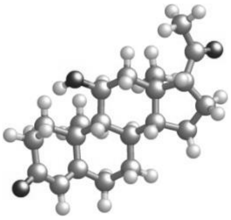


Chem!stry

Name: …………………… ( )

Class: ………………

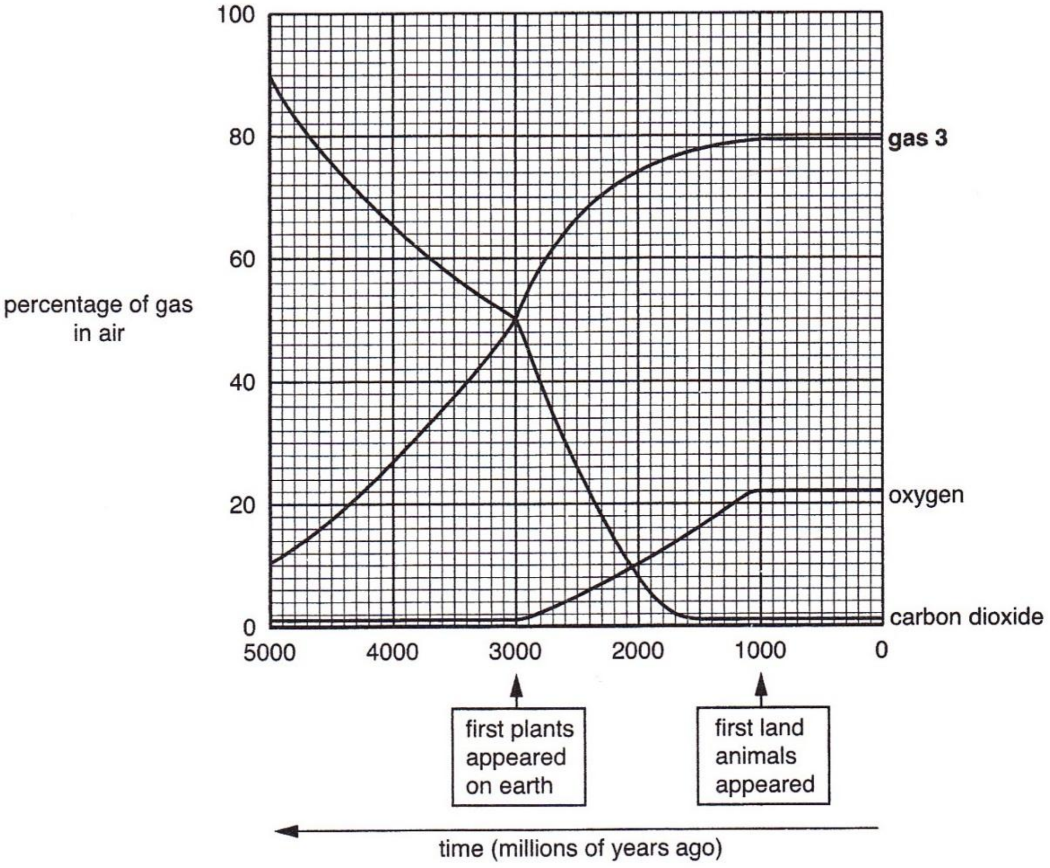
Date: …… / …… / ……

O’ Level Database Questions for Practice and Revision

- **Note:** A link to the answers is given on pg. 47. A copy of the Periodic Table is given on pg. 48.

Question 1.

This graph shows how the percentage of three of the gases in the Earth’s atmosphere has changed over five thousand million years.



Use the information from the graph to answer the following questions.

(a) **(i)** How long have the percentages of all gases in the atmosphere remained unchanged?

……………………………………………………………………………………………

(ii) Name **gas 3**. Give a reason for your answer. [3]

……………………………………………………………………………………………

……………………………………………………………………………………………

(b) **(i)** Describe how the percentages of carbon dioxide and oxygen have changed.

....

....

....

....

....

....

....

....

....

....

(ii) Suggest an explanation for the changes that have taken place in carbon dioxide and oxygen percentages, identifying the processes involved and giving equations for any reactions. [7]

....

....

....

....

....

....

....

....

....

....

[Total: 10]

Question 2.

Read the information about the chlorides of the elements in Period 3 of the Periodic Table.

