[2]

w/08/qp2

Question 39

(c) Magnesium reacts with propanoic acid to form magnesium propanoate and hydrogen.

$$Mg + 2C_2H_5CO_2H \rightarrow (C_2H_5CO_2)_2Mg + H_2$$

A student added 4.80 g of magnesium to 30.0 g of propanoic acid.

(i) Which one of these reactants, magnesium or propanoic acid, is in excess?
Explain your answer. [2]

(ii) Calculate both the number of moles of hydrogen and the volume of hydrogen formed at r.t.p. [2]

w/07/qp2

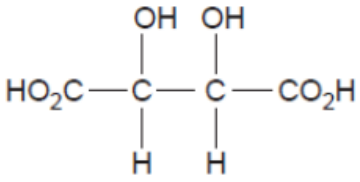
Question 40

(c) Carbon monoxide reacts with nickel to form a compound containing nickel, carbon and oxygen only. Analysis of 5.70 g of this compound showed that it contained 1.97 g nickel, 1.60 g carbon and 2.13 g oxygen.
Determine the empirical formula of this compound. [3]

w/07/qp2

Question 41

(b) Tartaric acid can also be extracted from grape juice.
The structure of tartaric acid is shown below.



(i) Deduce the empirical formula of tartaric acid.

.....[1]

(ii) A solution of tartaric acid was titrated with 0.100 mol/dm^3 potassium hydroxide.

$$C_2H_2(OH)_2(CO_2H)_2 + 2KOH \rightarrow C_2H_2(OH)_2(CO_2K)_2 + 2H_2O$$

tartaric acid

It required 6.00 cm^3 of the potassium hydroxide solution to neutralise 20.0 cm^3 of tartaric acid. Calculate the concentration, in mol/dm^3, of the tartaric acid solution.

.....mol/dm^3 [3]

(iii) Tartaric acid is purified by recrystallisation.
On analysis, 8.00 g of impure tartaric acid was found to contain 7.40 g of pure tartaric acid. Calculate the percentage purity of the impure tartaric acid.

.....% [1]

Question 42

(c) Butanoic acid can be converted into an ester by heating it with an alcohol and a few drops of concentrated sulphuric acid.

A sample of an ester contains 0.18 g of carbon, 0.03 g of hydrogen and 0.08 g of oxygen. The relative molecular mass of the ester is 116.
Calculate both the empirical and molecular formulae of this ester. [3]

w/06/qp2

Question 43

(d) 12.0 cm^3 of an aqueous solution of sulphuric acid exactly neutralised 20.0 cm^3 of a solution of sodium hydroxide of concentration 0.150 mol/dm^3.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration, in mol/dm^3 of the aqueous sulphuric acid. [3]

w/06/qp2

Question 44

(d) Fertilisers are added to the soil to improve crop yields.
A farmer has the choice of two fertilisers, ammonium nitrate, NH_4NO_3, or diammonium hydrogen phosphate, $(NH_4)_2HPO_4$.

Show by calculation which of these fertilisers contains the greater percentage of nitrogen by mass.
You must show your working. [3]

w/06/qp2

Question 45

(iii) Calculate the percentage of copper by mass in Cu_2O.

[5]

w/05/qp2

Question 46

5 An experiment was carried out to measure the rate of reaction between excess powdered calcium carbonate and dilute acids.

(a) In **Experiment 1**, 25 cm^3 of 1.5 mol/dm^3 hydrochloric acid was used.

Complete the equation for the reaction by filling in the missing state symbols.

(i) $2HCl(\ldots\ldots) + CaCO_3(\ldots\ldots) \rightarrow CaCl_2(aq) + H_2O\ (\ldots\ldots) + CO_2(\ldots\ldots)$

(ii) Calculate the total volume of carbon dioxide that is made from this reaction at r.t.p.

[4]

w/05/qp2

Question 47

(b) Calculate the maximum volume of carbon dioxide, at room temperature and pressure, that can be formed from 10.5 g of magnesium carbonate. [3]

(c) The experiment was repeated under the same conditions using zinc carbonate instead of magnesium carbonate.

(i) Describe how the rates of the reactions would be different. Explain your answer.

(ii) The same mass (10.5 g) of zinc carbonate was used. Would the total volume of carbon dioxide formed be the same? Explain your answer. [4]

w/04/qp2

Question 48

(b) Ammonium sulphate can be made by reacting aqueous ammonia with dilute sulphuric acid.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

Calculate the mass of ammonium sulphate that can be made from 51 g ammonia.

.....

.....

..... [3]

.

w/04/qp2

Question 49

Sodium oxide reacts with water to form sodium hydroxide.

(b) Write an equation for this reaction.

.....[1]

(c) 62 g of sodium oxide are used to make 2 dm^3 of aqueous sodium hydroxide.
What is the concentration of the sodium hydroxide solution?

Answer ..... mol/dm^3 [2]

w/03/qp2

Question 50

A3 Liquid Petroleum Gas (LPG) and ethanol can be used as fuels for cars instead of petrol. LPG contains mainly propane. This table shows some information about propane and ethanol.

name	formula	boiling point / °C	physical state at r.t.p.	enthalpy change of combustion / kJ per mole	method of manufacture
ethanol	C_2H_5OH	78	.....	– 1367	fermentation of sugar cane
propane	.....	– 42	.....	– 2220	.... of crude oil

(a) Complete the table by filling in the boxes. [4]

(b) When 1 kg propane burns, 50 450 kJ of energy are given out.
Show by calculation, using data from the table, that ethanol gives out less energy per kg than propane.

[3]

w/03/qp2

Question 51

(b) Chlorine is manufactured by the electrolysis of concentrated sodium chloride.

(i) Write equations for both of the electrode reactions.

(ii) Calculate the maximum volume of chlorine, at r.t.p., which can be obtained from 175.5 kg sodium chloride.

[5]

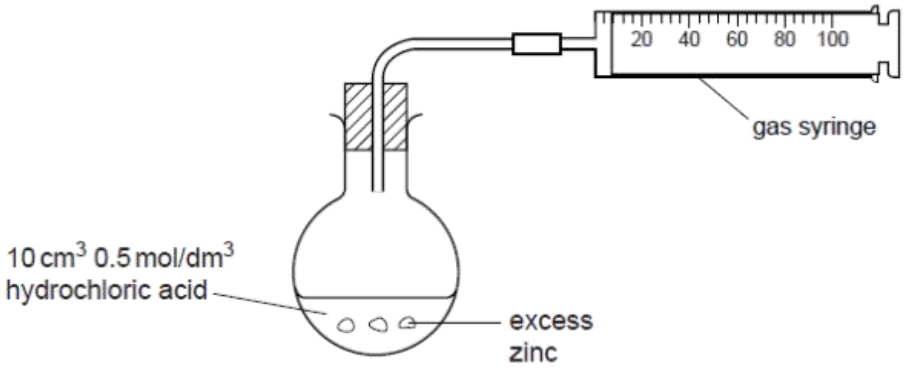
w/01/qp2

Question 52

(c) Ethanol can be used as a fuel.
The enthalpy change of combustion for 1 mole of ethanol is –1367 kJ.
Write an equation for the complete combustion of ethanol.
Calculate the total energy released by the complete combustion of 23 g of ethanol. [3]

Question 53

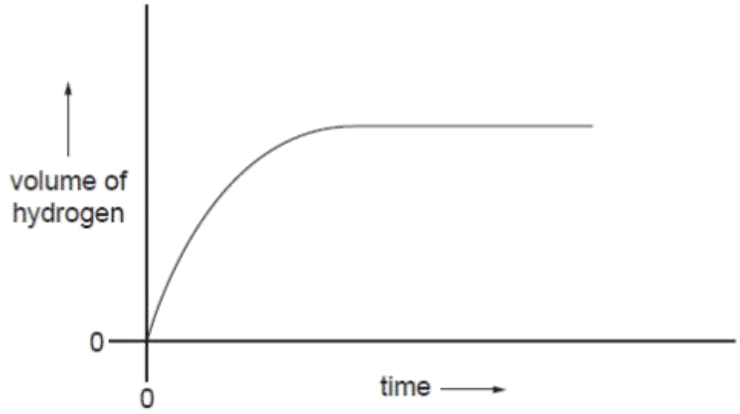
B7 An **excess** of zinc was added to 10 cm^3 of 0.5 mol/dm^3 hydrochloric acid, using the apparatus below.



