CHEMISTRY CLASSIFIED PAPER 3 - HAKIM ABBAS ALI (MSC)

Teacher

HAKIM ABBAS ALI

(M·Sc·) #66748570

Cambridge IGCSE

29 November 2013

Chemistry Paper-3

Classified Past Paper Questions

Web: https://sites.google.com/site/hakimabbas31site/

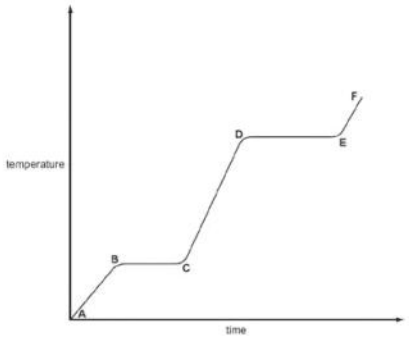
Table of Contents

Topic 1 – Matters

1. W05

Ethanoic acid is a colourless liquid at room temperature. It has the typical acid properties and forms compounds called ethanoates.

(a) A pure sample of ethanoic acid is slowly heated from 0°C to 150°C and its temperature is measured every minute. The results are represented on the graph below.



(i) Name the change that occurs in the region **D** to **E**.

..... [1]

(ii) What would be the difference in the region **B** to **C** if an impure sample had been used?

..... [1]

(iii) Sketch on the graph how the line would continue if the acid was heated to a higher temperature. [1]

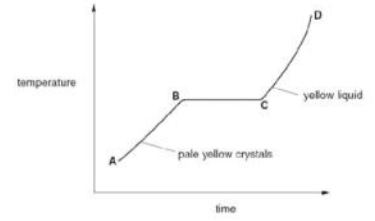
(iv) Complete the following table that compares the separation and movement of the molecules in regions **C** to **D** with those in **E** to **F**.

	C to D	E to F
separation (distance between particles)	.....	.....
movement of particles	random and slow	....
Can particles move apart to fill any volume?	.....	.....

[5]

2. M/J/03

When nitrogen dioxide is cooled, it forms a yellow liquid and then pale yellow crystals. These crystals are heated and the temperature is measured every minute. The following graph can be drawn.



(i) Describe the arrangement and movement of the molecules in the region **A–B**

.....

.....

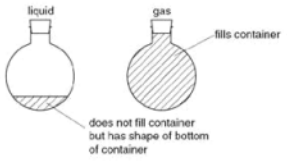
(ii) Name the change that occurs in the region **B–C**

.....[4]

3. M/J/02

(a) The Kinetic Theory explains the properties of solids, liquids and gases in terms of the movement of particles.

Liquids and gases both take up the shape of the container but a gas always fills the container. Explain this, using the ideas of the Kinetic Theory.



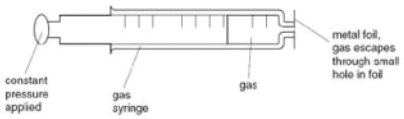
.....

.....

.....

.....[4]

(b) The following apparatus can be used to measure the rate of diffusion of a gas.



(i) What measurements would need to be taken to calculate the rate of diffusion of a gas?

.....[2]

(ii) Which gas, carbon dioxide or sulphur dioxide, would diffuse faster? Explain your choice.

.....

.....

.....[3]

4. J/05

(d) Traces of chlorine can be separated from bromine vapour by diffusion. Which gas would diffuse the faster and why?

.....

..... [2]

5. M/J/01

When carbon dioxide is cooled it can change directly from a gas to a molecular solid, dry ice. Complete the table by describing the arrangement and movement of the molecules in both the solid and gaseous states.

	solid	gas
arrangement of molecules		
movement of molecules		

[6]

6. N/99

Explain why the molecules of oxygen and nitrogen in air would diffuse into the bottle through an uncoated cork faster than carbon dioxide would diffuse out through the cork.

.....

.....[2]

7. M/J/99

Hydrogen could be transported in heavy cylinders as a gas under pressure or as a liquid at low temperatures.

(i) The pressure exerted by a gas is caused by the molecules of the gas colliding with the walls of the container. Why would the pressure inside a cylinder increase if the temperature was increased?

.....

.....[2]

(ii) Explain what happens to the molecules in gaseous hydrogen as it changes into a liquid at –253 °C.

.....

.....[3]

Topic 2 – Experimental techniques

1. S11

The following techniques are used to separate mixtures.

A simple distillation **B** fractional distillation **C** evaporation

D chromatography **E** filtration **F** diffusion

From this list, choose the most suitable technique to separate the following.

(a) methane from a mixture of the gases, methane and ethane ..... [1]

(b) water from aqueous magnesium sulfate ..... [1]

(c) glycine from a mixture of the amino acids, glycine and lysine ..... [1]

(d) iron filings from a mixture of iron filings and water ..... [1]

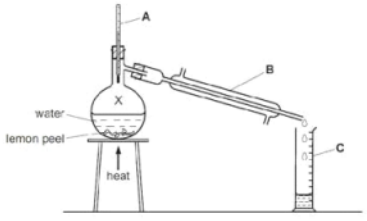
(e) zinc sulfate crystals from aqueous zinc sulfate ..... [1]

(f) hexane from a mixture of the liquids, hexane and octane ..... [1]

[Total: 6]

2. W09

Limonene can be extracted from lemon peel by steam distillation.



(i) State the name of the pieces of apparatus labelled **A**, **B** and **C**.

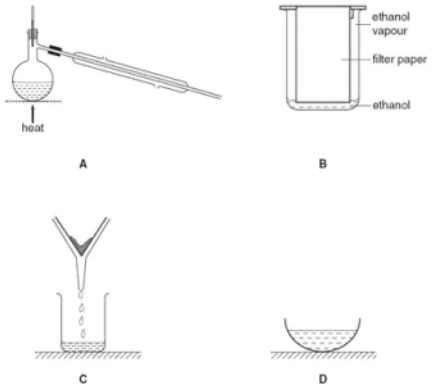
A .....

B .....

C ..... [3]

3. N/03

The diagrams show four methods of purifying substances.



(a) Which of these methods, **A**,**B**,**C** or **D**, is best used for

(i) separating the different colours in a sample of ink? ☐

(ii) separating two liquids with different boiling points? ☐

(iii) separating mud from water? ☐

(iv) making crystals of copper sulphate from copper sulphate solution? ☐

[4]

S08

Copper ions can be separated from other metal ions by paper chromatography. Draw a labelled diagram of the apparatus for paper chromatography.

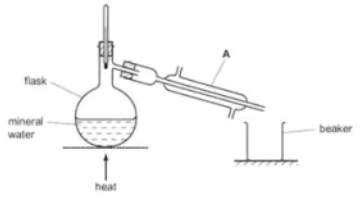
In your diagram include

- the solvent,
- the spot where the solution containing copper ions is placed.

[2]

4. W07

Pure water can be obtained by distilling the mineral water using the apparatus shown below.



(i) State the name of the piece of apparatus labelled **A**.

..... [1]

(ii) Where does the pure water collect?

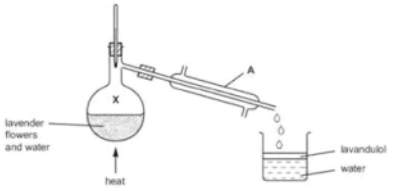
..... [1]

(iii) How does the boiling point of the mineral water in the flask compare with the boiling point of pure water?

..... [1]

5. N/06

(d) Lavandulol can be extracted from lavender flowers by distillation using the apparatus shown below. The lavandulol is carried off in small droplets with the steam.



(i) State the name of the piece of apparatus labelled **A**.

..... [1]

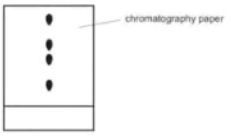
(ii) What is the temperature of the water at point **X** in the diagram?

..... [1]

(iii) The lavandulol and water are collected in the beaker.
What information in the diagram shows that lavandulol is less dense than water?

..... [1]

(e) Lavender flowers contain a variety of different pigments (colourings).
A student separated these pigments using paper chromatography.
The results are shown in the diagram below.



(i) Put an **X** on this diagram to show where the mixture of pigments was placed at the start of the experiment. [1]

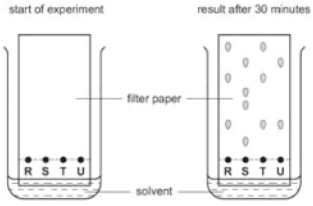
(ii) How many different pigments have been separated?

..... [1]

(iii) Draw a diagram to show how the chromatography apparatus was set up.
On your diagram label
- the solvent
- the origin line

6. N/04

Plants make a variety of coloured pigments.
A student extracted red colouring from four different plants, **R**, **S**, **T** and **U**.
The student put a spot of each colouring on a piece of filter paper.
The filter paper was dipped into a solvent and left for 30 minutes.
The results are shown below.



(i) What is name given to the process shown in the diagram?

..... [1]

(ii) Which plant contained the greatest number of different pigments?

..... [1]

(iii) Which two plants contained the same pigments?

..... [1]

7. N/02

(g) A sample of water was contaminated with clay, which is insoluble in water.

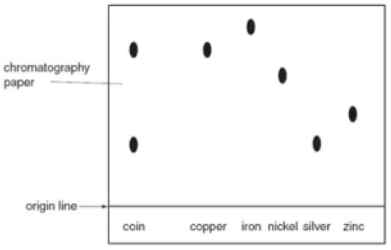
Explain with the help of a labelled diagram, how you would separate the clay from the water.

[3]

8. M/J/01

Coins are made from a variety of metals.

A student dissolved an old coin in nitric acid and used paper chromatography to find out what ions were present. The results are shown below for the coin and for samples of metal ions.



(a) (i) Which metals did the coin contain?

.....[2]

(ii) Where on the chromatography paper should the samples be placed at the start of the experiment?

.....[1]

(iii) A solvent was used in this chromatography to separate the different metals in the coin.
State what is meant by the term *solvent*.

.....[1]

(iv) Why do the metal ions end up at different positions?
Your answer should refer to the solvent.

.....

.....[2]

Topic 3: Atoms, elements and compounds

1. S11

Selenium and sulfur are in Group VI. They have similar properties.

(a) One of the main uses of selenium is in photoelectric cells. These cells can change light into electrical energy.

(i) Name a process which can change light into chemical energy.

.....

(ii) Name a device which can change chemical energy into electrical energy.

..... [2]

(b) The electron distribution of a selenium atom is 2 + 8 + 18 + 6.

(i) Selenium forms an ionic compound with potassium. Draw a diagram which shows the formula of this ionic compound, the charges on the ions and the arrangement of the **valency** electrons around the negative ion.
Use o to represent an electron from an atom of potassium.
Use x to represent an electron from an atom of selenium.

[3]

2. W11

This question is concerned with the following oxides.

sulfur dioxide
carbon monoxide
lithium oxide
aluminium oxide
nitrogen dioxide
strontium oxide

(c) Lithium oxide is an ionic compound.

(i) Identify another ionic oxide in the list on page 3.

..... [1]

(ii) Draw a diagram which shows the formula of lithium oxide, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use x to represent an electron from an atom of oxygen.
Use o to represent an electron from an atom of lithium.

[2]

(ii) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound selenium chloride.
Use x to represent an electron from an atom of selenium.
Use o to represent an electron from an atom of chlorine.

[3]

(iii) Predict **two** differences in the physical properties of these two compounds.

.....

..... [2]

(c) The selenide ion reacts with water.

$$Se^{2-} + H_2O \rightarrow HSe^- + OH^-$$

What type of reagent is the selenide ion in this reaction? Give a reason for your choice.

.....

..... [3]

[Total: 13]

3. W10

The table gives the composition of three particles.

particle	number of protons	number of electrons	number of neutrons
A	15	15	16
B	15	18	16
C	15	15	17

(a) What is the evidence in the table for each of the following?

(i) Particle **A** is an atom.

.....

..... [1]

(ii) They are all particles of the same element.

.....

..... [1]

(iii) Particle **B** is a negative ion.

.....

..... [2]

(iv) Particles **A** and **C** are isotopes.

.....

..... [2]

(b) (i) What is the electronic structure of particle **A**?

..... [1]

(ii) What is the valency of the element?

..... [1]

(iii) Is the element a metal or a non-metal? Give a reason for your choice.

.....

..... [1]

[Total: 9]

4.
It is now known that the smell of the seaside is due to the chemical dimethyl sulfide, $(CH_3)_2S$.

(i) Draw a diagram that shows the arrangement of the valency electrons in one molecule of this covalent compound.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from a hydrogen atom.
Use • to represent an electron from a sulfur atom.

[3]

(ii) Name the **three** compounds formed when dimethyl sulfide is burnt in excess oxygen.

.....

.....

..... [2]

5. S10
Carbon and silicon are elements in Group IV. Both elements have macromolecular structures.

(a) Diamond and graphite are two forms of the element carbon.

(i) Explain why diamond is a very hard substance.

.....

.....

..... [2]

(ii) Give **one** use of diamond.

..... [1]

(iii) Explain why graphite is a soft material.

.....

..... [2]

(iv) Give **one** use of graphite.

..... [1]

(b) Two of the oxides of these elements are carbon dioxide, CO_2, and silicon(IV) oxide, SiO_2.

(i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.

[3]

(ii) A section of the macromolecular structure of silicon(IV) oxide is given below.

Use this diagram to explain why the formula is SiO_2 not SiO_4.

.....

..... [2]

(iii) Predict **two** differences in the physical properties of these two oxides.

.....

..... [2]

[Total: 13]

6. S09
The following is a list of the electron distributions of atoms of unknown elements.

element	electron distribution
A	2,5
B	2,8,4
C	2,8,8,2
D	2,8,18,8
E	2,8,18,8,1
F	2,8,18,18,7

(a) Choose an element from the list for each of the following descriptions.

(i) It is a noble gas. .....

(ii) It is a soft metal with a low density. .....

(iii) It can form a covalent compound with element **A**. .....

(iv) It has a giant covalent structure similar to diamond. .....

(v) It can form a negative ion of the type X^{3-}. ..... [5]

(b) Elements **C** and **F** can form an ionic compound.

(i) Draw a diagram that shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use **o** to represent an electron from an atom of **C**.
Use **x** to represent an electron from an atom of **F**.

[3]

(ii) Predict **two** properties of this compound.

.....

.....

..... [2]

[Total: 10]

7. W08
There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium nitride is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a sodium atom.
Use o to represent an electron from a nitrogen atom.

[3]

(b) (i) Describe metallic bonding.

.....

..... [3]

(ii) Use the above ideas to explain why

metals are good conductors of electricity,

..... [1]

metals are malleable.

..... [2]

(c) Silicon(IV) oxide has a macromolecular structure.

(i) **Describe** the structure of silicon(IV) oxide (a diagram is not acceptable).

.....

.....

..... [3]

(ii) Diamond has a similar structure and consequently similar properties.
Give **two** physical properties common to both diamond and silicon(IV) oxide.

.....

..... [2]

8. S08

The structural formula of carbonyl chloride is given below.

Draw a diagram that shows the arrangement of the valency electrons in one molecule of this covalent compound.
Use x for an electron from a chlorine atom.
Use o for an electron from a carbon atom.
Use • for an electron from an oxygen atom.

[4]

9. W07

The table below gives the number of protons, neutrons and electrons in atoms or ions.

particle	number of protons	number of electrons	number of neutrons	symbol or formula
A	9	10	10	$^{19}_{9}F^{-}$
B	11	11	12	
C	18	18	22	
D	15	18	16	
E	13	10	14	

(a) Complete the table. The first line is given as an example. [6]

(b) Which atom in the table is an isotope of the atom which has the composition 11p, 11e and 14n? Give a reason for your choice.

.....

..... [2]

10. M/J/07

Complete the following table.

type of structure	particles present	electrical conductivity of solid	electrical conductivity of liquid	example
ionic	positive and negative ions	poor	.....	.....
macro molecular	atoms of two different elements in a giant covalent structure	poor	poor	.....
metallic	..... and	good	.....	copper

[Total: 6]

Magnesium reacts with bromine to form magnesium bromide.

(a) Magnesium bromide is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of outer electrons around the negative ion.
The electron distribution of a bromine atom is 2, 8, 18, 7.

Use x to represent an electron from a magnesium atom.
Use o to represent an electron from a bromine atom. [3]

(b) In the lattice of magnesium bromide, the ratio of magnesium ions to bromide ions is 1:2.

(i) Explain the term *lattice*.

..... [2]

(ii) Explain why the ratio of ions is 1:2.

..... [1]

11. S08

(a) Complete the table which gives the names, symbols, relative masses and relative charges of the three subatomic particles.

name	symbol	relative mass	relative charge
electron	e^-		
proton		1	
	n		0

[3]

(b) Use the information in the table to explain the following.

(i) Atoms contain charged particles but they are electrically neutral because they have no overall charge.

.....

..... [2]

(ii) Atoms can form positive ions.

.....

..... [2]

(iii) Atoms of the same element can have different masses.

.....

..... [2]

(iv) Scientists are certain that there are no undiscovered elements missing from the Periodic Table from hydrogen to lawrencium.

..... [1]

[Total: 10]

12. W08

There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium nitride is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a sodium atom.
Use o to represent an electron from a nitrogen atom.

[3]

(b) **(i)** Describe metallic bonding.

.....

..... [3]

(ii) Use the above ideas to explain why

metals are good conductors of electricity,

..... [1]

metals are malleable.

..... [2]

(c) Silicon(IV) oxide has a macromolecular structure.

(i) **Describe** the structure of silicon(IV) oxide (a diagram is not acceptable).

.....

.....

..... [3]

(ii) Diamond has a similar structure and consequently similar properties.
Give **two** physical properties common to both diamond and silicon(IV) oxide.

.....

..... [2]

[Total: 14]

13. N/06

2 The table shows the melting points, boiling points and electrical properties of the six substances **A** to **F**.

substance	melting point / °C	boiling point / °C	electrical conductor at room temperature	electrical conductor of substance dissolved in water
A	961	2193	good	does not dissolve
B	113	444	does not conduct	does not dissolve
C	0	100	very poor	very poor
D	803	1465	does not conduct	good
E	-5 to -10	102 to 105	good	good
F	-85	-60	does not conduct	does not dissolve

(i) Which **three** substances are solids at room temperature?

..... [1]

(ii) Which **one** is an ionic compound?

..... [1]

(iii) Which **one** is a gas at room temperature?

..... [1]

(iv) Which **two** substances are liquids at room temperature?

..... [1]

(v) Which substance is a metal?

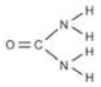
..... [1]

(vi) Which **one** is an impure substance?

..... [1]

14. N/06

(d) Give a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound urea. Its structural formula is given below.



Use o to represent an electron from a carbon atom.
Use x to represent an electron from a hydrogen atom.
Use • to represent an electron from a nitrogen atom.

[3]

15. J/05

(iii) Draw a diagram to show the arrangement of the valency electrons in one molecule of the covalent compound hydrogen sulphide.
Use o to represent an electron from a sulphur atom.
Use x to represent an electron from a hydrogen atom.

[2]

Topic 9 –Periodic table

1. W10

The table below shows the elements in the second period of the Periodic Table and some of their oxidation states in their most common compounds.

element	Li	Be	B	C	N	O	F	Ne
number of outer electrons	1	2	3	4	5	6	7	8
oxidation state	+1	+2	+3	+4	–3	–2	–1	0

(a) (i) What does it mean when the only oxidation state of an element is zero?

..... [1]

(II) Explain why some elements have positive oxidation states but others have negative ones.

..... [2]

(iii) Select **two** elements in the table which exist as diatomic molecules of the type X_2.

..... [1]

(b) Beryllium hydroxide, a white solid, is an amphoteric hydroxide.

(i) Name another metal which has an amphoteric hydroxide.

..... [1]

(ii) Suggest what you would observe when an excess of aqueous sodium hydroxide is added gradually to aqueous beryllium sulfate.

..... [2]

(c) (i) Give the formulae of lithium fluoride and nitrogen fluoride.

lithium fluoride .....

nitrogen fluoride ..... [2]

(ii) Predict **two** differences in their properties.

..... [2]

(iii) Explain why these two fluorides have different properties.

..... [2]

[Total: 13]

2. S10

Choose an element which fits each of the following descriptions.

(i) It is a yellow solid which burns to form an acidic oxide.

..... [1]

(ii) This element is a black solid which, when heated, forms a purple vapour.

..... [1]

(III) Most of its soluble salts are blue.

..... [1]

(iv) It has a basic oxide of the type MO which is used to treat acidic soils.

..... [1]

(v) It is an unreactive gas used to fill balloons.

..... [1]

[Total: 5]

3. W09

The first three elements in Group IV are carbon, silicon and germanium.
The elements and their compounds have similar properties.

(a) The compound, silicon carbide, has a macromolecular structure similar to that of diamond.

(i) A major use of silicon carbide is to reinforce aluminium alloys which are used in the construction of spacecraft. Suggest **three** of its physical properties.

.....

.....

..... [3]

(ii) Complete the following description of the structure of silicon carbide.

Each carbon atom is bonded to four ..... atoms.

Each silicon atom is bonded to ..... carbon atoms. [2]

(b) Germanium(IV) oxide, GeO_2, has the same macromolecular structure as silicon(IV) oxide. Draw the structural formula of germanium(IV) oxide.

[3]

(c) Germanium forms a series of hydrides comparable to the alkanes.

(i) Draw the structural formula of the hydride which contains four germanium atoms per molecule.

[1]

(ii) Predict the products of the complete combustion of this hydride.

..... [2]

[Total: 11]

4. S08

For each of the following select an element from Period 4, potassium to krypton, that matches the description.

(a) It is a brown liquid at room temperature. .....

(b) It forms a compound with hydrogen having the formula XH_4. .....

(c) A metal that reacts violently with cold water. .....

(d) It has a complete outer energy level. .....

(e) It has oxidation states of 2 and 3 only. .....

(f) It can form an ion of the type X^-. .....

(g) One of its oxides is the catalyst in the Contact Process. .....

[Total: 7]

5. M/J/07

Use your copy of the periodic table to help you answer these questions.

(a) Predict the formula of each of the following compounds.

(i) barium oxide ..... [1]

(ii) boron oxide ..... [1]

(b) Give the formula of the following ions.

(i) sulphide ..... [1]

(ii) gallium ..... [1]

6. M/J/07

(d) Potassium and vanadium are elements in Period IV.

(i) State **two** differences in their physical properties.

.....

..... [2]

(ii) Give **two** differences in their chemical properties.

.....

..... [2]

7. M/J/07

(e) Fluorine and astatine are halogens. Use your knowledge of the other halogens to predict the following:

(i) The physical state of fluorine at r.t.p. .....

The physical state of astatine at r.t.p. ..... [2]

(ii) **Two** similarities in their chemical properties

.....

..... [2]

8. J/06

(b) (i) In which Period in the Periodic Table is iron to be found?

..... [1]

(ii) Use the Periodic Table to work out the number of protons and the number of neutrons in one atom of iron.

number of protons = ... number of neutrons = ... [1]

9. M/J/03

The first three elements in Period 6 of the Periodic Table of the Elements are caesium, barium and lanthanum.

(a) How many **more** protons, electrons and neutrons are there in one atom of lanthanum than in one atom of caesium. Use your copy of the Periodic Table of the Elements to help you.

number of protons .....

number of electrons .....

number of neutrons ..... [3]

10. J/05

Three of the halogens in Group VII are:

chlorine
bromine
iodine

(a) (i) How does their colour change down the Group?

..... [1]

(ii) How does their physical state (solid, liquid or gas) change down the Group?

..... [1]

(iii) Predict the colour and physical state of fluorine.

colour .....

physical state ..... [2]

(b) Describe how you could distinguish between aqueous potassium bromide and aqueous potassium iodide.

test .....

result with bromide .....

result with iodide ..... [3]

11. N/02

Manganese is a transition element. It has more than one valency and the metal and its compounds are catalysts.

(a) (i) Predict **three** other properties of manganese that are typical of transition elements.

.....

.....[3]

(ii) Complete the electron distribution of manganese by inserting one number.

2 + 8 + ... + 2 [1]

12. N/02

The elements in Period 3 and some of their common oxidation states are shown below.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Oxidation State	+1	+2	+3	+4	–3	–2	–1	0

(a) (i) Why do the oxidation states increase from sodium to silicon?

.....[1]

(ii) After Group(IV) the oxidation states are negative and decrease across the period. Explain why.

.....

.....[2]

(b) The following compounds contain two elements. Predict their formulae.

aluminium sulphide .....

silicon phosphide ..... [2]

(c) Choose a different element from Period 3 that matches each description.

(i) It has a similar structure to diamond.

.....[1]

(ii) It reacts violently with cold water to form a solution pH = 14.

.....[1]

(iii) It has a gaseous oxide of the type XO_2, which is acidic.

.....[1]

(d) The only oxidation state of argon is zero. Why it is used to fill light bulbs?

.....

.....[1]

13. M/J/02

Bromine is one of the halogens in Group VII.

(a) (i) Predict which halogen has the lightest colour.

.....[1]

(ii) Predict which halogens are solids at room temperature.

.....[1]

(b) Bromine is obtained from the bromide ions in sea water. Sea water is concentrated by evaporation. Chlorine gas is bubbled through the solution. Chlorine oxidises the bromide ion to bromine.

(i) Complete the following equation.

Cl_2 + ...Br^- ⟶ ..... + ... [2]

(ii) Explain using the idea of electron transfer why the bromide ion is oxidised by chlorine.

The bromide ion is oxidised because .....

.....

Chlorine is the oxidising agent because .....

.....[2]

(iii) Name a reagent that can be oxidised by bromine molecules.

.....[1]

14. M/J/01

The Group I metals show trends in both their physical and chemical properties.

(i) How does the melting point of lithium compare with that of caesium?

.....

(ii) All Group I metals react with cold water to form the metal hydroxide and hydrogen. What is the trend in their reactivity with water?

.....

(iii) Write an equation for the reaction between water and lithium.

.....[4]

Topic4 – Stoichiometry

1. W11

(c) There are three possible equations for the thermal decomposition of sodium hydrogencarbonate.

$2NaHCO_3(s) \rightarrow Na_2O(s) + 2CO_2(g) + H_2O(g)$ **equation 1**

$NaHCO_3(s) \rightarrow NaOH(s) + CO_2(g)$ **equation 2**

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$ **equation 3**

The following experiment was carried out to determine which one of the above is the correct equation.

A known mass of sodium hydrogencarbonate was heated for ten minutes. It was then allowed to cool and weighed.

Results
Mass of sodium hydrogencarbonate = 3.36 g
Mass of the residue = 2.12 g

Calculation
M_r for $NaHCO_3$ = 84 g; M_r for Na_2O = 62 g; M_r for NaOH = 40 g
M_r for Na_2CO_3 = 106 g

(i) Number of moles of $NaHCO_3$ used = ... [1]

(ii) If residue is Na_2O, number of moles of Na_2O = ...

If residue is NaOH, number of moles of NaOH = ...

If residue is Na_2CO_3, number of moles of Na_2CO_3 = ... [2]

(iii) Use the number of moles calculated in **(i)** and **(ii)** to decide which one of the three equations is correct. Explain your choice.

.....

.....

..... [2]

2. W10

(b) 6.0 g of cobalt(II) carbonate was added to 40 cm^3 of hydrochloric acid, concentration 2.0 mol / dm^3. Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

Maximum yield

Number of moles of HCl used = ...

Number of moles of $CoCl_2$ formed = ...

Number of moles of $CoCl_2.6H_2O$ formed = ...

Mass of one mole of $CoCl_2.6H_2O$ = 238 g

Maximum yield of $CoCl_2.6H_2O$ = ... g [4]

To show that cobalt(II) carbonate is in excess

Number of moles of HCl used = ... (use value from above)

Mass of one mole of $CoCO_3$ = 119 g

Number of moles of $CoCO_3$ in 6.0 g of cobalt(II) carbonate = ... [1]

Explain why cobalt(II) carbonate is in excess .....

..... [1]

3. S10

(e) The titanium ore contains 36.8% iron, 31.6% titanium and the remainder is oxygen.

(i) Determine the percentage of oxygen in this titanium compound.

percentage of oxygen = ... % [1]

(ii) Calculate the number of moles of atoms for each element.
The number of moles of Fe is shown as an example.
number of moles of Fe = 36.8 / 56 = 0.66

number of moles of Ti = ...

number of moles of O = ... [1]

(iii) What is the simplest ratio for the moles of atoms?

Fe : Ti : O

....

[1]

(iv) What is the formula of this titanium compound?

..... [1]

4. W09

(c) 9.12 g of anhydrous iron(II) sulfate was heated. Calculate the mass of iron(III) oxide formed and the volume of sulfur trioxide, at r.t.p., formed.

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

mass of one mole of $FeSO_4$ = 152 g

number of moles of $FeSO_4$ used = ...

number of moles of Fe_2O_3 formed = ...

mass of one mole of Fe_2O_3 = ... g

mass of iron(III) oxide formed = ... g

number of moles of SO_3 formed = ...

volume of sulfur trioxide formed = ... dm^3

[6]

5. S09

Quantities of chemicals, expressed in moles, can be used to find the formula of a compound, to establish an equation and to determine reacting masses.

(a) A compound contains 72% magnesium and 28% nitrogen. What is its empirical formula?

.....

.....

.....

..... [2]

(b) A compound contains only aluminium and carbon. 0.03 moles of this compound reacted with excess water to form 0.12 moles of $Al(OH)_3$ and 0.09 moles of CH_4.

Write a balanced equation for this reaction.

.....

.....

.....

..... [2]

(c) 0.07 moles of silicon reacts with 25 g of bromine.

$$Si + 2Br_2 \longrightarrow SiBr_4$$

(i) Which one is the limiting reagent? Explain your choice.

.....

.....

.....

..... [3]

(ii) How many moles of $SiBr_4$ are formed?

..... [1]

[Total: 8]

6. W07

(ii) One piece of marble, 0.3 g, was added to 5 cm^3 of hydrochloric acid, concentration 1.00 mol / dm^3. Which reagent is in excess? Give a reason for your choice.

mass of one mole of $CaCO_3$ = 100 g

number of moles of $CaCO_3$ = ...

number of moles of HCl = ...

reagent in excess is .....

reason ..... [4]

(iii) Use your answer to **(ii)** to calculate the maximum volume of carbon dioxide produced measured at r.t.p.