$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

(a) Calculate the maximum volume of hydrogen which could be produced in the reaction at r.t.p. [3]

This graph shows how the volume of hydrogen changed during the reaction.



(b) **(i)** Describe how the rate of reaction changes as the reaction progresses.

(ii) Suggest a reason for this change. [2]

(c) The experiment was repeated using dilute sulphuric acid of the same concentration.
Write a balanced equation for the reaction between zinc and sulphuric acid.
Suggest how both the rate of reaction and the total volume of hydrogen obtained would differ from the reaction between zinc and hydrochloric acid.
Explain your reasoning. [5]
[10 marks]

Question 54

(b) Some redox reactions can be used to propel rockets.
The following equations represent redox reactions used to propel rockets.

Reaction **A**

$$N_2H_4(g) + 2H_2O_2(g) \rightarrow N_2(g) + 4H_2O(g)$$

Reaction **B**

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

(i) Use these equations to complete the following table.

reaction	*number of moles of reactants*	*number of moles of products*
A		
B		

(ii) Reactions used to propel rockets need to produce large volumes of gas.
Use the information in the table to suggest why reaction **A** is more likely to be used to propel rockets.

.....

.....

[3]

(c) Explain why gas volumes measured at r.t.p. cannot be used in calculations for gases produced in rocket engines.

.....[1]

w/01/qp2

Question 55

(b) The sulphur dioxide reacts with the calcium carbonate to produce calcium sulphite, $CaSO_3$, and carbon dioxide.

(i) Write an equation for the reaction between calcium carbonate and sulphur dioxide.

(ii) A large coal-fired power station produces 960 tonnes of sulphur dioxide each year.

Calculate the mass of calcium carbonate needed to react with 960 tonnes of sulphur dioxide (1 tonne = 1 x 10^6 g).

[3]

Question 56

Stage 2: the nitrogen dioxide is converted to nitric acid.

$$4NO\,(g) + 2H_2O(g) + 3O_2(g) \rightarrow 4HNO_3(aq)$$

(c) Calculate the maximum mass of nitric acid which can be made from 720 dm^3 of nitrogen(II) oxide, NO, at room temperature and pressure. [3]

(d) Use the two equations to construct an overall equation for the conversion of ammonia to nitric acid. [1]

w/02/qp2

Question 57

(c) Fermentation converts glucose into ethanol, a biofuel.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

(i) State **two** essential conditions for fermentation to take place.

1 .....

2 .....[2]

(ii) Calculate the maximum mass of ethanol that can be made from 1 tonne of glucose.
[One tonne is one million grams.]

maximum mass of ethanol = ... tonne [3]

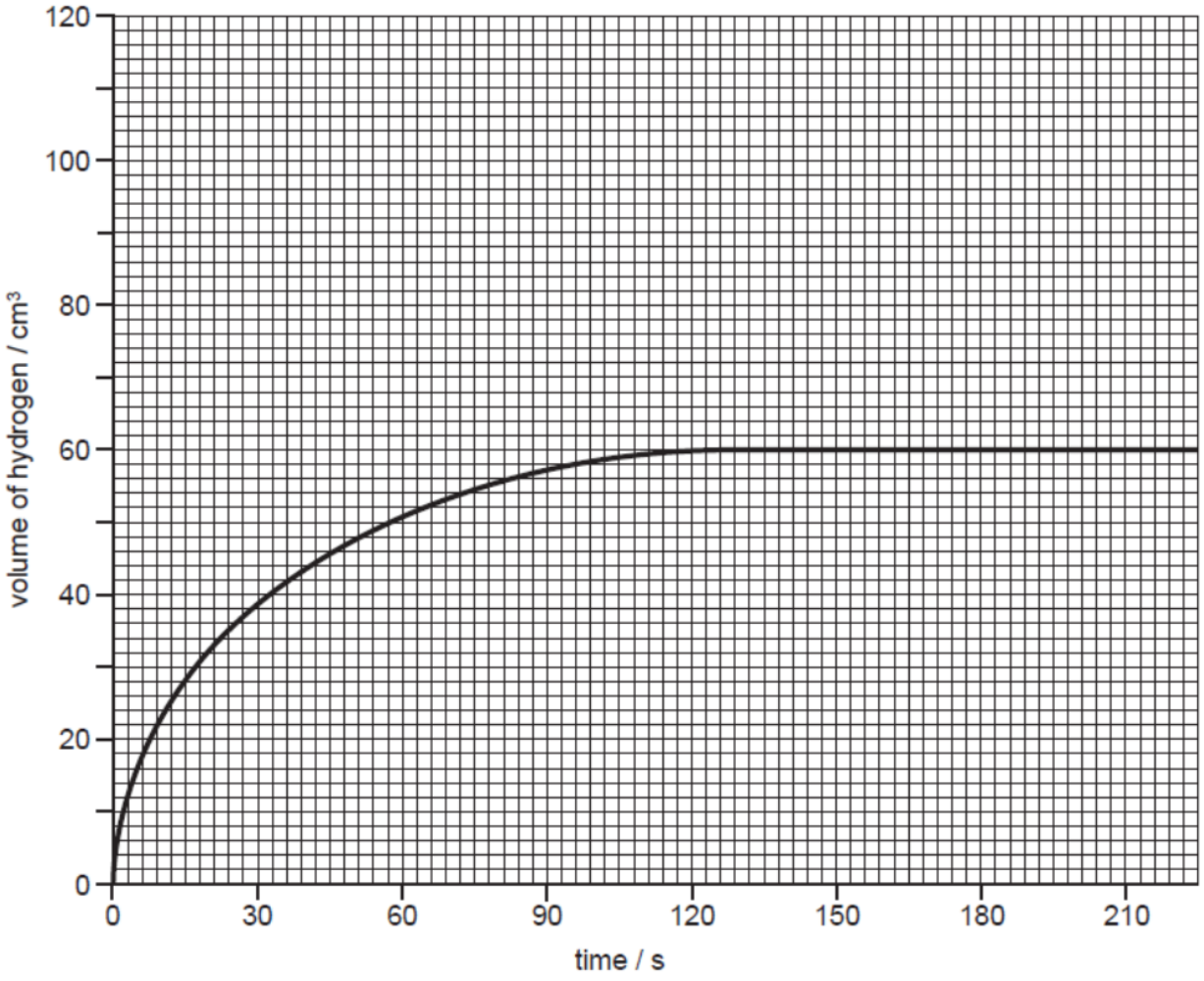
s/11/qp22

Question 58

(c) In an experiment magnesium ribbon is added to 25.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid, an excess.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Every 30 seconds the total volume of hydrogen formed is measured at room temperature and pressure. The results are shown on the grid below.



(i) Use information from the graph to calculate the mass of magnesium ribbon used in the experiment.
[One mole of any gas at room temperature and pressure occupies a volume of 24 000 cm^3.]

mass of magnesium ribbon = ... g [3]

(ii) The experiment was repeated using the same mass of magnesium ribbon but with 25.0 cm^3 of 1.00 mol/dm^3 propanoic acid, an excess.
Draw on the grid a graph of the results for the reaction between magnesium ribbon and propanoic acid.