..... [1]

7. S08

Using 25.0 cm^3 of aqueous sodium hydroxide, 2.24 mol / dm^3, 3.86 g of crystals were obtained. Calculate the percentage yield.

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

$$Na_2SO_4 + 10H_2O \longrightarrow Na_2SO_4.10H_2O$$

Number of moles of NaOH used = ...

Maximum number of moles of $Na_2SO_4.10H_2O$ that could be formed = ...

Mass of one mole of $Na_2SO_4.10H_2O$ = 322 g

Maximum yield of sodium sulphate-10-water = ... g

Percentage yield = ... % [4]

W08

Both iron and steel rust. The formula for rust is $Fe_2O_3.2H_2O$.
It is hydrated iron(III) oxide.

(i) Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

..... [1]

(ii) Use your answer to **(i)** to calculate the percentage of iron in rust.

.....

..... [2]

8. W08

Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

.....

..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

9. W08

The complete combustion of an alkane gives carbon dioxide and water.

(i) 10 cm^3 of butane is mixed with 100 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

10. /J/07

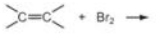
Cooking products, fats and vegetable oils, are mixtures of saturated and unsaturated esters.

The degree of unsaturation can be estimated by the following experiment. 4 drops of the oil are dissolved in 5 cm^3 of ethanol. Dilute bromine water is added a drop at a time until the brown colour no longer disappears. Enough bromine has been added to the sample to react with all the double bonds.

cooking product	mass of saturated fat in 100 g of product / g	mass of unsaturated fat in 100 g of product / g	number of drops of bromine water
margarine	35	35	5
butter	45	28	4
corn oil	10	84	12
soya oil	15	70	10
lard	38	56	.....

(i) Complete the one blank space in the table. [1]

(ii) Complete the equation for bromine reacting with a double bond.



[2]

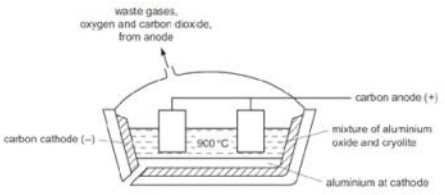
(iii) Using saturated fats in the diet is thought to be a major cause of heart disease. Which of the products is the least likely to cause heart disease?

..... [1]

Topic 5 – Electricity and chemistry

11. W11

Aluminium is extracted by the electrolysis of a molten mixture of alumina, which is aluminium oxide, and cryolite.



(a) (i) Alumina is obtained from the main ore of aluminium. Name this ore.

..... [1]

(ii) Explain why it is necessary to use a mixture, alumina and cryolite, rather than just alumina.

.....

..... [2]

(iii) Copper can be extracted by the electrolysis of an aqueous solution. Suggest why the electrolysis of an aqueous solution cannot be used to extract aluminium.

.....

.....

..... [2]

(b) The ions which are involved in the electrolysis are Al^{3+} and O^{2-}. The products of this electrolysis are given on the diagram.
Explain how they are formed. Use equations where appropriate.

.....

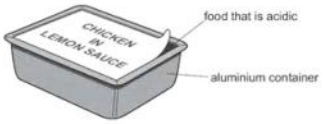
.....

.....

..... [4]

(c) The uses of a metal are determined by its properties.

(i) Foods which are acidic can be supplied in aluminium containers.

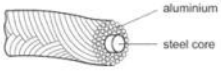


Explain why the acid in the food does not react with the aluminium.

.....

..... [1]

(ii) Explain why overhead electrical power cables are made from aluminium with a steel core.



.....

.....

..... [3]

[Total: 13]

12. S09

The results of experiments on electrolysis using inert electrodes are given in the table.

Complete the table; the first line has been completed as an example.

electrolyte	change at negative electrode	change at positive electrode	change to electrolyte
molten lead(II) bromide	lead formed	bromine formed	used up
.....	potassium formed	iodine formed	used up
dilute aqueous sodium chloride	.....	.....	.....
aqueous copper(II) sulfate	.....	.....	.....
.....	hydrogen formed	bromine formed	potassium hydroxide formed

[Total: 8]

13. W08

The electrolysis of concentrated aqueous sodium chloride produces three commercially important chemicals hydrogen, chlorine and sodium hydroxide.

(a) The ions present are $Na^+(aq)$, $H^+(aq)$, $Cl^-(aq)$ and $OH^-(aq)$.

(i) Complete the ionic equation for the reaction at the negative electrode (cathode).

..... + ... → H_2 [1]

(ii) Complete the ionic equation for the reaction at the positive electrode (anode).

..... – ..... → Cl_2 [1]

(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

..... [1]

14. W07

The remaining zinc oxide reacts with sulphuric acid to give aqueous zinc sulphate. This is electrolysed with inert electrodes (the electrolysis is the same as that of copper(II) sulphate with inert electrodes).
ions present: $Zn^{2+}(aq)$ $SO_4^{2-}(aq)$ $H^+(aq)$ $OH^-(aq)$

(i) Zinc forms at the negative electrode (cathode). Write the equation for this reaction.

..... [1]

(ii) Write the equation for the reaction at the positive electrode (anode).

..... [2]

(iii) The electrolyte changes from aqueous zinc sulphate to

..... [1]

15. S08

Copper is purified by electrolysis.

(a) Complete the following.

The positive electrode (anode) is made from .....

The negative electrode (cathode) is made from .....

The electrolyte is aqueous ..... [3]

(b) Write an ionic equation for the reaction at the positive electrode (anode).

..... [2]

(c) **(i)** Give **two** reasons why copper is used,

in electric wiring, ...

..... [2]

in cooking utensils, ...

..... [2]

(ii) Give another use of copper.

..... [1]

[Total: 10]

16. M/J/07

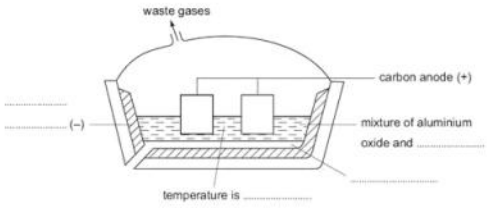
Aluminium is extracted by the electrolysis of a molten mixture that contains alumina, which is aluminium oxide, Al_2O_3.

(a) The ore of aluminium is bauxite. This contains alumina, which is amphoteric, and iron(III) oxide, which is basic. The ore is heated with aqueous sodium hydroxide. Complete the following sentences.

The ..... dissolves to give a solution of .....

The ..... does not dissolve and can be removed by ..... [4]

(b) Complete the labelling of the diagram.



[4]

(c) The ions that are involved in the electrolysis are Al^{3+} and O^{2-}.

(i) Write an equation for the reaction at the cathode.

..... [2]

(ii) Explain how carbon dioxide is formed at the anode.

.....

..... [2]

(d) Give an explanation for each of the following.

(i) Aluminium is used extensively in the manufacture of aircraft.

..... [1]

(ii) Aluminium is used to make food containers.

..... [2]

(iii) Aluminium electricity cables have a steel core.

..... [1]

17. N/06

(b) Impure copper is extracted from the ore. This copper is refined by electrolysis.

(i) Name;
the material used for the positive electrode (anode).

.....

the material used for the negative electrode (cathode).

.....

a suitable electrolyte.

..... [3]

(ii) Write an ionic equation for the reaction at the negative electrode.

..... [1]

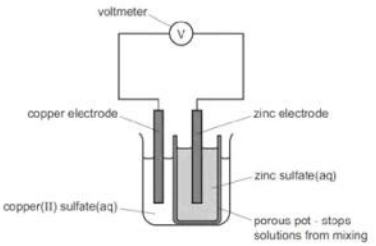
(iii) One use of this pure copper is electrical conductors, another is to make alloys. Name the metal that is alloyed with copper to make brass.

..... [1]

Topic 6 –Chemical Changes

1. W09

(c) Zinc electrodes have been used in cells for many years, one of the first was the Daniel cell in 1831.



(i) Give an explanation for the following in terms of atoms and ions.

observation at zinc electrode – *the electrode becomes smaller*

explanation .....

..... [1]

observation at copper electrode – *the electrode becomes bigger*

explanation .....

..... [1]

(ii) When a current flows, charged particles move around the circuit.

What type of particle moves through the electrolytes?

..... [1]

Which particle moves through the wires and the voltmeter?

..... [1]

[Total: 10]

2. S09

Hydrogen reacts with the halogens to form hydrogen halides.

(a) Bond energy is the amount of energy, in kJ, that must be supplied (endothermic) to break one mole of a bond.

bond	bond energy in kJ/mol
H–H	+436
Cl–Cl	+242
H–Cl	+431

Use the above data to show that the following reaction is exothermic.

H–H + Cl–Cl → 2H–Cl

.....

.....

.....

.....

..... [3]

3. W07

The alcohols form a homologous series. The first four members are methanol, ethanol, propan-1-ol and butan-1-ol.

(a) One characteristic of a homologous series is that the physical properties vary in a predictable way. The table below gives the heats of combustion of the first three alcohols.

alcohol	formula	heat of combustion in kJ/mol
methanol	CH_3OH	-730
ethanol	CH_3-CH_2-OH	-1370
propan-1-ol	CH_3-CH_2-CH_2-OH	-2020
butan-1-ol	CH_3-CH_2-CH_2-CH_2-OH	

(i) The minus sign indicates that there is less chemical energy in the products than in the reactants. What form of energy is given out by the reaction?

..... [1]

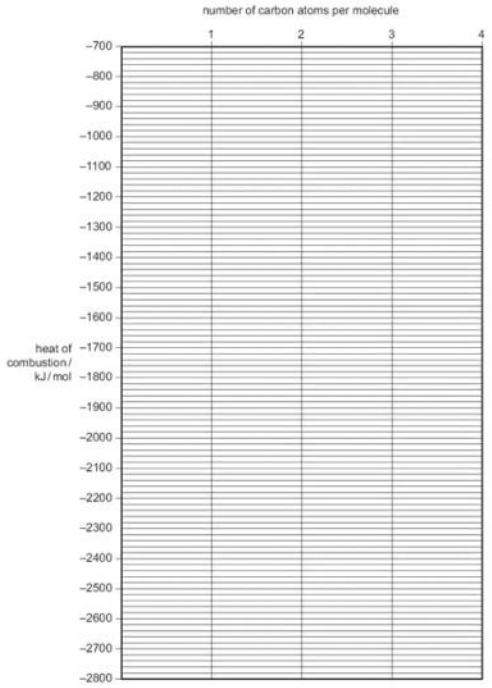
(ii) Is the reaction exothermic or endothermic?

..... [1]

(iii) Complete the equation for the complete combustion of ethanol.

C_2H_5OH + ...O_2 → ..... + ... [2]

(iv) Determine the heat of combustion of butan-1-ol by plotting the heats of combustion of the first three alcohols against the number of carbon atoms per molecule.



The heat of combustion of butan-1-ol = ... kJ / mol [3]

4. M/J/06

(a) Exothermic reactions produce heat energy.

An important fuel is methane, natural gas. The equation for its combustion is as follows.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

(i) In chemical reactions bonds are broken and new bonds are formed. Using this reaction give an example of

a bond that is broken, ...

a bond that is formed. ..... [2]

(ii) Explain, using the idea of bonds forming and breaking, why this reaction is exothermic, that is it produces heat energy.

.....

..... [2]

(b) Some radioactive isotopes are used as nuclear fuels.

(i) Give the symbol and the nucleon number of an isotope that is used as a nuclear fuel.

..... [2]

(ii) Give another use of radioactive isotopes.

..... [1]

5. N/05

(i) Complete the following table that describes the bond breaking and forming in the reaction between nitrogen and hydrogen to form ammonia.

bonds	energy change /kJ	exothermic or endothermic
1 mole of N ≡ N broken	+945	.....
3 moles of ..... broken	+1308	.....
6 moles of N – H formed	-2328	.....

[3]

(ii) Explain, using the above data, why the forward reaction is exothermic.

.....

..... [2]

6. M/J/03

The reactions of these metals with oxygen are exothermic.

$$2Ba(s) + O_2(g) \rightarrow 2BaO(s)$$

(i) Give an example of bond forming in this reaction.

.....

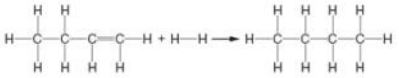
(ii) Explain using the idea of bond breaking and forming why this reaction is exothermic.

.....

.....[3]

7. M/J/01

The equation, given below, represents the formation of one mole of butane from butene.



(i) What is the mass of one mole of butane molecules?

.....

(ii) Complete the table that shows the bonds broken and formed in this reaction.

bond	energy change in kJ/mol	exothermic or endothermic
1 mole of C=C bonds broken	+610	endothermic
1 mole of H—H bonds broken	+436	.....
1 mole of C—C bonds formed	–346	.....
2 moles of ..... bonds formed	–826	.....

(iii) Use the data in the table to determine if the reaction is exothermic or endothermic. Give a reason for your choice.

.....

.....[6]

8. M/J/00

When aqueous solutions of germanium(II) chloride and of iron(III) chloride are mixed, the following reaction occurs.

$$GeCl_2 + 2FeCl_3 \longrightarrow 2FeCl_2 + GeCl_4$$

or $Ge^{2+} + 2Fe^{3+} \longrightarrow 2Fe^{2+} + Ge^{4+}$

(i) Is the germanium(II) chloride acting as an oxidising agent or reducing agent? Explain your choice using the idea of electron transfer.

.....

..... [2]

9. N/99

The thermal decomposition of calcium carbonate is a reversible reaction.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \qquad \Delta H = +178\,kJ$$

(i) Explain why the forward reaction is described as *endothermic*.

..... [1]

(ii) Describe **two** ways of moving the position of the above equilibrium towards the right-hand side.

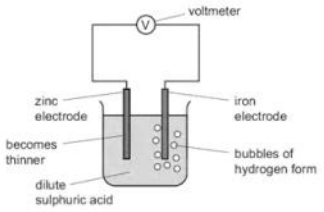
.....

..... [2]

10. M/J/06

Cell reactions are both exothermic and redox. They produce electrical energy as well as heat energy.

(i) The diagram shows a simple cell.



Which substance in this cell is the reductant and which ion is the oxidant?

reductant .....

oxidant ..... [2]

(ii) How could the voltage of this cell be increased?

..... [1]

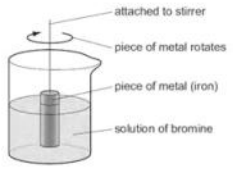
(iii) What is the important large scale use, relating to iron and steel, of this type of cell reaction?

..... [1]

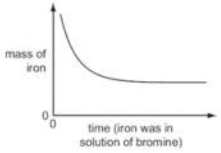
Topic 7.1 – Chemical reactions

1. W11

The rate of the reaction between iron and aqueous bromine can be investigated using the apparatus shown below.



(a) A piece of iron was weighed and placed in the apparatus. It was removed at regular intervals and the clock was paused. The piece of iron was washed, dried, weighed and replaced. The clock was restarted.
This was continued until the solution was colourless.
The mass of iron was plotted against time. The graph shows the results obtained.



(i) Suggest an explanation for the shape of the graph.

.....

.....

..... [3]

(ii) Predict the shape of the graph if a similar piece of iron with a much rougher surface had been used.
Explain your answer.

.....

..... [2]

(iii) Describe how you could find out if the rate of this reaction depended on the speed of stirring.

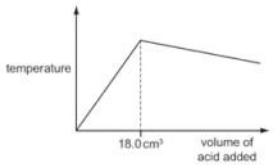
.....

.....

..... [2]

2. S11

(d) 20.0 cm^3 of aqueous sodium hydroxide, 2.00 mol / dm^3, was placed in a beaker. The temperature of the alkali was measured and 1.0 cm^3 portions of hydriodic acid were added. After each addition, the temperature of the mixture was measured. Typical results are shown on the graph.



$$NaOH(aq) + HI(aq) \rightarrow NaI(aq) + H_2O(l)$$

(i) Explain why the temperature increases rapidly at first then stops increasing.

.....

..... [2]

(ii) Suggest why the temperature drops after the addition of 18.0 cm^3 of acid.

..... [1]

(iii) In another experiment, it was shown that 15.0 cm^3 of the acid neutralised 20.0 cm^3 of aqueous sodium hydroxide, 1.00 mol / dm^3. Calculate the concentration of the acid.

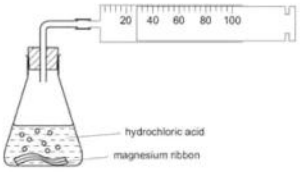
.....

..... [2]

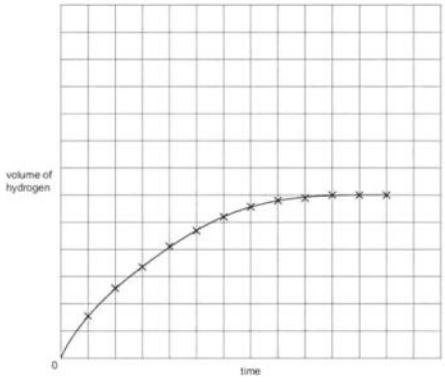
3. N/06

The rate of a reaction depends on concentration of reactants, temperature and possibly a catalyst or light.

(a) A piece of magnesium ribbon was added to 100 cm^3 of 1.0 mol/dm^3 hydrochloric acid. The hydrogen evolved was collected in a gas syringe and its volume measured every 30 seconds.



In all the experiments mentioned in this question, the acid was in excess.
The results were plotted to give a graph.



(i) The experiment was repeated. Two pieces of magnesium ribbon were added to 100 cm^3 of 1.0 mol/dm^3 hydrochloric acid. Sketch this graph on the same grid and label it X.

[2]

(ii) The experiment was repeated using one piece of magnesium ribbon and 100 cm^3 of 1.0 mol/dm^3 ethanoic acid. Describe how the **shape** of this graph would differ from the one given on the grid.

.....

..... [2]

(b) Reaction rate increases when concentration or temperature is increased.
Using the idea of reacting particles, explain why;

increasing concentration increases reaction rate,

.....

..... [2]

increasing temperature increases reaction rate.

.....

..... [2]

(c) The rate of a photochemical reaction is affected by light. A reaction, in plants, between carbon dioxide and water is photochemical.

(i) Name the **two** products of this reaction.

.....

..... [2]

(ii) This reaction will only occur in the presence of light and another chemical. Name this chemical.

..... [1]

4. W07

(a) A small piece of marble, calcium carbonate, was added to 5 cm^3 of hydrochloric acid at 25 °C. The time taken for the reaction to stop was measured.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

Similar experiments were performed always using 5 cm^3 of hydrochloric acid.

experiment	number of pieces of marble	concentration of acid in mol/dm^3	temperature / °C	time / min
1	1	1.00	25	3
2	1	0.50	25	7
3	1 piece crushed	1.00	25	1
4	1	1.00	35	2

Explain each of the following in terms of **collisions between reacting particles.**

(i) Why is the rate in experiment 2 slower than in experiment 1?

.....

..... [2]

(ii) Why is the rate in experiment 3 faster than in experiment 1?

.....

..... [2]

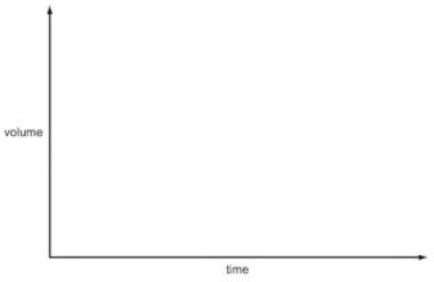
(iii) Why is the rate in experiment 4 faster than in experiment 1?

.....

..... [2]

(b) An alternative method of measuring the rate of this reaction would be to measure the volume of carbon dioxide produced at regular intervals.

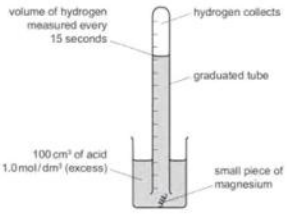
(i) Sketch this graph



[2]

5. S10

A diagram of the apparatus which could be used to investigate the rate of reaction between magnesium and an excess of an acid is drawn below.



(a) The magnesium kept rising to the surface. In one experiment, this was prevented by twisting the magnesium around a piece of copper. In a second experiment, the magnesium was held down by a plastic net fastened to the beaker.

(i) Suggest a reason why magnesium, which is denser than water, floated to the surface.

.....

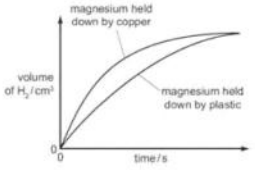
..... [1]

(ii) Iron, zinc and copper have similar densities. Why was copper a better choice than iron or zinc to weigh down the magnesium?

.....

..... [1]

(b) The only difference in the two experiments was the method used to hold down the magnesium. The results are shown below.



(i) In which experiment did the magnesium react faster?

..... [1]

(ii) Suggest a reason why the experiment chosen in **(i)** had the faster rate.

..... [1]

(c) The experiment was repeated using 1.0 mol / dm³ propanoic acid instead of 1.0 mol / dm³ hydrochloric acid. Propanoic acid is a weak acid.

(i) How would the graph for propanoic acid **differ** from the graph for hydrochloric acid?

..... [1]

(ii) How would the graph for propanoic acid be the **same** as the graph for hydrochloric acid?

..... [1]

(d) Give **two** factors which would alter the rate of this reaction.
For each factor explain why it alters the rate.

factor .....

explanation .....

.....

factor .....

explanation .....

..... [4]

[Total: 10]

6. S08

6 Three of the factors that can influence the rate of a chemical reaction are:

- physical state of the reactants
- light
- the presence of a catalyst

(a) The first recorded dust explosion was in a flour mill in Italy in 1785. Flour contains carbohydrates. Explosions are very fast exothermic reactions.

(i) Use the collision theory to explain why the reaction between the particles of flour and the oxygen in the air is very fast.

.....

..... [2]

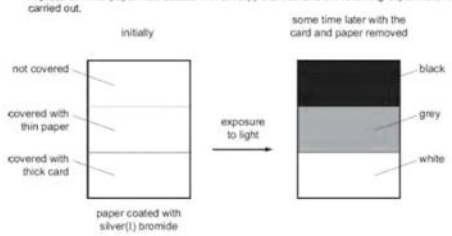
(ii) Write a word equation for this exothermic reaction.

..... [1]

The decomposition of silver(I) bromide is the basis of film photography. The equation for this decomposition is:

$$\underset{\text{white}}{2AgBr} \longrightarrow \underset{\text{black}}{2Ag} + Br_2$$

This reaction is photochemical.
A piece of white paper was coated with silver(I) bromide and the following experiment was carried out.



(b) Explain the results.

.....

.....

..... [3]

(c) The fermentation of glucose is catalysed by enzymes from yeast. Yeast is added to aqueous glucose, the solution starts to bubble and becomes cloudy as more yeast cells are formed.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

The reaction is exothermic.

Eventually the fermentation stops when the concentration of ethanol is about 12%.

(i) What is an enzyme?

..... [1]

(ii) Pasteur said that fermentation was respiration in the absence of air. Suggest a definition of *respiration*.

.....

..... [2]

(iii) On a large scale, the reaction mixture is cooled. Suggest a reason why this is necessary.

..... [1]

(iv) Why does the fermentation stop? Suggest **two** reasons.

.....

..... [2]

7. N/03

Some of the factors that can determine the rate of a reaction are concentration, temperature and light intensity.

(a) A small piece of calcium carbonate was added to an excess of hydrochloric acid. The time taken for the carbonate to react completely was measured.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The experiment was repeated at the same temperature, using pieces of calcium carbonate of the same size but with acid of a different concentration. In all the experiments an excess of acid was used.

concentration of acid / mol dm^{-3}	4	2	2	.....
number of pieces of carbonate	1	1	2	1
time / s	.....	80	.....	160

(i) Complete the table (assume the rate is proportional to both the acid concentration and the number of pieces of calcium carbonate). [3]

(ii) Explain why the reaction rate would increase if the temperature was increased.

.....

.....[2]

(iii) Explain why the rate of this reaction increases if the piece of carbonate is crushed to a powder.

.....[1]

(iv) Fine powders mixed with air can explode violently. Name an industrial process where there is a risk of this type of explosion.

.....

.....[1]

(b) Sodium chlorate(I) decomposes to form oxygen and sodium chloride. This is an example of a photochemical reaction. The rate of reaction depends on the intensity of the light.

$$2NaClO(aq) \longrightarrow 2NaCl(aq) + O_2(g)$$

(i) Describe how the rate of this reaction could be measured.

.....

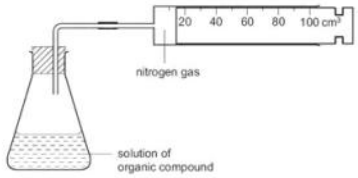
.....[2]

(ii) How could you show that this reaction is photochemical?

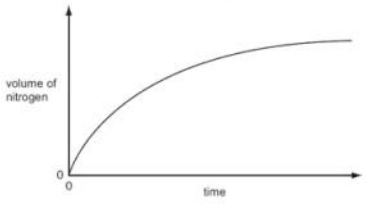
.....

.....[1]

(c) The rate of this reaction can be measured using the following apparatus.



The results of this experiment are shown on the graph below.



(i) How does the rate of this reaction vary with time?

.....

..... [1]

(ii) Why does the rate vary?

.....

..... [2]

(iii) The reaction is catalysed by copper powder. Sketch the graph for the catalysed reaction on the same grid. [2]

(iv) Why is copper powder more effective as a catalyst than a single piece of copper?

..... [1]

Topic 7.2–Reversible reactions

1. W11

Reversible reactions can come to equilibrium. The following are three examples of types of gaseous equilibria.

$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ **reaction 1**

$A_2(g) + 3B_2(g) \rightleftharpoons 2AB_3(g)$ **reaction 2**

$2AB_3(g) \rightleftharpoons 2AB(g) + B_2(g)$ **reaction 3**

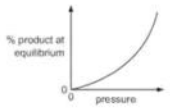
(a) Explain the term *equilibrium*.

.....

..... [2]

(b) The following graphs show how the percentage of products of a reversible reaction at equilibrium could vary with pressure.
For each graph, decide whether the percentage of products decreases, increases or stays the same when the pressure is **increased**, then match each graph to one of the above reactions and give a reason for your choice.

(i)



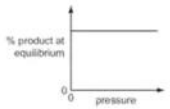
effect on percentage of products .....

reaction .....

reason .....

..... [3]

(ii)



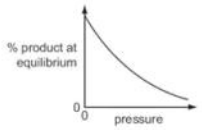
effect on percentage of products .....

reaction .....

reason .....

..... [3]

(iii)



effect on percentage of products .....

reaction .....

reason .....

..... [3]

[Total: 11]

2. W09

(b) Sulfuric acid was first made in the Middle East by heating the mineral, green vitriol, $FeSO_4.7H_2O$. The gases formed were cooled.

$FeSO_4.7H_2O(s) \rightarrow FeSO_4(s) + 7H_2O(g)$
green crystals yellow powder

$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$

On cooling

$SO_3 + H_2O \rightarrow H_2SO_4$ sulfuric acid
$SO_2 + H_2O \rightarrow H_2SO_3$ sulfurous acid

(i) How could you show that the first reaction is reversible?

.....

..... [2]

(ii) Sulfurous acid is a reductant. What would you see when acidified potassium manganate(VII) is added to a solution containing this acid?

.....

..... [2]

(iii) Suggest an explanation why sulfurous acid in contact with air changes into sulfuric acid.

..... [1]

3. S10

Iodine reacts with chlorine to form dark brown iodine monochloride.

$I_2 + Cl_2 \rightarrow 2ICl$

This reacts with more chlorine to give yellow iodine trichloride.
There is an equilibrium between these iodine chlorides.

$ICl(l) + Cl_2(g) \rightleftharpoons ICl_3(s)$
dark brown yellow

(a) Explain what is meant by *equilibrium*.

.....

.....

..... [2]

(b) When the equilibrium mixture is heated it becomes a darker brown colour.
Is the reverse reaction endothermic or exothermic? Give a reason for your choice.

.....

.....

..... [2]

(c) The pressure on the equilibrium mixture is decreased.

(i) How would this affect the position of equilibrium and why?

It would move to the ..... [1]

reason .....

..... [1]

(ii) Describe what you would observe.

.....

..... [1]

[Total: 7]

4. S09

Carbon monoxide can be removed from coal gas by mixing it with steam and passing the mixture over a catalyst of iron(III) oxide at 400°C.

$CO + H_2O \rightleftharpoons CO_2 + H_2$

(i) Write a word equation for this reaction.

..... [1]

(ii) What does the symbol $\rightleftharpoons$ mean?

..... [1]

5. S08

Carbonyl chloride, $COCl_2$, is a colourless gas. It is made by the following reaction.

$CO(g) + Cl_2(g) \overset{\text{cool}}{\underset{\text{heat}}{\rightleftharpoons}} COCl_2(g)$

(a) When the pressure on the equilibrium mixture is decreased, the position of equilibrium moves to left.

(i) How does the concentration of each of the three chemicals change?

.....

..... [2]

(ii) Explain why the position of equilibrium moves to left.

.....

..... [2]

(b) Using the information given with the equation, is the forward reaction exothermic or endothermic? Give a reason for your choice.

.....

..... [2]

6. S09

Ammonia is manufactured by the Haber process.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ the forward reaction is exothermic

(a) (i) Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen from ..... [1]

hydrogen from ..... [1]

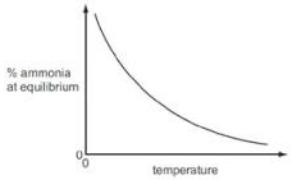
(ii) Name the catalyst used in this process.

..... [1]

(iii) What is the most important use of ammonia?

..... [1]

(b) The following graph shows how the percentage of ammonia in the equilibrium mixture changes with temperature.



(i) Explain the term *equilibrium*.

.....

.....

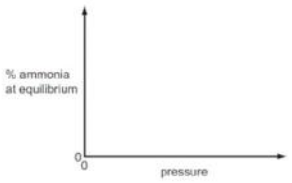
.....

..... [2]

(ii) How does the percentage of ammonia vary with temperature?

..... [1]

(c) (i) Sketch a graph which shows how the percentage of ammonia in the equilibrium mixture varies with pressure.