[2]

s/11/qp22

Question 59

B7 Nitric oxide, NO, is an atmospheric pollutant formed inside car engines by the reaction between nitrogen and oxygen.

$$N_2(g) + O_2(g) \longrightarrow 2NO(g) \quad \Delta H = +66\,kJ\,mol^{-1}$$

This reaction is endothermic.

(c) Calculate the mass of nitric oxide formed when 100 g of nitrogen reacts completely with oxygen.

mass of nitric oxide = ... g [3]

s/11/qp22

Question 60

(d) Farmers that grow vegetable oil crops often use large quantities of ammonium nitrate fertiliser, NH_4NO_3.
Calculate the percentage by mass of nitrogen in ammonium nitrate.

percentage = ... % [2]

s/11/qp22

Question 61

B9 Sulfamic acid, SO_3NH_3, is a weak acid used to remove limescale from kettles.

(a) Explain the meaning of the term *weak acid*?

.....

.....[1]

(b) The pH of an aqueous solution of sulfamic acid can be determined using a pH meter. Describe another way of estimating the pH of a solution of sulfamic acid.

.....

.....

.....[2]

(c) A 0.105 g sample of sulfamic acid is dissolved in 25.0 cm^3 of water. The sulfamic acid solution requires 10.8 cm^3 of 0.100 mol dm^{-3} potassium hydroxide for complete neutralisation.

Calculate the number of moles of sulfamic acid that react with one mole of potassium hydroxide.

number of moles of sulfamic acid = ... [3]

s/11/qp21

Question 62

B8 Ethanoic acid is manufactured by a reaction between methanol, CH_3OH, and carbon monoxide.

$$CH_3OH + CO \rightleftharpoons CH_3COOH \quad \Delta H = -137\,kJ\,mol^{-1}$$

This reaction is exothermic.

(d) In an investigation 10.0 moles of methanol are mixed with 20.0 moles of carbon monoxide.
At the end of the reaction 9.8 moles of ethanoic acid are formed.
Calculate the percentage yield of ethanoic acid.

percentage yield = ... % [2]

s/11/qp21

Question 63

(b) Uranium is manufactured from uranium(IV) oxide, UO_2, in a two-step process.

Step **1** – uranium(IV) oxide is heated with hydrogen fluoride to make uranium(IV) fluoride, UF_4, and water.

Step **2** – uranium(IV) fluoride is reduced by magnesium to give uranium and one other product.

(iv) Calculate the mass of uranium that can be made from 1.00 tonne of uranium(IV) oxide.

[One tonne is one million grams.]

mass of uranium = ... tonnes [3]

s/11/qp21

Question 64

A2 Small pieces of copper were added to excess concentrated sulfuric acid and the mixture heated for 30 minutes. A colourless gas **Z** was formed. When **Z** was tested with filter paper dipped into acidified potassium dichromate(VI), there was a colour change from orange to green.

The reaction mixture was cooled and then diluted with water. A blue solution, **Y**, was formed. Aqueous sodium hydroxide was added drop by drop to the blue solution. Eventually a blue precipitate, **X**, was formed. On heating the blue precipitate turned black to form compound **V**. Analysis of **V** showed that it contained 79.9 % copper and 20.1 % oxygen by mass.

(e) Calculate the empirical formula of the black solid **V**.

empirical formula of **V** is ..... [2]

s/11/qp21

Question 65

B8 One of the reactions in the manufacture of nitric acid involves the oxidation of ammonia. This reaction is exothermic.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -909\,kJ\,mol^{-1}$$

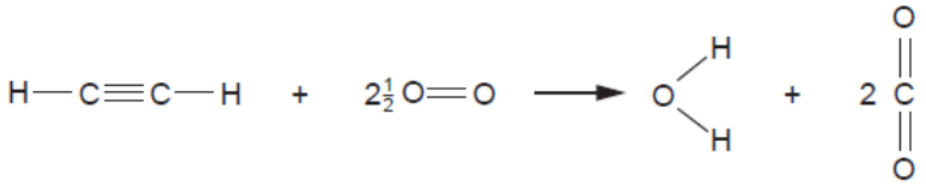
(b) A factory uses 100 tonnes of ammonia each day to produce 160 tonnes of nitrogen monoxide, NO.
Calculate the percentage yield of nitrogen monoxide.

percentage yield = ... % [3]

s/10/qp21

Question 66

(d) Ethyne reacts with oxygen in an exothermic reaction.



(i) Explain why the combustion of ethyne is an exothermic reaction.
Use ideas about the energy changes that take place during bond breaking and bond forming.

.....

.....

.....

..... [2]

(ii) The complete combustion of one mole of ethyne releases 1410 kJ of energy.
Calculate the energy released when 1000 dm^3 of ethyne, measured at room temperature and pressure, is completely combusted.

energy released = ... kJ [2]

s/10/qp21

Question 67

(c) When paraffin burns in a jet engine some nitrogen monoxide, NO, is formed. This is because the high temperature of the engine allows nitrogen to react with oxygen.

Write an equation to describe how nitrogen monoxide is formed in this reaction. Calculate the mass of nitrogen monoxide formed from 55 kg of nitrogen.

.....

.....

.....

.....

mass of nitrogen monoxide = ... kg [3]

(f) Using the information that one mole contains 6.02×10^{23} particles, calculate the number of electrons in one mole of NO molecules.

.....

..... [1]

s/10/qp21

Question 68

A3 Analysis of a compound **Z** obtained from the planet Mars showed **Z** has the following composition.

element	percentage by mass
potassium	39.4
iron	28.3
oxygen	32.3

(a) Show that the empirical formula of **Z** is K_2FeO_4.

.....

.....

.....

.....

..... [2]

(b) K_2FeO_4 can be prepared in the laboratory by the reaction between iron(III) oxide, Fe_2O_3, chlorine, Cl_2, and potassium hydroxide, KOH.

$$Fe_2O_3 + 3Cl_2 + 10KOH \longrightarrow 2K_2FeO_4 + 6KCl + 5H_2O$$

A 2.00 g sample of Fe_2O_3 is added to 20.0 cm^3 of 4.00 mol dm^{-3} KOH.

(i) Calculate the amount, in moles, of Fe_2O_3 used.

.....

..... [2]

(ii) Calculate the amount, in moles, of KOH used.

.....

..... [1]

(iii) Which reagent, Fe_2O_3 or KOH, is in excess in this reaction?

.....

Explain your answer.

.....

..... [1]

Question 69

B10 Fertilisers supply the essential elements, nitrogen, phosphorus and potassium for plant growth.
A bag of fertiliser contains 500 g of ammonium sulfate, $(NH_4)_2SO_4$, and 500 g of potassium nitrate, KNO_3.

(a) Calculate the percentage by mass of nitrogen in the bag of fertiliser.

[4]

s/09/qp2

Question 70

(d) Ethanol can also be manufactured from glucose, $C_6H_{12}O_6$.

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH.$$

A solution containing 18 kg of glucose makes only 0.92 kg of ethanol.
Calculate the percentage yield of ethanol.

[3]

s/09/qp2

Question 71

(b) Octane burns in air.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

A petrol-powered motor car travels at a constant speed of 80 km/h. For every kilometre travelled 108 g of carbon dioxide are formed.

When the motor car travels 100 km calculate

(i) the mass of carbon dioxide emitted by the car,

[1]

(ii) the mass of petrol burned by the car assuming that petrol is 100% octane.