[1]

(ii) Explain why the graph has the shape shown.

.....

.....

..... [2]

[Total: 10]

7. N/05

Reversible reactions can come to equilibrium. They have both a forward and a backward reaction.

(a) When water is added to an acidic solution of bismuth(III) chloride, a white precipitate forms and the mixture slowly goes cloudy.

$$\underset{\text{colourless}}{BiCl_3(aq)} + H_2O(l) \underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}} \underset{\text{white}}{BiOCl(s)} + 2HCl(aq)$$

(i) Explain why the rate of the forward reaction decreases with time.

.....

..... [2]

(ii) Why does the rate of the backward reaction increase with time?

.....

..... [1]

(iii) After some time why does the appearance of the mixture remain unchanged?

.....

..... [2]

(iv) When a few drops of concentrated hydrochloric acid are added to the cloudy mixture, it changes to a colourless solution. Suggest an explanation.

.....

..... [2]

Topic 7.3 –Redox reactions

1. W11

(b) Iron has two oxidation states +2 and +3. There are two possible equations for the redox reaction between iron and bromine.

$$Fe + Br_2 \rightarrow Fe^{2+} + 2Br^-$$

$$2Fe + 3Br_2 \rightarrow 2Fe^{3+} + 6Br^-$$

(i) Indicate, on the first equation, the change which is oxidation. Give a reason for your choice.

.....

..... [2]

(ii) Which substance in the first equation is the reductant (reducing agent)?

..... [1]

2. S11

Hydriodic acid, HI(aq), is a strong acid. Its salts are iodides.

(a) It has the reactions of a typical strong acid. Complete the following equations.

(i) .....Li + ...HI → ..... + ... [1]

(ii) zinc carbonate + hydriodic acid → ..... + ... + ... + ... [1]

(iii) MgO + ...HI → ..... + ... [1]

(b) Two of the reactions in **(a)** are acid / base and one is redox. Which one is redox? Explain your choice.

.....

.....

..... [2]

(c) Describe how you could distinguish between hydriodic, HI(aq), and hydrobromic, HBr(aq) acids, by bubbling chlorine through these two acids.

result with hydriodic acid .....

result with hydrobromic acid ..... [2]

3. W09

(b) Ozone is an oxidant. It can oxidise an iodide to iodine.

$$2I^- + O_3 + 2H^+ \rightarrow I_2 + O_2 + H_2O$$

(i) What would you see when ozone is bubbled through aqueous acidified potassium iodide?

.....

.....

.....

..... [2]

(ii) Explain in terms of electron transfer why the change from iodide ions to iodine molecules is oxidation.

.....

..... [1]

(iii) Explain, using your answer to **b(ii)**, why ozone is the oxidant in this reaction.

.....

..... [1]

4. W07

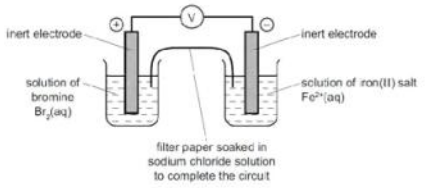
The reaction between magnesium and bromine is redox. Complete the sentences.

Magnesium is the .....agent because it has .....electrons.

Bromine has been .....because it has ..... electrons. [4]

5. W10

The diagram shows a cell. This is a device which produces electrical energy. The reaction in a cell is a redox reaction and involves electron transfer.



(i) Complete the sentence.

A cell will change ..... energy into electrical energy. [1]

(ii) Draw an arrow on the diagram to show the direction of the electron flow. [1]

(iii) In the left hand beaker, the colour changes from brown to colourless. Complete the equation for the reaction.

Br_2 + ... → .....

[2]

(iv) Is the change in **(iii)** oxidation or reduction? Give a reason for your choice.

.....

..... [1]

(v) Complete the following description of the reaction in the right hand beaker.

Fe^{2+} changes into ..... . [1]

(vi) When a solution of bromine is replaced by a solution of chlorine, the voltage increases. When a solution of bromine is replaced by a solution of iodine, the voltage decreases.
Suggest an explanation for this difference.

.....

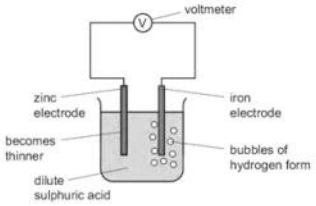
..... [1]

[Total: 7]

6. M/J/06

Cell reactions are both exothermic and redox. They produce electrical energy as well as heat energy.

(i) The diagram shows a simple cell.



Which substance in this cell is the reductant and which ion is the oxidant?

reductant .....

oxidant ..... [2]

(ii) How could the voltage of this cell be increased?

..... [1]

(iii) What is the important large scale use, relating to iron and steel, of this type of cell reaction?

..... [1]

7. W08

The following is a redox reaction.

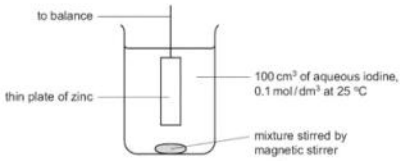
$$Mn + Sn^{2+} \longrightarrow Mn^{2+} + Sn$$

Indicate on the equation the change which is oxidation.
Give a reason for your choice.

..... [2]

8. J/05

The following apparatus was used to measure the rate of the reaction between zinc and iodine.



The mass of the zinc plate was measured every minute until the reaction was complete.

(a) Write an ionic equation for the redox reaction that occurred between zinc atoms and iodine molecules.

..... [2]

(b) Describe how you could show by adding aqueous sodium hydroxide and aqueous ammonia that a solution contained zinc ions.

result with sodium hydroxide .....

excess sodium hydroxide .....

result with aqueous ammonia .....

excess aqueous ammonia ..... [3]

9. W09

(b) Ozone is an oxidant. It can oxidise an iodide to iodine.

$$2I^- + O_3 + 2H^+ \rightarrow I_2 + O_2 + H_2O$$

(i) What would you see when ozone is bubbled through aqueous acidified potassium iodide?

.....

.....

.....

..... [2]

(ii) Explain in terms of electron transfer why the change from iodide ions to iodine molecules is oxidation.

.....

..... [1]

(iii) Explain, using your answer to **b(ii)**, why ozone is the oxidant in this reaction.

.....

..... [1]

10. W07

The reaction between magnesium and bromine is redox. Complete the sentences.

Magnesium is the ..... agent because it has

..... electrons.

Bromine has been ..... because it has .....

electrons. [4]

Topic 8 –Acids, bases and salts

1. N11

This question is concerned with the following oxides.

sulfur dioxide
carbon monoxide
lithium oxide
aluminium oxide
nitrogen dioxide
strontium oxide

(a) (i) Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?

..... [1]

(ii) Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?

..... [1]

(iii) Which of the above oxides will react with both hydrochloric acid and aqueous sodium hydroxide?

..... [1]

(iv) Which of the above oxides will not react with hydrochloric acid or with aqueous sodium hydroxide?

..... [1]

2. W11

(c) Describe how you could test the solution to find out which ion, Fe^{2+} or Fe^{3+}, is present.

.....

.....

..... [3]

3. S09

Insoluble salts are made by precipitation.

(a) A preparation of the insoluble salt calcium fluoride is described below.

To 15 cm^3 of aqueous calcium chloride, 30 cm^3 of aqueous sodium fluoride is added. The concentration of both solutions is 1.00 mol / dm^3. The mixture is filtered and the precipitate washed with distilled water. Finally, the precipitate is heated in an oven.

(i) Complete the equation.

Ca^{2+} + ...F^- ⟶ ..... [2]

(ii) Why is the volume of sodium fluoride solution double that of the calcium chloride solution?

.....

..... [1]

(iii) Why is the mixture washed with distilled water?

.....

..... [1]

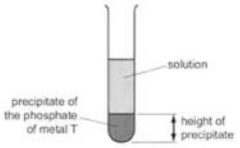
(iv) Why is the solid heated?

.....

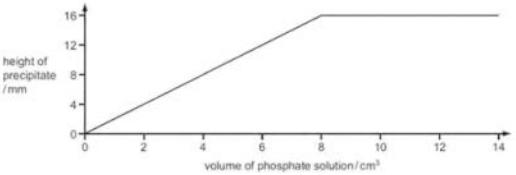
..... [1]

(b) The formulae of insoluble compounds can be found by precipitation reactions.

To 12.0 cm^3 of an aqueous solution of the nitrate of metal T was added 2.0 cm^3 of aqueous sodium phosphate, Na_3PO_4. The concentration of both solutions was 1.00 mol / dm^3. When the precipitate had settled, its height was measured.



The experiment was repeated using different volumes of the phosphate solution. The results are shown on the following graph.



What is the formula of the phosphate of metal T? Give your reasoning.

.....

.....

.....

..... [3]

[Total: 8]

4. W10

Soluble salts can be made using a base and an acid.

(a) Complete this method of preparing dry crystals of the soluble salt cobalt(II) chloride-6-water from the insoluble base cobalt(II) carbonate.

Step 1

Add an excess of cobalt(II) carbonate to hot dilute hydrochloric acid.

Step 2

.....

.....

Step 3

.....

.....

Step 4

.....

..... [4]

5. M/J/06

(a) Four bottles were known to contain aqueous ammonia, dilute hydrochloric acid, sodium hydroxide solution and vinegar, which is dilute ethanoic acid. The bottles had lost their labels. The pH values of the four solutions were 1, 4, 10 and 13.

Complete the table.

solution	pH
aqueous ammonia	
dilute hydrochloric acid	
sodium hydroxide solution	
vinegar	

[2]

6. S09

They react with water to form acidic solutions.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$$HF + H_2O \rightleftharpoons H_3O^+ + F^-$$

(i) Explain why water behaves as a base in both of these reactions.

.....

..... [2]

(ii) At equilibrium, only 1% of the hydrogen chloride exists as molecules, the rest has formed ions. In the other equilibrium, 97% of the hydrogen fluoride exists as molecules, only 3% has formed ions.

What does this tell you about the strength of each acid?

.....

..... [2]

(iii) How would the pH of these two solutions differ?

..... [1]

7. W08

Complete the following table.

gas	test for gas
ammonia	
	bleaches damp litmus paper
hydrogen	
	relights a glowing splint
	turns limewater milky

[Total: 5]

8. W08

Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.

(a) Sodium benzoate is a salt, it has the formula C_6H_5COONa. It can be made by the neutralisation of benzoic acid by sodium hydroxide.

(i) Deduce the formula of benzoic acid.

..... [1]

(ii) Write a word equation for the reaction between benzoic acid and sodium hydroxide.

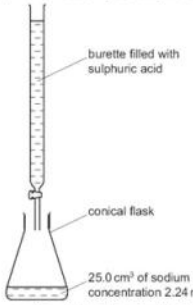
..... [1]

(iii) Name **two** other compounds that would react with benzoic acid to form sodium benzoate.

..... [2]

9. S08

Crystals of sodium sulphate-10-water, $Na_2SO_4.10H_2O$, are prepared by titration.



(a) 25.0 cm^3 of aqueous sodium hydroxide is pipetted into a conical flask. A few drops of an indicator are added. Using a burette, dilute sulphuric acid is slowly added until the indicator just changes colour. The volume of acid needed to neutralise the alkali is noted.

Suggest how you would continue the experiment to obtain pure, dry crystals of sodium sulphate-10-water.

.....

.....

.....

..... [4]

10. S08

Sulphuric acid is a typical strong acid.

(a) Change the equations given into a different format.

(i) $Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$
Change into a word equation.

..... [1]

(ii) lithium oxide + sulphuric acid $\longrightarrow$ lithium sulphate + water
Change into a symbol equation.

..... [2]

(iii) $CuO + 2H^+ \longrightarrow Cu^{2+} + H_2O$
Change the ionic equation into a symbol equation.

..... [2]

(iv) $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + H_2O$
Change into a word equation.

..... [1]

(b) When sulphuric acid dissolves in water, the following reaction occurs.
$H_2SO_4 + H_2O \longrightarrow HSO_4^- + H_3O^+$
Explain why water is behaving as a base in this reaction.

..... [2]

(c) Sulphuric acid is a strong acid, ethanoic acid is a weak acid.
Explain the difference between a strong acid and a weak acid.

.....

..... [2]

[Total: 10]

11. W07

Methylamine, CH_3NH_2, is a weak base. Its properties are similar to those of ammonia.

(a) When methylamine is dissolved in water, the following equilibrium is set up.

$$\underset{\text{base}}{CH_3NH_2} + H_2O \rightleftharpoons \underset{\text{acid}}{CH_3NH_3^+} + OH^-$$

(i) Suggest why the arrows are not the same length.

..... [1]

(ii) Explain why water is stated to behave as an acid and methylamine as a base.

.....

..... [2]

(b) An aqueous solution of the strong base, sodium hydroxide, is pH 12. Predict the pH of an aqueous solution of methylamine which has the same concentration. Give a reason for your choice of pH.

.....

..... [2]

(c) Methylamine is a weak base like ammonia.

(i) Methylamine can neutralise acids.

$$2CH_3NH_2 + H_2SO_4 \rightarrow \underset{\text{methylammonium sulphate}}{(CH_3NH_3)_2SO_4}$$

Write the equation for the reaction between methylamine and hydrochloric acid. Name the salt formed.

.....

..... [2]

(ii) When aqueous methylamine is added to aqueous iron(II) sulphate, a green precipitate is formed. What would you see if iron(III) chloride solution had been used instead of iron(II) sulphate?

..... [1]

(iii) Suggest the name of a reagent that will displace methylamine from one of its salts, for example methylammonium sulphate.

..... [1]

12. M/J/07

There are three methods of preparing salts.

Method **A** – use a burette and an indicator.

Method **B** – mix two solutions and obtain the salt by precipitation.

Method **C** – add an excess of base or a metal to a dilute acid and remove the excess by filtration.

For each of the following salt preparations, choose one of the methods **A**, **B** or **C**, name any additional reagent needed and then write or complete the equation.

(i) the soluble salt, zinc sulphate, from the insoluble base, zinc oxide

method .....

reagent .....

word equation ..... [3]

(ii) the soluble salt, potassium chloride, from the soluble base, potassium hydroxide

method .....

reagent .....

equation ..... + ... → $KCl + H_2O$ [3]

(iii) the insoluble salt, lead(II) iodide, from the soluble salt, lead(II) nitrate

method .....

reagent .....

equation Pb^{2+} + ... → ..... [4]

[Total: 10]

13. M/J/06

This question is concerned with the following oxides.

aluminium oxide	Al_2O_3
calcium oxide	CaO
carbon dioxide	CO_2
carbon monoxide	CO
magnesium oxide	MgO
sulphur dioxide	SO_2

(i) Which of the above oxides will react with hydrochloric acid but not with aqueous sodium hydroxide?

..... [1]

(ii) Which of the above oxides will react with aqueous sodium hydroxide but not with hydrochloric acid?

..... [1]

(iii) Which of the above oxides will react both with hydrochloric acid and with aqueous sodium hydroxide?

..... [1]

(iv) Which of the above oxides will react neither with hydrochloric acid nor with aqueous sodium hydroxide?

..... [1]

14. J/05

(b) To show that the polymer contains silver the following test was carried out.

The polymer fibres were chopped into small pieces and warmed with nitric acid. The silver atoms were oxidised to silver(I) ions. The mixture was filtered. Aqueous sodium chloride was added to the filtrate and a white precipitate formed.

(i) Why was the mixture filtered?

..... [1]

(ii) Explain why the change of silver atoms to silver ions is oxidation.

..... [1]

(iii) Give the name of the white precipitate.

..... [1]

15. N/05

(b) In the above method, a soluble salt was prepared by neutralising an acid with an insoluble base. Other salts have to be made by different methods.

(i) Give a brief description of how the soluble salt, rubidium sulphate could be made from the soluble base, rubidium hydroxide.

.....

.....

.....

..... [3]

(ii) Suggest a method of making the insoluble salt, calcium fluoride.

.....

.....

.....

..... [3]

16. M/J/05

(c) Complete the following table by writing "reaction" or "no reaction" in the spaces provided.

oxide	type of oxide	reaction with acid	reaction with alkali
magnesium	basic	.....	.....
aluminium	amphoteric	.....	.....

[2]

(d) Predict the equations for the decomposition of the following aluminium compounds.

(i) ..... $Al(OH)_3$ ⟶ ..... + ... [2]

(ii) aluminium nitrate ⟶ ..... + ... + ...

.... [2]

17. J/05

(d) Propanoic acid is a weak acid.

(i) The following equation represents its reaction with ammonia.

$CH_3-CH_2-COOH + NH_3 \longrightarrow CH_3-CH_2-COO^- + NH_4^+$

Explain why propanoic acid behaves as an acid and ammonia as a base.

..... [3]

(ii) Explain the expression *weak acid*.

..... [1]

18. J/05

The Carlsbad caverns in New Mexico are very large underground caves. Although the walls of these caves are coated with gypsum (hydrated calcium sulphate), the caves have been formed in limestone.

(a) It is believed that the caves were formed by sulphuric acid reacting with the limestone.

(i) Complete the word equation.

calcium carbonate + sulphuric acid ⟶ calcium sulphate + ... + ...

[1]

(ii) Describe how you could test the water entering the cave to show that it contained sulphate ions.

test .....

result ..... [2]

(iii) How could you show that the water entering the cave has a high concentration of hydrogen ions?

..... [1]

(b) Hydrogen sulphide gas which was escaping from nearby petroleum deposits was being oxidised to sulphuric acid.

(i) Complete the equation for this reaction forming sulphuric acid.

H_2S + ...O_2 ⟶ ..... [2]

(ii) Explain why all the hydrogen sulphide should be removed from the petroleum before it is used as a fuel.

..... [1]

Topic 10 – Metals

15. W11

Some hydroxides, nitrates and carbonates decompose when heated.

(a) (i) Name a metal hydroxide which does not decompose when heated.

..... [1]

(ii) Write the equation for the thermal decomposition of copper(II) hydroxide.

..... [2]

(iii) Suggest why these two hydroxides behave differently.

..... [1]

(b) (i) Metal nitrates, except those of the Group 1 metals, form three products when heated. Name the products formed when zinc nitrate is heated.

.....

..... [2]

(ii) Write the equation for the thermal decomposition of potassium nitrate.

..... [2]

16. S11

A major ore of zinc is zinc blende, ZnS. A by-product of the extraction of zinc from this ore is sulfur dioxide which is used to make sulfuric acid.

(a) (i) Zinc blende is heated in air. Zinc oxide and sulfur dioxide are formed. Write the balanced equation for this reaction.

..... [2]

(ii) Zinc oxide is reduced to zinc by heating with carbon. Name **two** other reagents which could reduce zinc oxide.

..... [2]

(iii) The zinc obtained is impure. It is a mixture of metals. Explain **how** fractional distillation could separate this mixture.
zinc bp = 908 °C, cadmium bp = 765 °C, lead bp = 1751 °C

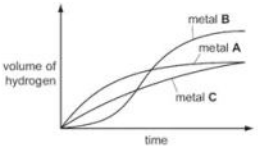
.....

..... [2]

17. S11

Excess hydrochloric acid was added to powdered zinc. The hydrogen evolved was collected and its volume measured every 20 seconds.

The experiments were repeated at the same temperature using the same number of moles of powdered magnesium and aluminium.



(a) Identify metals **A**, **B** and **C** by choosing from zinc, magnesium and aluminium. Give a reason for each choice.

metal **A** .....

.....

metal **B** .....

.....

metal **C** .....

..... [5]

(b) Using 'moles', explain why two of the metals form the same volume of hydrogen but the third metal forms a larger volume.

.....

.....

..... [3]

[Total: 8]

18. S11

Iron from the blast furnace is impure. It contains about 4 % carbon and 0.5 % silicon. Most of this impure iron is used to make mild steel, an alloy of iron containing less then 0.25 % carbon.

(a) A jet of oxygen is blown through the molten iron in the presence of a base, usually calcium oxide. Explain how the percentage of carbon is reduced and how the silicon is removed.

.....

.....

.....

..... [4]

(b) (i) Why are steel alloys used in preference to iron?

..... [1]

(ii) State a use of the following alloys.

mild steel .....

stainless steel ..... [2]

(c) Both iron and steel have typical metallic structures - a lattice of positive ions and a sea of electrons.

(i) Suggest an explanation for why they have high melting points.

.....

.....

..... [2]

(ii) Explain why, when a force is applied to a piece of steel, it does not break but just changes its shape.

.....

..... [2]

[Total: 11]

19. W10

About 4000 years ago the Bronze Age started in Britain. Bronze is an alloy of copper and tin.

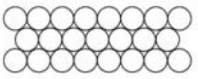
(a) (i) Suggest a reason why a bronze axe was better than a copper axe.

..... [1]

(ii) Brass is another copper alloy. Name the other metal in brass.

..... [1]

(b) The diagram below shows the arrangement of particles in a pure metal.



(i) What is the name given to a regular arrangement of particles in a crystalline solid?

..... [1]

(ii) Draw a diagram which shows the arrangement of particles in an alloy.

[2]

(iii) Explain the term *malleable*.

..... [1]

(iv) Why are metals malleable?

.....

..... [2]

(c) The common ore of tin is tin(IV) oxide and an ore of copper is malachite, $CuCO_3.Cu(OH)_2$.

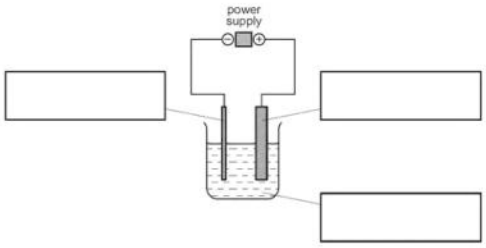
(i) Write a word equation for the reduction of tin(IV) oxide by carbon.

..... [1]

(ii) Malachite is heated to form copper oxide and two other chemicals. Name these chemicals.

..... and ..... [2]

(iii) Copper oxide is reduced to copper which is then refined by electrolysis. Label the diagram of the apparatus which could be used to refine copper.



[3]

(iv) Give **one** use of copper, other than making alloys.

..... [1]

[Total: 15]

20. S10

Titanium is a transition element. It is isolated by the following reactions.

titanium ore → titanium(IV) oxide → titanium(IV) chloride → titanium

TiO_2 $TiCl_4$ Ti

(a) Why is it usually necessary to include a number in the name of the compounds of transition elements?

..... [1]

(b) Titanium(IV) chloride is made by heating the oxide with coke and chlorine.

$$TiO_2 + 2Cl_2 \rightleftharpoons TiCl_4 + O_2$$

$$2C + O_2 \rightleftharpoons 2CO$$

Explain why the presence of coke ensures the maximum yield of the metal chloride.

.....

.....

..... [2]

(c) Explain why the change, titanium(IV) chloride to titanium, is reduction.

.....

..... [1]

(d) Complete the table which shows some of the properties of titanium and its uses. The first line has been completed as an example.

property	related use
soluble in molten steel	making steel titanium alloys
.....	making aircraft and space vehicles
resistant to corrosion, especially in sea water	.....

[2]

21. W09

(a) An important ore of zinc is zinc blende, ZnS.

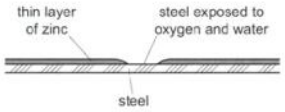
(i) How is zinc blende changed into zinc oxide?

..... [1]

(ii) Write a balanced equation for the reduction of zinc oxide to zinc by carbon.

..... [2]

(b) A major use of zinc is galvanizing; steel objects are coated with a thin layer of zinc. This protects the steel from rusting even when the layer of zinc is broken.



Explain, by mentioning ions and electrons, why the exposed steel does not rust.

.....

.....

.....

.....

.....

..... [3]

22. S09

The reactivity series of metals given below contains both familiar and unfamiliar elements. For most of the unfamiliar elements, which are marked *, their common oxidation states are given.

* barium	Ba
* lanthanum	La (+3)
magnesium	
zinc	
* chromium	Cr (+2), (+3), (+6)
iron	
copper	
* palladium	(+2)

Choose metal(s) from the above list to answer the following questions.

(i) Which **two** metals would not react with dilute hydrochloric acid?

..... [2]

(ii) Which **two** unfamiliar metals (*) would react with cold water?

..... [2]

(iii) What is the oxidation state of barium?

..... [1]

(iv) Name an unfamiliar metal (*) whose oxide cannot be reduced by carbon.

..... [1]

(v) Why should you be able to predict that metals such as iron and chromium have more than one oxidation state?

.....

..... [1]

[Total: 7]

23. W07

Zinc is extracted from zinc blende, ZnS.

(a) Zinc blende is heated in air to give zinc oxide and sulphur dioxide. Most of the sulphur dioxide is used to make sulphur trioxide. This is used to manufacture sulphuric acid. Some of the acid is used in the plant, but most of it is used to make fertilisers.

(i) Give another use of sulphur dioxide.

..... [1]

(ii) Describe how sulphur dioxide is converted into sulphur trioxide.

.....

.....

..... [3]

(iii) Name a fertiliser made from sulphuric acid.

..... [1]

(b) Some of the zinc oxide was mixed with an excess of carbon and heated to 1000 °C. Zinc distils out of the furnace.

$$2ZnO + C \rightleftharpoons 2Zn + CO_2$$
$$C + CO_2 \rightarrow 2CO$$

(i) Name the **two** changes of state involved in the process of distillation.

..... [2]

(ii) Why is it necessary to use an excess of carbon?

.....

..... [2]

24. W08

Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is $Fe_2O_3.2H_2O$.
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

..... [2]

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

.....

..... [2]

(b) (i) Name a reagent that can reduce iron(III) oxide to iron.

..... [1]

(ii) Write a symbol equation for the reduction of iron(III) oxide, Fe_2O_3, to iron.

..... [2]

(c) (i) Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

..... [1]

(ii) Use your answer to **(i)** to calculate the percentage of iron in rust.

.....

..... [2]

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

.....

..... [1]

(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

.....

..... [2]

(c) The remaining zinc oxide reacts with sulphuric acid to give aqueous zinc sulphate. This is electrolysed with inert electrodes (the electrolysis is the same as that of copper(II) sulphate with inert electrodes).
ions present: $Zn^{2+}(aq)$ $SO_4^{2-}(aq)$ $H^+(aq)$ $OH^-(aq)$

(i) Zinc forms at the negative electrode (cathode). Write the equation for this reaction.

..... [1]

(ii) Write the equation for the reaction at the positive electrode (anode).

..... [2]

(iii) The electrolyte changes from aqueous zinc sulphate to

..... [1]

(d) Give two uses of zinc.

1. .....

2. ..... [2]

[Total: 15]

25. M/J/07

(a) Titanium is produced by the reduction of its chloride. This is heated with magnesium in an inert atmosphere of argon.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

(i) Explain why it is necessary to use argon rather than air.

..... [1]

(ii) Name another metal that would reduce titanium chloride to titanium.

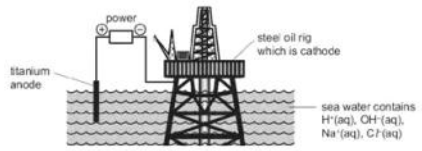
..... [1]

(iii) Suggest how you could separate the metal, titanium, from the soluble salt magnesium chloride.

.....

..... [2]

(b) Titanium is very resistant to corrosion. One of its uses is as an electrode in the cathodic protection of large steel structures from rusting.



(i) Define oxidation in terms of electron transfer.

..... [1]

(ii) The steel oil rig is the cathode. Name the gas formed at this electrode.

..... [1]

(iii) Name the **two** gases formed at the titanium anode.

..... and ..... [2]

(iv) Explain why the oil rig does not rust.

.....

..... [2]

(v) Another way of protecting steel from corrosion is sacrificial protection.
Give **two** differences between sacrificial protection and cathodic protection.

.....

..... [2]

26. J/06

Iron is a transition element.

(a) Which of the following statements about transition elements are correct?

Tick **three** boxes.

The metals are highly coloured e.g. yellow, green, blue. ☐

The metals have low melting points. ☐

Their compounds are highly coloured. ☐

Their compounds are colourless. ☐

The elements and their compounds are often used as catalysts. ☐

They have more than one oxidation state. ☐

[3]

27. J/06

(c) Iron is extracted in a blast furnace. The list below gives some of the substances used or formed in the extraction.

carbon monoxide **coke** **iron ore** **limestone** **slag**

(i) Which substance is a mineral containing largely calcium carbonate?

..... [1]

(ii) Which substance is formed when impurities in the ore react with calcium oxide?

..... [1]

(iii) Which substance is also called hematite?

..... [1]

(d) State **two** functions of the coke used in the blast furnace.

.....

..... [2]

(e) Most of the iron is converted into mild steel or stainless steel. Give **one** use for each.

mild steel .....

stainless steel ..... [2]

28. J/06

Some reactions of metals **W**, **X**, **Y** and **Z** are given below.

metal	reaction with water	reaction with dilute hydrochloric acid
W	A few bubbles form slowly in cold water.	Vigorous reaction. Gas given off.
X	Vigorous reaction. Metal melts. Gas given off.	Explosive reaction. Should not be attempted.
Y	No reaction.	No reaction.
Z	Does not react with cold water. Hot metal reacts with steam.	Steady fizzing.

(a) Arrange these metals in order of reactivity.

most reactive .....

.....

.....

least reactive ..... [2]

(b) Which of these metals could be

(i) magnesium,

..... [1]

(ii) copper?

..... [1]

(c) The equation for the reaction of **X** with cold water is given below.

$$2X(s) + 2H_2O(l) \longrightarrow 2XOH(aq) + H_2(g)$$

(i) Describe the test you would use to show that the gas evolved is hydrogen.

.....

..... [1]

(ii) How could you show that the water contained a compound of the type **X**OH?

.....

..... [2]

(iii) In which group of the Periodic Table does metal **X** belong?

..... [1]

(iv) The ore of **X** is its chloride. Suggest how metal **X** could be extracted from its chloride.

..... [2]

Topic 11 – Air and water

1. W11

(b) Two of the oxides are responsible for acid rain.
Identify the **two** oxides and explain their presence in the atmosphere.

.....

.....

.....

.....

..... [5]

2. W11

Two important greenhouse gases are methane and carbon dioxide.

(a) Methane is twenty times more effective as a greenhouse gas than carbon dioxide. The methane in the atmosphere comes from both natural and industrial sources.

(i) Describe **two** natural sources of methane.

.....