[4]

s/09/qp2

Question 72

A6 The table shows the concentration of different ions found in a sample of aqueous industrial waste.

ion	concentration in mol/dm^3
Ca^{2+}	0.125
H^+	2.30
K^+	0.234
NO_3^-	3.68
Fe^{2+}	0.450

Use the information in the table to answer the following questions.

(a) Write the formula of one salt that could be obtained from the sample.

.....[1]

(b) Is the sample of aqueous waste acidic, neutral or alkaline? Explain your answer.

.....

.....[1]

(c) Calculate the mass of dissolved iron(II) ions, Fe^{2+}, in 25 dm^3 of the aqueous waste.

mass of iron(II) ions = ... g [2]

s/09/qp2

Question 73

(ii) Calculate the percentage by mass of nitrogen in ammonium phosphate.

% by mass = ... [2]

s/10/qp22

Question 74

B9 Hydrogen and iodine react together to form hydrogen iodide in a reversible redox reaction. The forward reaction is endothermic.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +53 \text{ kJ mol}^{-1}$$

Hydrogen and hydrogen iodide are colourless gases whereas iodine gas is purple.

(c) Calculate the maximum mass of hydrogen iodide that can be made from 45.3g of hydrogen.

maximum mass of hydrogen iodide = ... g [3]

s/10/qp22

Question 75

B8 An ester is made from a carboxylic acid and an alcohol.

The carboxylic acid has the molecular formula $C_4H_8O_2$. Analysis of the alcohol shows it has the following percentage composition by mass:
52.2% carbon; 13.0% hydrogen; 34.8% oxygen.

(iii) What is the empirical formula for the carboxylic acid?

..... [1]

(b) Calculate the empirical formula for the alcohol.

.....

.....

.....

.....

..... [2]

s/10/qp2

Question 76

B7 Hydrazine, N_2H_4, is a liquid that has been used as a rocket fuel. It reacts with oxygen as shown in the equation.

$$N_2H_4 + O_2 \longrightarrow N_2 + 2H_2O$$

(c) (i) Calculate the volume of oxygen, measured at room temperature and pressure, needed to completely combust 1.00 tonne of hydrazine.
[One tonne is 10^6 grams. One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

volume of oxygen = ... dm^3 [3]

(ii) A rocket burns hydrazine in an atmosphere of oxygen. Both hydrazine and oxygen are stored in the rocket as liquids. Suggest why oxygen is stored as a liquid rather than as a gas.

.....

..... [1]

s/10/qp22

Question 77

(c) A 1.2 g sample of powdered brass was analysed by reaction with excess dilute sulphuric acid.
The zinc reacts as shown in the equation to form 0.072 dm^3 of hydrogen measured at room temperature and pressure.

$$Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$$

(i) Suggest why brass was used in a powdered rather than lump form. [1]

(ii) Calculate the mass of zinc in the sample of brass. [2]

(iii) Calculate the percentage of zinc in the sample of brass. [1]

s/08/qp2

Question 78

B9 Dilute ethanoic acid and dilute hydrochloric acid both react with magnesium ribbon to form hydrogen.

(a) Give the formula of one ion found in both of these dilute acids. [1]

(b) Magnesium ribbon reacts with hydrochloric acid as shown in the equation.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

A 0.24 g sample of magnesium ribbon is added to 5.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid.

(i) Which reactant, magnesium or hydrochloric acid, is in excess? Use calculations to explain your answer. [2]

(ii) Calculate the maximum mass of magnesium chloride that can be formed in this reaction. [2]

(iii) A 0.24 g sample of magnesium ribbon is added to 5.0 cm^3 of 2.0 mol/dm^3 ethanoic acid.
Explain why this reaction forms the same volume of hydrogen but takes place much more slowly than the reaction of the same mass of magnesium with 5.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid. [3]

(c) **(i)** Write an equation for the reaction between dilute ethanoic acid and sodium carbonate. [1]

(ii) What observations would be made during this reaction? [1]

[Total: 10]

s/08/qp2

Question 79

A2 Iron(II) sulphate, $FeSO_4$, is easily oxidised to iron(III) sulphate.

(a) Calculate the percentage by mass of iron in iron(II) sulphate.

..... % [2]

(e) An impure sample of iron(II) sulphate was analysed by titration.

The sample was dissolved in 25.0 cm^3 of dilute sulphuric acid and then titrated against 0.0400 mol/dm^3 potassium dichromate(VI) solution.

19.0 cm^3 of potassium dichromate(VI) solution was required to reach the end-point.

(i) Calculate the number of moles of potassium dichromate(VI) used in the titration.

..... moles [1]

(ii) One mole of potassium dichromate(VI) reacts with six moles of iron(II) ions. Calculate the mass, in grams, of iron(II) ions in the sample analysed.

mass of iron(II) ions..... g [2]

[Total: 11]

s/08/qp2

Question 80

(d) Ethene can be used to make poly(ethene).

(i) Draw a 'dot-and-cross' diagram for an ethene molecule, C_2H_4. You must draw all of the electrons. [2]

(ii) What is the maximum mass of poly(ethene) that can be made from 28 tonnes of ethene? [1]

s/07/qp2

Question 81

(c) The exhaust system of a motor car is fitted with a catalytic converter. When nitrogen monoxide passes through the converter it reacts with carbon monoxide.

$$2NO(g) + 2CO(g) \longrightarrow N_2(g) + 2CO_2(g)$$

The catalyst increases the rate of this reaction.

(i) Explain how the catalyst in the converter increases the rate of this reaction. [1]

(ii) During the course of a journey 2.4 dm^3 of nitrogen monoxide was produced by the engine. Calculate the volume of nitrogen gas produced if all the nitrogen monoxide reacted in the converter. [1]

(iii) In reality, only 1.0 dm^3 of nitrogen was produced after the gases had passed over the catalytic converter. Calculate the percentage of nitrogen monoxide that had reacted. [2]

s/07/qp2

Question 82

(c) Verdigris has the formula $[Cu(CH_3CO_2)_2]_2.Cu(OH)_2.\mathbf{x}H_2O$.
It has a relative formula mass of 552.
Calculate the value of **x** in the formula.

x is ..... [2]

[Total: 5]

s/07/qp2

Question 83

(d) The nitrates of metallic elements also decompose when heated.
Calcium nitrate decomposes to form calcium oxide, nitrogen dioxide and oxygen.

$$2Ca(NO_3)_2(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

A 0.010 mol sample of calcium nitrate is heated. Calculate the number of moles of gas produced when this sample is completely decomposed.

..... moles [1]

s/07/qp2

Question 84

(d) The mass of iron(II) ions in a sample of fertiliser can be determined by the reaction between iron(II) ions and acidified potassium manganate(VII), $KMnO_4$.

A student analysed a sample of the fertiliser. He dissolved the sample in 25.0 cm^3 of dilute sulphuric acid and titrated the solution formed with 0.0200 mol/dm^3 potassium manganate(VII).

The student used 22.5 cm^3 of potassium manganate(VII) to reach the end-point.

(i) Calculate the number of moles of potassium manganate(VII) used in the titration.

..... moles [1]

(ii) One mole of potassium manganate(VII) reacts with five moles of iron(II) ions.
Calculate the mass, in grams, of iron(II) ions in the sample analysed.

..... g [2]

[Total: 9]

s/07/qp2

Question 85

A2 A fertiliser contains three compounds:

- ammonium sulphate, $(NH_4)_2SO_4$,
- iron(II) sulphate, $FeSO_4$,
- sand, SiO_2.

(a) Calculate the percentage by mass of nitrogen in ammonium sulphate.

..... % [2]

s/07/qp2

Question 86

(c) Potassium sulphate can be prepared by the reaction between dilute sulphuric acid and potassium carbonate.

$$H_2SO_4 + K_2CO_3 \rightarrow K_2SO_4 + CO_2 + H_2O$$

Calculate the mass of potassium sulphate that can be prepared from 3.45 g of potassium carbonate. [3]

s/06/qp2

Question 87

(d) The concentration of dissolved oxygen in river water can be determined by a series of reactions that is summarised by the equation below.

$$2H_2O(l) + O_2(aq) + 4I^-(aq) \rightarrow 4OH^-(aq) + 2I_2(aq)$$

When a 2000 cm^3 sample of river water was tested, 0.508 g of iodine was liberated.

Calculate the concentration, in mol/dm^3, of dissolved oxygen in the river water sample. [3]

s/06/qp2

Question 88

(d) Cement is made by heating calcium carbonate and clay together at a very high temperature.

One of the compounds produced is a form of calcium silicate, Ca_3SiO_5.

In the presence of water a chemical reaction takes place that helps in the setting of cement.

$$2Ca_3SiO_5 + 6H_2O \rightarrow Ca_3Si_2O_7.3H_2O + 3Ca(OH)_2$$

Calculate the mass of calcium hydroxide formed from 912 g of Ca_3SiO_5.

.....

.....

.....

.....

..... [3]

s/06/qp2

Question 89

(e) Magnesium reacts with ethanoic acid to make magnesium ethanoate and hydrogen.

Write the equation for this reaction. Use the equation to calculate the mass of magnesium needed to react completely with 50 cm^3 of 1.0 mol/dm^3 of ethanoic acid.

[3]

s/05/qp2

Question 90

B8 Sunglasses can be made from photochromic glass. When bright light strikes photochromic glass it darkens.

Photochromic glass contains small amounts of silver chloride, AgCl, and copper(I) chloride, CuCl.

In the presence of bright light, silver chloride decomposes into silver atoms which make the glass go dark, and into chlorine atoms.

$$AgCl \rightarrow Ag + Cl$$

Chlorine atoms immediately react with copper(I) chloride to make copper(II) chloride.

$$CuCl + Cl \rightarrow CuCl_2$$

When the exposure to bright light ends, silver atoms reduce copper(II) chloride back into copper(I) chloride and silver chloride.

(a) Calculate the maximum mass of silver that can be formed when 0.287 g of silver chloride decomposes. [2]

(b) Explain why the reaction between copper(I) chloride and chlorine involves both oxidation and reduction. [3]

(c) Construct the equation for the reaction between silver and copper(II) chloride. [1]

(d) Aqueous copper(II) chloride reacts with aqueous sodium hydroxide to form a precipitate.

(i) Write the ionic equation, including state symbols, for the precipitation reaction.

(ii) What is the name and colour of the precipitate?

[4]

s/05/qp2

Question 91

(c) At room temperature ozone decomposes slowly to form oxygen, O_2.

The decomposition can be represented by the equation below. The reaction is exothermic. One mole of ozone will release 143 kJ when it is fully decomposed.

$$2O_3 \rightarrow 3O_2$$

(i) In terms of the energy changes that take place during bond breaking and bond making, explain why this reaction is exothermic.

(ii) Explain why the **rate** of this decomposition increases as the **temperature** increases.

(iii) Calculate the energy released when 16 g of ozone is decomposed.

[6]

s/05/qp2

Question 92

(e) A sample of a compound of iron is analysed. The sample contains 0.547 g of potassium, 0.195 g of iron, 0.252 g of carbon and 0.294 g of nitrogen.
Calculate the empirical formula of this compound.

Answer .....[3]

s/05/qp2

Question 93

B10 The table below shows some of the ores of iron.

ore	formula
haematite	Fe_2O_3
magnetite	Fe_3O_4
siderite	$FeCO_3$

(a) Which ore in the table contains the greatest percentage by mass of iron? Explain your answer. [2]

s/04/qp2

Question 94

(c) Ethene can also be converted into a compound that contains carbon, hydrogen and oxygen. A sample of the compound was analysed and found to contain 0.72 g of carbon, 0.18 g of hydrogen and 0.96 g of oxygen.
Show that the empirical formula of the compound is CH_3O. [3]

s/04/qp2

Question 95

B8 Nickel is a transition element. It is manufactured in a four-stage process from nickel(II) sulphide, NiS.

- Stage 1 – nickel(II) sulphide is heated in air to form nickel(II) oxide and sulphur dioxide.
- Stage 2 – nickel(II) oxide is heated with carbon to give impure nickel.
- Stage 3 – impure nickel is reacted with carbon monoxide to make nickel tetracarbonyl, $Ni(CO)_4$.
- Stage 4 – nickel tetracarbonyl is decomposed to give pure nickel.

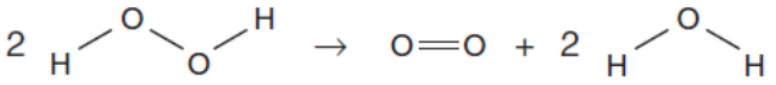
(a) **(i)** Construct the balanced equation for the reaction in stage 1.

(ii) Calculate the mass of sulphur dioxide that is formed when 182 kg of nickel sulphide is heated in air. [3]

s/04/qp2

Question 96

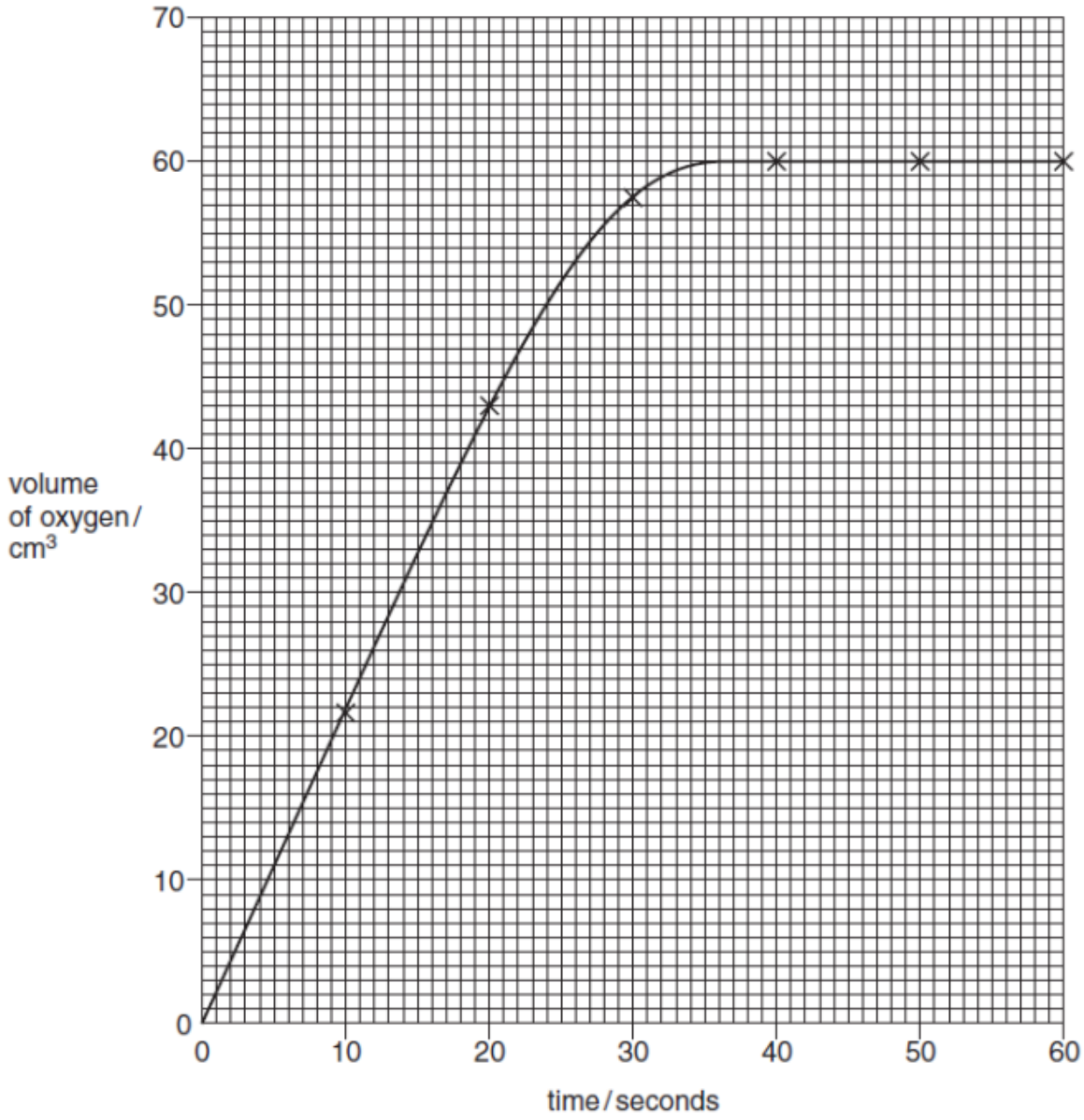
The decomposition can be represented by the equation below.