..... [2]

(ii) Although methane can persist in the atmosphere for up to 15 years, it is eventually removed by oxidation.
What are the products of this oxidation?

..... [2]

(b) How do the processes of respiration, combustion and photosynthesis determine the percentage of carbon dioxide in the atmosphere?

.....

.....

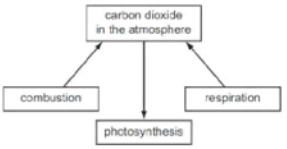
.....

..... [4]

[Total: 8]

3. W10

The diagram shows part of the carbon cycle. This includes some of the processes which determine the percentage of carbon dioxide in the atmosphere.



(i) Carbon dioxide is one greenhouse gas. Name another one.

..... [1]

(ii) Explain the term *respiration* and how this process increases the percentage of carbon dioxide in the atmosphere.

.....

.....

..... [3]

(iii) Explain why the combustion of waste crop material should not alter the percentage of carbon dioxide in the atmosphere.

.....

..... [2]

(iv) In 1960 the percentage of carbon dioxide in the atmosphere was 0.032% and in 2008 it was 0.038%. Suggest an explanation for this increase.

.....

..... [2]

[Total: 8]

4. W10

Ammonia is an important industrial chemical.

(a) (i) Give the electron structure of an atom of nitrogen.

..... [1]

(ii) Use this electronic structure, rather than the valency of nitrogen, to explain why the formula of ammonia is NH_3 not NH_4.

.....

.....

..... [2]

(b) Ammonia is made by the Haber Process.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ forward reaction is exothermic

The percentage of ammonia in the equilibrium mixture varies with conditions.

pressure / atmospheres	100	200	300	400
% ammonia at 300 °C	45	65	72	76
% ammonia at 500 °C	9	18	25	31

The conditions actually used are 200 atmospheres, 450 °C and an iron catalyst.

(i) The original catalyst was platinum. Suggest a reason why it was changed to iron.

..... [1]

(ii) Explain why the highest pressure gives the highest percentage of ammonia in the equilibrium mixture.

.....

..... [2]

(iii) What happens to the unreacted nitrogen and hydrogen?

.....

..... [1]

(iv) State **one** advantage and **one** disadvantage of using a lower temperature.

advantage .....

..... [1]

disadvantage .....

..... [1]

[Total: 9]

5. S10

Ozone is a form of oxygen. Ozone is present in the upper atmosphere and it prevents dangerous solar radiation from reaching the Earth's surface. Some of the chemicals that diffuse into the upper atmosphere decompose ozone. Chemicals that have this effect are methane (CH_4), chloromethane (CH_3Cl) and an oxide of nitrogen (NO_2).

(i) Which of these three chemicals diffuses the most slowly? Give a reason for your choice.

.....

.....

..... [2]

(ii) Chloromethane is formed when seaweed decomposes. Name the compounds in the environment from which seaweed might have obtained the following elements:

carbon; .....

hydrogen; .....

chlorine. ..... [3]

(iii) How can chloromethane be made from methane?

reagent .....

condition ..... [2]

(iv) The oxides of nitrogen are atmospheric pollutants. Describe how they are formed.

.....

.....

..... [2]

(v) Complete the equation for the decomposition of ozone.

..... $O_3 \rightarrow$ .....

[2]

[Total: 11]

6. N/05

In 1909, Haber discovered that nitrogen and hydrogen would react to form ammonia. The yield of ammonia was 8%.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ the forward reaction is exothermic

catalyst platinum
temperature 600 °C
pressure 200 atm

(a) Describe how hydrogen is obtained for the modern process.

.....

..... [2]

(b) (i) What is the catalyst in the modern process?

..... [1]

(ii) Explain why the modern process, which uses a lower temperature, has a higher yield of 15%.

.....

..... [2]

7. W09

(a) The major gases in unpolluted air are 79% nitrogen and 20% oxygen.

(i) Name another gaseous element in unpolluted air.

..... [1]

(ii) Name **two** compounds in unpolluted air.

..... [2]

(b) Two common pollutants in air are carbon monoxide and the oxides of nitrogen.

(i) Name another pollutant in air.

..... [1]

(ii) Describe how carbon monoxide is formed.

.....

.....

..... [2]

(iii) How are the oxides of nitrogen formed?

.....

.....

..... [2]

(iv) Explain how a catalytic converter reduces the emission of these two gases.

.....

.....

..... [2]

[Total: 10]

8. N/06

Minimising air pollution is essential for health and for the environment.

(a) Natural gas is methane.

(i) Write the equation for complete combustion of methane.

..... [2]

(ii) Explain why it is dangerous to use a gas fire in a poorly ventilated room.

.....

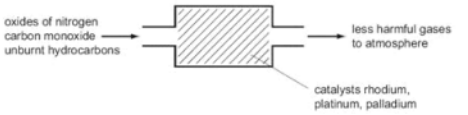
..... [2]

(b) Low sulphur fuels are being introduced. Ordinary diesel contains 500 ppm of sulphur but low sulphur diesel contains less than 50 ppm. Why is this an advantage to the environment?

.....

..... [2]

(c) Catalytic converters reduce pollution from motor vehicles, as shown in the following diagram.



(i) What type of elements are the metals rhodium, platinum and palladium?

..... [1]

(ii) Rhodium catalyses the decomposition of the oxides of nitrogen.

$$2NO \rightarrow N_2 + O_2$$

Two other pollutants are carbon monoxide and unburnt hydrocarbons. How are they made into less harmful substances?

.....

..... [2]

9. N/06

Ammonia is manufactured by the Haber Process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
200 atmospheres
450°C

The forward reaction is exothermic.

(a) (i) What is the catalyst for this reaction?

..... [1]

(ii) Newer catalysts have been discovered for this process. Using these catalysts, the operating temperature is lowered from 450°C to 400°C. What is the advantage of using a lower temperature?
Explain your answer.

advantage .....

explanation .....

..... [2]

(b) After passing over the catalyst, the mixture contains 15% of ammonia. It is cooled and the ammonia liquefies and is separated from the unreacted nitrogen and hydrogen. They are recycled.

(i) How are the gases recycled?

..... [1]

(ii) Only ammonia gas liquefies. Suggest an explanation for this.

..... [1]

(c) Urea, $CO(NH_2)_2$, is one of the fertilisers manufactured from ammonia.
Ammonia is heated with carbon dioxide.

(i) Write an equation for the manufacture of urea.

..... [2]

(ii) Explain why urea on its own might not be very effective in promoting crop growth.

..... [1]

10. N/04

(a) Two of the gases in air are nitrogen and oxygen. Name **two** other gases present in unpolluted air.

[2]

(b) Two common pollutants present in air are sulphur dioxide and lead compounds. State the source and harmful effect of each.

sulphur dioxide

source	.....
harmful effect	[3]

lead compounds

source	.....
harmful effect	[2]

(c) Respiration and photosynthesis are two of the processes that determine the percentage of oxygen and of carbon dioxide in the air.

(i) Name another process that changes the percentages of these two gases in air.

[1]

(ii) The equation for photosynthesis is given below.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

This is an endothermic reaction.

Complete the reaction for respiration.

$C_6H_{12}O_6 + 6O_2 \longrightarrow$ [ ] + [ ]

This is an [ ] reaction.

[2]

Topic 12 – Sulfur

1. S11

(b) Sulfur dioxide is used to make sulfur trioxide in the Contact Process.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic. The conditions used are:

temperature: 450 °C
pressure: 2 atmospheres
catalyst: vanadium(V) oxide

Explain, mentioning both position of equilibrium and rate, why these conditions give the most economic yield.

.....

.....

.....

..... [4]

2. N/02

(a) Sulphuric acid is made by the Contact Process.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$ forward reaction is exothermic

(i) What are the reaction conditions for the Contact Process?

.....

.....[3]

(ii) Would the yield of sulphur trioxide increase, decrease or stay the same when the temperature is increased? Explain your answer.

.....

.....

.....[2]

(iii) Describe how sulphur trioxide is changed into concentrated sulphuric acid.

.....

.....[2]

3. W09

(a) Sulfuric acid is made by the Contact process.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

This is carried out in the presence of a catalyst at 450 °C and 2 atmospheres pressure.

(i) How is the sulfur dioxide made?

.....

..... [1]

(ii) Give another use of sulfur dioxide.

..... [1]

(iii) Name the catalyst used.

..... [1]

(iv) If the temperature is decreased to 300 °C, the yield of sulfur trioxide increases. Explain why this lower temperature is not used.

.....

..... [1]

(v) Sulfur trioxide is dissolved in concentrated sulfuric acid. This is added to water to make more sulfuric acid. Why is sulfur trioxide not added directly to water?

.....

..... [1]

4. M/J/06

Sulphuric acid is made by the Contact process in the following sequence of reactions.

sulphur → sulphur dioxide → sulphur trioxide → sulphuric acid

(a) (i) How is sulphur dioxide made from sulphur?

..... [1]

(ii) Sulphur dioxide has other uses.
Why is it used in the manufacture of paper?

..... [1]

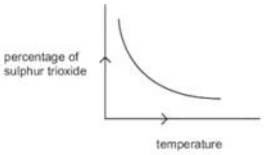
(iii) How does it preserve food?

..... [1]

(b) The equation for a stage of the Contact process is

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

The percentage of sulphur trioxide in the equilibrium mixture varies with temperature.



(i) How does the percentage of sulphur trioxide in the equilibrium mixture vary as the temperature increases? Circle the correct answer.

increases **stays the same** **decreases** [1]

(ii) Is the forward reaction in the equilibrium $2SO_2 + O_2 \rightleftharpoons 2SO_3$ exothermic or endothermic? Give a reason for your choice.

.....

..... [2]

(iii) Explain, mentioning both rate and percentage yield, why the temperature used in the Contact process is 450°C.

.....

..... [2]

(iv) Describe how the sulphur trioxide is changed into concentrated sulphuric acid.

.....

..... [2]

5. J/05

Sulphuric acid is manufactured by the Contact Process. Sulphur dioxide is oxidised to sulphur trioxide by oxygen.

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

(i) Name the catalyst used in this reaction.

..... [1]

(ii) What temperature is used for this reaction?

..... [1]

(iii) Describe how sulphur trioxide is changed into sulphuric acid.

.....

..... [2]

6. M/J/04

Sulphur is used to make sulphuric acid. In the UK, the annual production of the acid is about 2.5 million tonnes.

(a) The reactions in the manufacture of sulphuric acid by the Contact Process are shown below.

Sulphur	⟶	Sulphur dioxide
S	**reaction 1**	SO_2
Sulphur dioxide + oxygen	⟶	Sulphur trioxide
$2SO_2 + O_2$	**reaction 2**	$2SO_3$
Sulphur trioxide	⟶	Oleum
SO_3	**reaction 3**	$H_2S_2O_7$
Oleum + water	⟶	Sulphuric acid
$H_2S_2O_7$	**reaction 4**	H_2SO_4

(i) Give a large scale source of the element sulphur.

..... [1]

(ii) State another use of sulphur dioxide.

..... [1]

(iii) How is sulphur changed into sulphur dioxide?

..... [1]

(iv) Name the catalyst used in reaction **2**.

..... [1]

(v) Reaction **2** is exothermic. Why is a catalyst, rather than a higher temperature, used to increase the rate of this reversible reaction?

.....

..... [2]

(vi) Write a word equation for reaction **3**.

..... [1]

(vii) Write a symbol equation for reaction **4**.

..... [1]

7. N/03

Sulphur dioxide, SO_2, and sulphur trioxide, SO_3, are the two oxides of sulphur.

(a) Sulphur dioxide can kill bacteria and has bleaching properties. Give a use of sulphur dioxide that depends on each of these properties.

(i) ability to kill bacteria .....[1]

(ii) bleaching properties .....[1]

(b) Sulphur trioxide can be made from sulphur dioxide.

(i) Why is this reaction important industrially?

.....[1]

(ii) Complete the word equation.

sulphur dioxide + ... → sulphur trioxide [1]

(iii) What are the conditions for this reaction?

.....

.....[2]

(c) Sulphur dioxide is easily oxidised in the presence of water.

$$SO_2 + 2H_2O - 2e^- \rightarrow SO_4^{2-} + 4H^+$$

(i) What colour change would be observed when an excess of aqueous sulphur dioxide is added to an acidic solution of potassium manganate(VII)?

.....[2]

(ii) To aqueous sulphur dioxide, acidified barium chloride solution is added. The mixture remains clear. When bromine is added, a thick white precipitate forms. What is the white precipitate? Explain why it forms.

.....

.....[3]

8. (a) N/01

In the USA, sulphur is obtained from underground deposits. It burns to form sulphur dioxide. This is used in paper making, to preserve food and in the manufacture of sulphuric acid.

(i) Why is sulphur dioxide needed in paper making?

.....[1]

(ii) How does sulphur dioxide preserve food?

.....[1]

(b)

Sulphuric acid is a typical strong acid.

(i) Explain the term *strong acid.*

.....[2]

(ii) Write a word equation for the reaction between zinc carbonate and sulphuric acid.

.....[2]

(iii) Write an equation for the reaction between sodium hydroxide and sulphuric acid.

.....[2]

(iv) Write an ionic equation for the reaction between magnesium and sulphuric acid.

.....[2]

Topic 13 –Carbonates

1. M/J/06

Calcium carbonate is an important raw material.

(a) Name a rock which is made up of calcium carbonate.

..... [1]

(b) When calcium carbonate is heated strongly, it decomposes.

$$CaCO_3 \rightarrow CaO + CO_2$$

(i) Calculate the relative formula mass of:

$CaCO_3$ .....

CaO ..... [2]

(ii) 7.00 kg of calcium oxide was formed. What mass of calcium carbonate was heated?

.....

..... [2]

(c) Calcium carbonate is used to control soil acidity.

(i) Why is it important to control soil acidity?

..... [1]

(ii) Both calcium carbonate, insoluble in water, and calcium oxide, slightly soluble, are used to increase soil pH. Suggest **two** advantages of using calcium carbonate.

.....

..... [2]

(iii) Give **one** use of calcium carbonate other than for making calcium oxide and controlling soil pH.

..... [1]

Topic 14 – Organic chemistry

1. W11

Structural formulae are an essential part of Organic Chemistry.

(a) Draw the structural formula of each of the following. Show all the bonds in the structure.

(i) ethanoic acid

[1]

(ii) ethanol

[1]

(b) (i) Ethanoic acid and ethanol react to form an ester.
What is the name of this ester?

..... [1]

(ii) The same linkage is found in polyesters. Draw the structure of the polyester which can be formed from the monomers shown below.

HOOC—C_6H_4—COOH and HO—CH_2—CH_2—OH

[3]

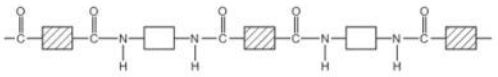
(iii) Describe the pollution problems caused by non-biodegradable polymers.

.....

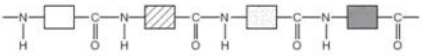
.....

..... [2]

(c) Two macromolecules have the same amide linkage.
Nylon, a synthetic polymer, has the following structure.



Protein, a natural macromolecule, has the following structure.



How are they different?

.....

.....