$\Delta H = -206\ \text{kJ/mol}$

(c) Manganese(IV) oxide catalyses the decomposition of aqueous hydrogen peroxide. In an experiment 50.0 cm^3 of aqueous hydrogen peroxide was mixed with 0.50 g of manganese(IV) oxide. The total volume of oxygen formed was measured every 10 seconds.

The results of the experiment are shown in the graph.



(i) After how many seconds did the decomposition of hydrogen peroxide finish?

(ii) How many moles of oxygen were produced at the end of the decomposition? [At room temperature and pressure one mole of oxygen occupies 24000 cm^3.]

(iii) Use your answer to **(ii)** to calculate the concentration, in mol/dm^3, of the 50.0 cm^3 of aqueous hydrogen peroxide used in the experiment.

[5]

Question 97

(c) A sample of 0.195 g of potassium was added to 500 cm^3 of cold water. When the reaction was finished, 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid was added to form solution **X**.

(i) Calculate the number of moles of hydroxide ions formed when the potassium was added to water.

(ii) Calculate the number of moles of hydrogen ions in 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid.

(iii) Give an ionic equation to represent the neutralisation reaction.

.....

(iv) Suggest a pH value for solution **X**.
Explain your answer.

.....

.....

[4]

s/04/qp2

Question 98

(c) Analysis of an organic acid isolated from red ants shows that it contains 0.060 g of carbon, 0.010 g of hydrogen and 0.16 g of oxygen.
Calculate the empirical formula for this acid. [2]

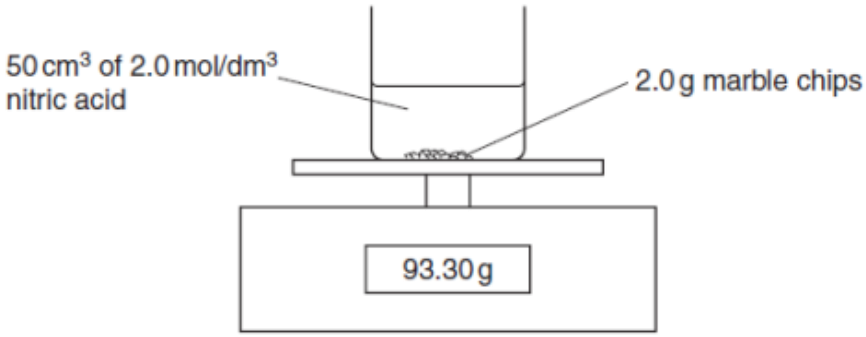
s/03/qp2

A5 Marble statues are being damaged by acid rain. The chemical name for marble is calcium carbonate.

A student investigated the reaction between marble chips and nitric acid.

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

The diagram shows the apparatus the student used.



The student recorded the balance reading every minute.

The table shows the results.

time / minutes	balance reading / g
0	93.30
1	93.28
2	93.26
3	93.24
4	93.22
5	93.21
6	93.20
7	93.19
8	93.18
9	93.17
10	93.16
11	93.15
12	93.15
13	93.14
14	93.14

(a) Explain why the balance reading decreases during the experiment.

.....

.....[1]

(b) How can the student tell when the reaction has finished?

.....

.....[1]

(c) **(i)** Calculate the number of moles of nitric acid in 50 cm^3 of 2.0 mol / dm^3 solution.

(ii) Calculate the number of moles of calcium carbonate in 2.0 g.

(iii) Which reagent, calcium carbonate or nitric acid, is in excess?
Explain your answer.

[5]

(d) The student repeats the experiment using the same quantities of calcium carbonate and nitric acid. This time the acid is at a higher temperature. Describe and explain, in terms of collisions between reacting particles, the effect of increasing the temperature on the rate of reaction.

.....

.....

.....[2]

s/03/qp2

Question 100

(e) A sample of a hydrocarbon contains 0.240 g of carbon and 0.050 g of hydrogen.

(i) Calculate the empirical formula of this hydrocarbon.

(ii) The hydrocarbon is one of the compounds in the table. Which one? [3]

s/02/qp2

Question 101

(d) Hydrogen is used to manufacture ammonia, NH_3. Calculate the volume of hydrogen needed to react completely with 240 dm^3 of nitrogen, all gas volumes measured at room temperature and pressure. [3]

s/02/qp2

Question 102

A2 Hydrogen reacts with chlorine to make hydrogen chloride. The reaction is exothermic.

The reaction can be represented by the equation below.

$$H-H + Cl-Cl \longrightarrow H-Cl + H-Cl \qquad \Delta H = -184\ kJ/mol$$

(a) A mixture of 2.5 g of hydrogen and 142 g of chlorine is allowed to react.

(i) Which gas, hydrogen or chlorine, is in excess?

Explain your answer.

.....

.....

.....

.....

(ii) Calculate the energy released when 2.5 g of hydrogen reacts completely with chlorine gas.

[3]

(b) Explain why the reaction is exothermic, in terms of the energy changes that take place during bond breaking and bond making.

.....

.....

.....

..... [3]

S/02/qp2

Question 103

B7 **(a)** A compound of carbon, hydrogen and chlorine contains 0.48 g of carbon, 0.08 g of hydrogen and 1.42 g of chlorine.

(i) Deduce the empirical formula of this compound.

[2]

(ii) The relative molecular mass of this compound is 99.

Deduce the molecular formula of this compound.

[1]

w/13/qp21

Question 104

(c) Iron reacts with dilute hydrochloric acid to form iron(II) chloride.

$$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$$

A student added 2.1 g of iron to 50 cm^3 of 0.10 mol/dm^3 hydrochloric acid.

(i) Calculate the amount, in moles, of iron present.

..... mol [1]

(ii) Calculate the amount, in moles, of hydrochloric acid present.

..... mol [1]

(iii) Calculate the volume of hydrogen formed in this reaction, measured at room temperature and pressure.

..... cm^3 [2]

w/13/qp21

Question 105

(d) Calculate the mass of Fe_3O_4 formed when 2.80 g of iron completely reacts with excess steam.

mass of Fe_3O_4 = ... g [3]

s/14/qp22

Question 106

(d) Nonane, C_9H_{20}, is heated strongly in the presence of a catalyst. Two products are made: an alkane, **G**, and an alkene, **H**.

(i) Name this type of reaction.

.....[1]

(ii) Alkane **G** contains 84% carbon by mass.

Calculate the molecular formula for **G**.

molecular formula ..... [3]

(iii) Suggest a molecular formula for **H**.

.....[1]

s/14/qp22

Question 107

A2 Farmers use chemicals to improve crop yield.

Ammonium phosphate, $(NH_4)_3PO_4$, is used as a fertiliser and calcium hydroxide, $Ca(OH)_2$, is used to reduce the acidity of soils.

The relative formula mass of ammonium phosphate is 149.

(a) Calculate the percentage by mass of nitrogen in ammonium phosphate.

percentage = ... % [1]

(c) A sample of ammonium phosphate can be produced by the reaction of aqueous ammonia and phosphoric acid.

$$3NH_3(aq) + H_3PO_4(aq) \rightarrow (NH_4)_3PO_4(aq)$$

25.0 cm^3 of 1.25 mol/dm^3 phosphoric acid is neutralised by 45.3 cm^3 of aqueous ammonia.

(i) Calculate the concentration, in mol/dm^3, of the ammonia used.

concentration of ammonia = ... mol/dm^3 [3]

(ii) Show, by calculation, that 4.66 g of ammonium phosphate would be produced. Assume that the yield is 100%.
[M_r: $(NH_4)_3PO_4$, 149]

[1]

(iii) In practice, the actual mass of ammonium phosphate produced is 2.93 g.

Calculate the percentage yield of ammonium phosphate.

percentage yield = ... % [1]

s/14/qp22

Question 108

(c) In an experiment, 220 g of carbon dioxide and an excess of hydrogen are reacted in a sealed container until an equilibrium is established.

A mass of 46 g of methane is produced.

(i) Calculate the mass of methane that should have been made if the percentage yield was 100%.

mass of methane = ... g [2]

(ii) Calculate the percentage yield of methane in this experiment.

percentage yield = ...% [1]

s/14/qp21

Question 109

(e) A solution containing 0.172 g of an unknown carboxylic acid, $C_xH_yCO_2H$, is titrated with 0.100 mol/dm^3 aqueous sodium hydroxide. The volume of sodium hydroxide solution needed to exactly neutralise the acid is 23.2 cm^3.

$$C_xH_yCO_2H + NaOH \rightarrow C_xH_yCO_2Na + H_2O$$

Calculate the relative formula mass, M_r, of the carboxylic acid and suggest its identity.

relative formula mass = ...

identity of the acid ..... [4]

s/14/qp21

Question 110

A2 A power station burns methane, CH_4, which is contaminated by hydrogen sulfide, H_2S.

The equation shows the combustion of methane.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

The combustion of the hydrogen sulfide forms water and sulfur dioxide.

(a) Construct the equation to show the combustion of hydrogen sulfide.

..... [1]

(b) Explain why the burning of the contaminated methane at the power station causes atmospheric problems.

.....

.....

.....

..... [2]

(c) A 1000 dm^3 sample of the contaminated methane gas burnt at the power station produces 999 dm^3 of carbon dioxide and 1 dm^3 of sulfur dioxide. All gas volumes are measured at room temperature and pressure.

(i) What is the volume of methane, at room temperature and pressure, in the 1000 dm^3 of the gas burnt?

volume of methane = ... dm^3 [1]

(ii) What is the volume of hydrogen sulfide, at room temperature and pressure, in the 1000 dm^3 of the gas burnt?

volume of hydrogen sulfide = ... dm^3 [1]

(iii) Calculate the percentage, by volume, of hydrogen sulfide in the contaminated methane. You must show your working.

percentage = ...% [2]

s/14/qp21

Question 111

(c) Sodium chloride is dissolved in distilled water.

Excess aqueous silver nitrate is added to this solution and 0.232 g of a white precipitate is formed.

(i) Construct an ionic equation, including state symbols, for the formation of the white precipitate.

..... [2]

(ii) Calculate the mass of sodium chloride present in the solution.

mass of sodium chloride = ... g [3]

s/13/qp22

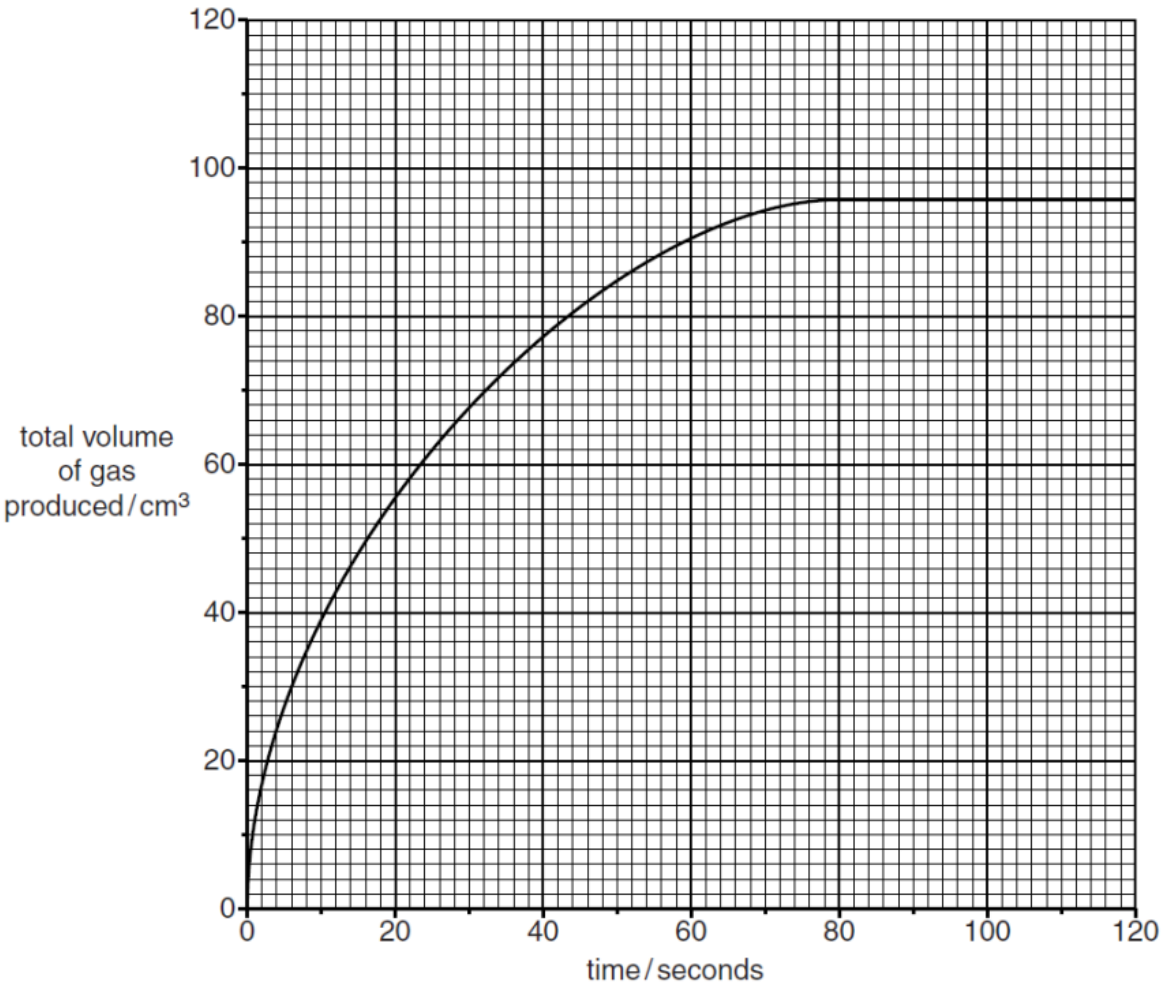
Question 112

B7 An antacid tablet contains a mixture of magnesium hydroxide, $Mg(OH)_2$, and calcium carbonate, $CaCO_3$.