..... [2]

[Total: 10]

2. S11
The structural formula of a butanol is given below.

$$CH_3—CH_2—CH_2—CH_2—OH$$

(a) Butanol can be made from petroleum and also by fermentation.

(i) Describe the chemistry of making butanol from petroleum by the following route.

petroleum → butene → butanol

.....

.....

..... [3]

(ii) Explain, in general terms, what is meant by *fermentation*.

.....

.....

.....

..... [3]

(b) Butanol can be oxidised to a carboxylic acid by heating with acidified potassium manganate(VII). Give the name and structural formula of the carboxylic acid.

name ..... [1]

structural formula

[1]

(c) Butanol reacts with ethanoic acid to form a liquid, **X**, which has the sweet smell of bananas. Its empirical formula is C_2H_5O and its M_r is 116.

(i) What type of compound is liquid **X**?

..... [1]

(ii) Give the molecular formula of liquid **X**.

..... [1]

(iii) Draw the structural formula of **X**. Show all the individual bonds.

[2]

[Total: 12]

3. S11
There are two types of polymerisation - addition and condensation.

(a) Explain the difference between them.

.....

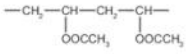
.....

..... [2]

(b) Poly(dichloroethene) is used to package food. Draw its structure. The structural formula of dichloroethene is shown below.

[2]

(c) The polymer known as PVA is used in paints and adhesives. Its structural formula is shown below.



Deduce the structural formula of its monomer.

[1]

(d) A condensation polymer can be made from the following monomers.

$$HOOC(CH_2)_4COOH \text{ and } H_2N(CH_2)_6NH_2$$

Draw the structural formula of this polymer.

[3]

[Total: 8]

4. S10

Methanoic acid is the first member of the homologous series of carboxylic acids.

(a) Give **two** general characteristics of a homologous series.

.....

.....

..... [2]

(b) In some areas when water is boiled, the inside of kettles become coated with a layer of calcium carbonate. This can be removed by adding methanoic acid.

(i) Complete the equation.

..... $HCOOH + CaCO_3 \rightarrow Ca(HCOO)_2 +$ ..... + ...

[2]

(ii) Methanoic acid reacts with most metals above hydrogen in the reactivity series. Complete the word equation.

zinc + methanoic acid → ..... + ...

[2]

(iii) Aluminium is also above hydrogen in the reactivity series.
Why does methanoic acid not react with an aluminium kettle?

.....

..... [1]

(c) Give the name, molecular formula and empirical formula of the fourth acid in this series.

name ..... [1]

molecular formula ..... [1]

empirical formula ..... [1]

[Total: 10]

5. W10

Monomers polymerise to form polymers or macromolecules.

(a) (i) Explain the term *polymerise*.

.....

..... [1]

(ii) There are two types of polymerisation - addition and condensation. What is the difference between them?

.....

.....

..... [2]

(b) An important monomer is chloroethene which has the structural formula shown below.

It is made by the following method.

$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$ dichloroethane

This is heated to make chloroethene.

$C_2H_4Cl_2 \rightarrow C_2H_3Cl + HCl$

(i) Ethene is made by cracking alkanes. Complete the equation for cracking dodecane.

$C_{12}H_{26} \rightarrow$ ..... $+ 2C_2H_4$

[1]

Another method of making dichloroethane is from ethane.

$C_2H_6 + 2Cl_2 \rightarrow C_2H_4Cl_2 + 2HCl$

(ii) Suggest a reason why the method using ethene is preferred.

.....

..... [1]

(iii) Describe an industrial method of making chlorine.

.....

..... [2]

(iv) Draw the structural formula of poly(chloroethene).

Include three monomer units.

[2]

[Total: 9]

6. M/J/07

A major source of energy is the combustion of fossil fuels.

(a) (i) Name a solid fossil fuel.

..... [1]

(ii) Name a gaseous fossil fuel.

..... [1]

(b) Petroleum is separated into more useful fractions by fractional distillation.

(i) Name **two** liquid fuels obtained from petroleum.

..... and ..... [2]

(ii) Name **two** other useful products obtained from petroleum that are not used as fuels.

..... and ..... [2]

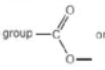
(iii) Give another mixture of liquids that is separated on an industrial scale by fractional distillation.

..... [1]

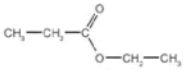
[Total: 7]

7. S10

Hydrolysis is used in chemistry to break down complex molecules into simpler ones.

(a) Compounds containing the group  or —COO— are esters.

(i) Give the names and formulae of the two compounds formed when the ester ethyl propanoate is hydrolysed.

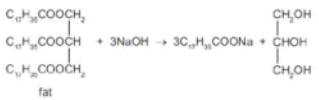


name ..... name .....

formula formula

[4]

(ii) Fats are naturally occurring esters. They can be hydrolysed by boiling with aqueous sodium hydroxide.



fat

What type of compound has the formula $C_{17}H_{35}COONa$ and what is its main use?

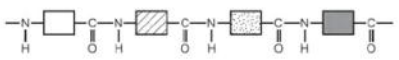
type of compound ..... [1]

use ..... [1]

(iii) Name a synthetic polyester.

..... [1]

(b) The structure of a typical protein is drawn below.



(i) What is the name of the polymer linkage?

..... [1]

(ii) Draw the structural formula of a man-made polymer with the same linkage.

[3]

(iii) A protein can be hydrolysed to a mixture of amino acids which are colourless. Individual amino acids can be identified by chromatography. The R_f value of the amino acid glycine is 0.5. Describe how you could show that glycine was present on a chromatogram.

.....

.....

..... [3]

[Total: 14]

8. W09

Butan-1-ol is used as a solvent for paints and varnishes, to make esters and as a fuel. Butan-1-ol can be manufactured from but-1-ene, which is made from petroleum.

Biobutanol is a fuel of the future. It can be made by the fermentation of almost any form of biomass - grain, straw, leaves etc.

(a) But-1-ene can be obtained from alkanes such as decane, $C_{10}H_{22}$, by cracking.

(i) Give the reaction conditions.

.....

..... [2]

(ii) Complete an equation for the cracking of decane, $C_{10}H_{22}$, to give but-1-ene.

$C_{10}H_{22} \rightarrow$ ..... [2]

(iii) Name the reagent that reacts with but-1-ene to form butan-1-ol.

..... [1]

(b) **(i)** Balance the equation for the complete combustion of butan-1-ol.

..... C_4H_9OH + ... $O_2 \rightarrow$ ..... CO_2 + ... H_2O [2]

(ii) Write a word equation for the preparation of the ester butyl methanoate.

..... [2]

(c) The fermentation of biomass by bacteria produces a mixture of products which include biobutanol, propanol, hydrogen and propanoic acid.

(i) Draw the structural formula of propanol and of propanoic acid. Show all the bonds.

propanol

propanoic acid

[2]

(ii) Why is it important to develop these fuels, such as biobutanol, as alternatives to petroleum?

..... [1]

(d) How could you show that butanol made from petroleum and biobutanol are the same chemical?

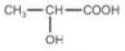
.....

..... [1]

[Total: 13]

9. S09

Lactic acid can be made from corn starch.



lactic acid

It polymerises to form the polymer, polylactic acid (PLA) which is biodegradable.

(a) Suggest **two** advantages that PLA has compared with a polymer made from petroleum.

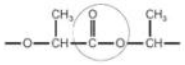
.....

.....

.....

..... [2]

(b) The structure of PLA is given below.



(i) What type of compound contains the group that is circled?

..... [1]

(ii) Complete the following sentence.

Lactic acid molecules can form this group because they contain both an

..... group and an .....group. [2]

(iii) Is the formation of PLA, an addition or condensation polymerisation? Give a reason for your choice.

.....

.....

..... [2]

(c) When lactic acid is heated, acrylic acid is formed.

lactic acid acrylic acid

(i) Complete the word equation for the action of heat on lactic acid.

lactic acid → ..... + ... [1]

(ii) Describe a test that would distinguish between lactic acid and acrylic acid.

test .....

result for lactic acid .....

result for acrylic acid ..... [3]

(iii) Describe a test, other than using an indicator, which would show that both chemicals contain an acid group.

test .....

result .....

..... [2]

[Total: 13]

10. W08

The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) 10 cm^3 of butane is mixed with 100 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

(ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....

..... [2]

(b) The equation for a substitution reaction of butane is given below.

$$CH_3{-}CH_2{-}CH_2{-}CH_3 + Cl_2 \longrightarrow CH_3{-}CH_2{-}CH_2{-}CH_2{-}Cl + HCl$$

(i) Name the organic product.

..... [1]

(ii) This reaction does not need increased temperature or pressure.
What is the essential reaction condition?

..... [1]

(iii) Write a different equation for a substitution reaction between butane and chlorine.

..... [1]

(c) Alkenes are more reactive and industrially more useful than alkanes.
They are made by cracking alkanes.

$$\underset{\text{heptane}}{C_7H_{16}} \longrightarrow \underset{\text{propene}}{CH_3{-}CH{=}CH_2} + \underset{\text{but-1-ene}}{CH_3{-}CH_2{-}CH{=}CH_2} + H_2$$

(i) Draw the structural formula of the polymer poly(propene).

[2]

(ii) Give the structural formula and name of the alcohol formed when but-1-ene reacts with steam.

name ..... [1]

structural formula

[1]

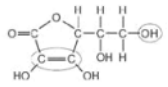
(iii) Deduce the structural formula of the product formed when propene reacts with hydrogen chloride.

[1]

[Total: 12]

11. W08

The structural formula of Vitamin C is drawn below.



(i) What is its molecular formula?

..... [1]

(ii) Name the two functional groups which are circled.

..... [2]

12. W07

The alcohols form a homologous series. The first four members are methanol, ethanol, propan-1-ol and butan-1-ol.

(a) One characteristic of a homologous series is that the physical properties vary in a predictable way. The table below gives the heats of combustion of the first three alcohols.

alcohol	formula	heat of combustion in kJ / mol
methanol	CH_3OH	-730
ethanol	$CH_3{-}CH_2{-}OH$	-1370
propan-1-ol	$CH_3{-}CH_2{-}CH_2{-}OH$	-2020
butan-1-ol	$CH_3{-}CH_2{-}CH_2{-}CH_2{-}OH$	

(i) The minus sign indicates that there is less chemical energy in the products than in the reactants. What form of energy is given out by the reaction?

..... [1]

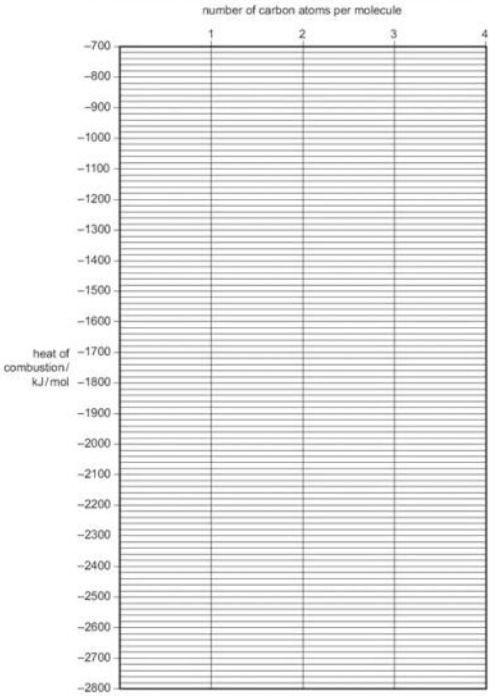
(ii) Is the reaction exothermic or endothermic?

..... [1]

(iii) Complete the equation for the complete combustion of ethanol.

C_2H_5OH + ...O_2 → ..... + ... [2]

(iv) Determine the heat of combustion of butan-1-ol by plotting the heats of combustion of the first three alcohols against the number of carbon atoms per molecule.



The heat of combustion of butan-1-ol = ... kJ / mol [3]

(v) Describe **two** other characteristics of homologous series.

.....

..... [2]

(b) Give the name and structural formula of an isomer of propan-1-ol.
structural formula

name ..... [2]

(c) Methanol is made from carbon monoxide.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ the forward reaction is exothermic

(i) Describe how hydrogen is obtained from alkanes.

.....

..... [2]

(ii) Suggest a method of making carbon monoxide from methane.

..... [2]

(iii) Which condition, high or low pressure, would give the maximum yield of methanol? Give a reason for your choice.

pressure .....

reason ..... [2]

(d) For each of the following predict the name of the organic product.

(i) reaction between methanol and ethanoic acid

..... [1]

(ii) oxidation of propan-1-ol by potassium dichromate(VI)

..... [1]

(iii) removal of H_2O from ethanol (dehydration)

..... [1]

[Total: 20]

13. S08

Large areas of the Amazon rain forest are cleared each year to grow soya beans. The trees are cut down and burnt.

(a) Why do these activities increase the percentage of carbon dioxide in the atmosphere?

.....

..... [2]

(b) Soya beans contain all three main food groups. Two of which are protein and carbohydrate.

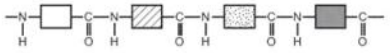
(i) What is the third group?

..... [1]

(ii) Draw the structural formula of a complex carbohydrate such as starch.

[3]

(iii) Compare the structure of a protein with that of a synthetic polyamide. The structure of a typical protein is given below.



How are they similar?

.....

How are they different?

.....

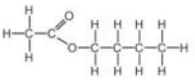
..... [3]

[Total: 9]

14. M/J/07

Esters, fats and polyesters all contain the ester linkage.

(a) The structural formula of an ester is given below.



Name **two** chemicals that could be used to make this ester and draw their structural formulae. Show all bonds.

names ..... and ..... [2]

structural formulae

[2]

(b) **(i)** Draw the structural formula of a polyester such as *Terylene*.

[2]

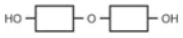
(ii) Suggest a use for this polymer.

..... [1]

15. N/06

The three types of food are carbohydrates, proteins and fats.

(a) Aqueous starch is hydrolysed to maltose by the enzyme amylase.
The formula of maltose is:



Starch is hydrolysed by dilute sulphuric acid to glucose.

(i) What is an enzyme?

..... [1]

(ii) Draw the structure of starch.

[1]

(iii) Name the technique that would show that the products of these two hydrolyses are different.

..... [1]

(b) Proteins have the same linkage as nylon but there is more than one monomer in the macromolecule.

(i) Draw the structure of a protein.

[2]

(ii) What class of compound is formed by the hydrolysis of proteins?

..... [1]

(c) Fats are esters. Some fats are saturated, others are unsaturated.

(i) Write the word equation for the preparation of the ester, propyl ethanoate.

..... [2]

(ii) Deduce the structural formula of this ester showing each individual bond.

[2]

(iii) How could you distinguish between these two fats?
Fat 1 has the formula

$CH_2 - CO_2 - C_{17}H_{33}$
|
$CH - CO_2 - C_{17}H_{33}$
|
$CH_2 - CO_2 - C_{17}H_{33}$

Fat 2 has the formula

$CH_2 - CO_2 - C_{17}H_{35}$
|
$CH - CO_2 - C_{17}H_{35}$
|
$CH_2 - CO_2 - C_{17}H_{35}$

test .....

result with fat 1 .....

result with fat 2 ..... [3]

(iv) Both of these fats are hydrolysed by boiling with aqueous sodium hydroxide. What type of compounds are formed?

.....and ..... [2]

Periodic Table