Stomach acid contains dilute hydrochloric acid.

A student adds a 0.500 g antacid tablet to 50.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid, HC*l*. The acid is in excess.

The graph shows how the total volume of gas produced at r.t.p. changes with time.



(a) Describe, with the aid of a labelled diagram, the apparatus needed to collect this data.

[2]

(b) **(i)** Write equations for the reactions of HC*l* with $Mg(OH)_2$ and also with $CaCO_3$.

$Mg(OH)_2$

.....

$CaCO_3$

..... [2]

(ii) Calculate the amount, in moles, of carbon dioxide formed at r.t.p. once the reaction had stopped.

amount in moles = ... [2]

(iii) Calculate the mass of $CaCO_3$ in the tablet.

mass of $CaCO_3$ = ... g [2]

Question 113

A6 A 0.250 g sample of iron filings is added to 25.0 cm^3 of 0.100 mol/dm^3 aqueous copper(II) sulfate.

$$Cu^{2+}(aq) + Fe(s) \rightarrow Fe^{2+}(aq) + Cu(s)$$

(a) Explain, using electron transfer, why iron is oxidised in this reaction.

.....

..... [1]

(b) Show, by calculation, which reactant is in excess.

[3]

s/13/qp22

Question 114

A5 Analysis of compound **X** shows it has the following composition.

element	percentage by mass
hydrogen	3.40
nitrogen	12.0
oxygen	41.0
vanadium	43.6

(a) Show that **X** has the formula H_4NO_3V.

[2]

s/13/qp22

Question 115

B7 Malachite is an ore of copper. The formula of malachite is $CuCO_3.Cu(OH)_2$.

Malachite reacts as though it is a mixture of copper(II) carbonate and copper(II) hydroxide.

A small sample of malachite is added to excess dilute hydrochloric acid, HC*l*(aq). The carbon dioxide formed is collected and has a volume of 96 cm^3 at room temperature and pressure.

(a) What would you observe when malachite reacts with HC*l*(aq)?

.....

..... [2]

(b) Construct the equation for the reaction between malachite and HC*l*(aq).

..... [2]

(c) Calculate the mass of carbonate ion, CO_3^{2-}, in the sample of malachite.

mass of CO_3^{2-} = ... g [3]

s/13/qp21

Question 116

A5 Analysis of compound **X** shows it has the following composition.

element	percentage by mass
nitrogen	11.1
hydrogen	3.20
chromium	41.3
oxygen	44.4

(a) Show that **X** has the formula $N_2H_8Cr_2O_7$.

[3]

s/13/qp21

Question 117

(c) In the reaction when 3.0 moles of hydrogen react, 49 kJ of heat energy is released.

Calculate how much heat energy is released when 500 kg of hydrogen react.

heat energy = ... kJ [2]

(d) Methanol can be used as a fuel.

Construct the equation for the complete combustion of methanol.

..... [1]

s/12/qp22

Question 118

(c) A hydrogen-oxygen fuel cell uses 2000 dm^3 of hydrogen measured at room temperature and pressure.
Calculate the volume of oxygen, measured at room temperature and pressure, used by the fuel cell.
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

.....

.....

.....

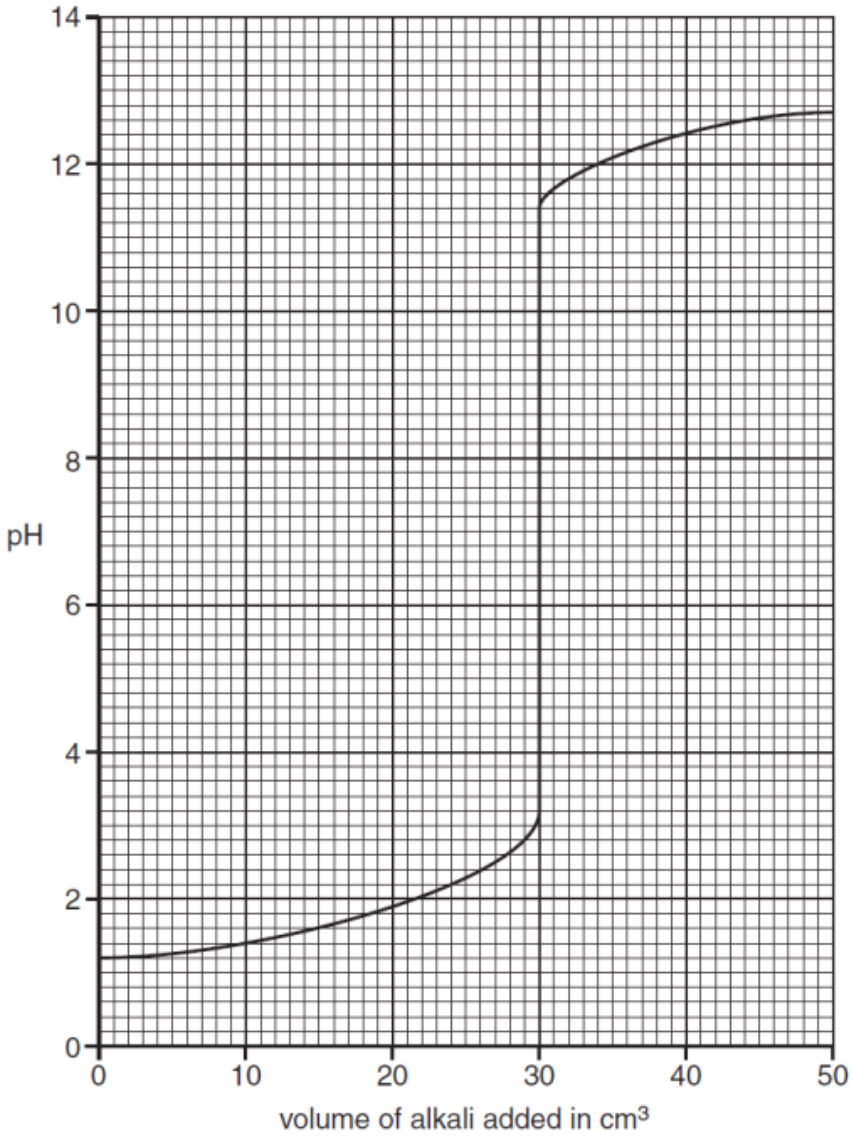
volume of oxygen = ... dm^3 [2]

s/12/qp22

Question 119

A5 Aqueous potassium hydroxide, KOH, is added slowly from a burette into a flask containing 25.0 cm^3 of 0.0500 mol/dm^3 dilute sulfuric acid, H_2SO_4. At the same time the pH of the contents of the flask is measured until all of the aqueous potassium hydroxide has been added.

The graph shows how the pH changes with the addition of the aqueous potassium hydroxide.



(a) What is the pH of 0.0500 mol/dm^3 sulfuric acid?

..... [1]

(b) Construct the equation for the reaction between sulfuric acid and potassium hydroxide.

..... [1]

(c) **(i)** What volume of aqueous potassium hydroxide has been added when the mixture has a pH of 7?

volume = ... cm^3 [1]

(ii) Calculate the concentration, in mol/dm^3, of the aqueous potassium hydroxide.

concentration = ... mol/dm^3 [3]

(d) The experiment is repeated with $25.0\,cm^3$ of $0.0500\,mol/dm^3$ ethanoic acid, CH_3COOH, instead of $25.0\,cm^3$ of $0.0500\,mol/dm^3$ sulfuric acid.

Describe and explain any differences in the graph which would be obtained.

.....

.....

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..... [2]

[Total: 8]

s/12/qp22