Elements and their Chlorides

The formulae and chemical properties of the chlorides of the elements change across Period 3. The chlorides behave differently when they are added to water. Some of the chlorides dissolve in water to form a solution. Some hydrolyse when they are added to water. This means that they react chemically with water to produce new products.

element	**metal or non-metal**	**formula of main chloride**	**bonding in chloride**	**effect of adding chloride to water**	**products of adding chloride to water**
Na	metal	$\mathrm{NaC}l$	ionic	dissolves	$\mathrm{NaC}l\mathrm{(aq)}$
Mg	metal	$\mathrm{MgC}l_2$	ionic	dissolves	$\mathrm{MgC}l_2\mathrm{(aq)}$
$\mathrm{A}l$	metal	$\mathrm{A}l\mathrm{C}l_3$	covalent	hydrolyses	complex mixture of products including $\mathrm{HC}l\mathrm{(aq)}$
Si	non-metal	$\mathrm{SiC}l_4$	covalent	hydrolyses	$\mathrm{SiO_2(s)}$ $\mathrm{HC}l\mathrm{(aq)}$
P	non-metal	$\mathrm{PC}l_3$	covalent	hydrolyses	$\mathrm{H_3PO_3(aq)}$ $\mathrm{HC}l\mathrm{(aq)}$
S	non-metal	$\mathrm{S_2C}l_2$	covalent	hydrolyses	complex mixture of products including $\mathrm{HC}l\mathrm{(aq)}$
$\mathrm{C}l$	non-metal	$\mathrm{C}l_2$	covalent	hydrolyses	$\mathrm{HC}l\mathrm{O(aq)}$ $\mathrm{HC}l\mathrm{(aq)}$

The reaction of chlorine with water is interesting because it is an example of a **disproportionation** reaction. Disproportionation happens when the oxidation state of the same element both increases and decreases in the reaction.

The chlorides have different formulae and the ratio of the element to chlorine changes across Period 3. Some examples are shown in the table below.

formulae of chloride	**ratio of element to chlorine**
$\mathrm{NaC}l$	1:1
$\mathrm{MgC}l_2$	1:2
$\mathrm{A}l\mathrm{C}l_3$	1:3

(a) Describe the pattern for the ratio of each element to chlorine across Period 3. Include ratios in your answer. [2]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(b) **(i)** Which chloride forms a precipitate when added to water? [1]

……………………………………………………………………………………………

(ii) Write a balanced equation for the reaction of phosphorus(III) chloride with water. [1]

……………………………………………………………………………………………

(c) Use ideas about oxidation states to explain why the reaction of chlorine with water is a disproportionation reaction. [2]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(d) Two students talk about the data.

Student 1: "I think that whether or not the chloride hydrolyses is linked to the metal or non-metal character of the chloride."

Student 2: "I think that whether or not the chloride hydrolyses is linked to the bonding of the chloride."

Does the information in the table support the ideas of the students?

Explain your reasoning. [3]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(e) Another student performs an experiment to test whether some other chlorides dissolve or hydrolyse when they are added to water.

She adds each chloride to water and tests the pH of the mixture.

Explain how the result of a pH test shows whether or not the chloride has hydrolysed. [2]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(f) Suggest a reason why argon is not included in the table of information about Period 3 chlorides. [1]

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

[Total: 12]

Question 3.

A series of experiments were carried out to investigate the effect of different catalysts on the rate of a reaction.

The table shows the time taken for the reaction to finish when different metal compounds were used as catalysts.

The metal compounds contain Group 1 metals, Group 2 metals or transition metals.

experiment	**catalyst**	**temperature at start / °C**	**time taken for reaction to finish / s**
1	$NaCl$	19	45
2	$FeCl_2$	20	22
3	$CoCl_2$	19	26
4	$MgCl_2$	20	46
5	$NaNO_3$	19	45
6	$Fe(NO_3)_2$	20	22
7	$Fe(NO_3)_3$	19	15
8	$Co(NO_3)_2$	19	26
9	$Mg(NO_3)_2$	19	46

(a) Explain why it is important to take note of the temperature at the start of the reaction. [1]

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

(b) Group 1 and Group 2 metal compounds are less effective than transition metal compounds as catalysts.

Explain how the information in the table supports this statement. [2]

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

(c) Two different iron ions were used in the experiment.

(i) Give the formulae for the two ions. [1]

....

(ii) Which iron ion seems to be the more effective catalyst? Explain your reasoning. [2]

....

....

....

....

(d) A student wrote this conclusion from the results in the table.

> The type of anion in the catalyst compound does not affect the rate of reaction.

(i) Do you agree with this conclusion?

Use the results to explain your reasoning. [2]

....

....

....

....

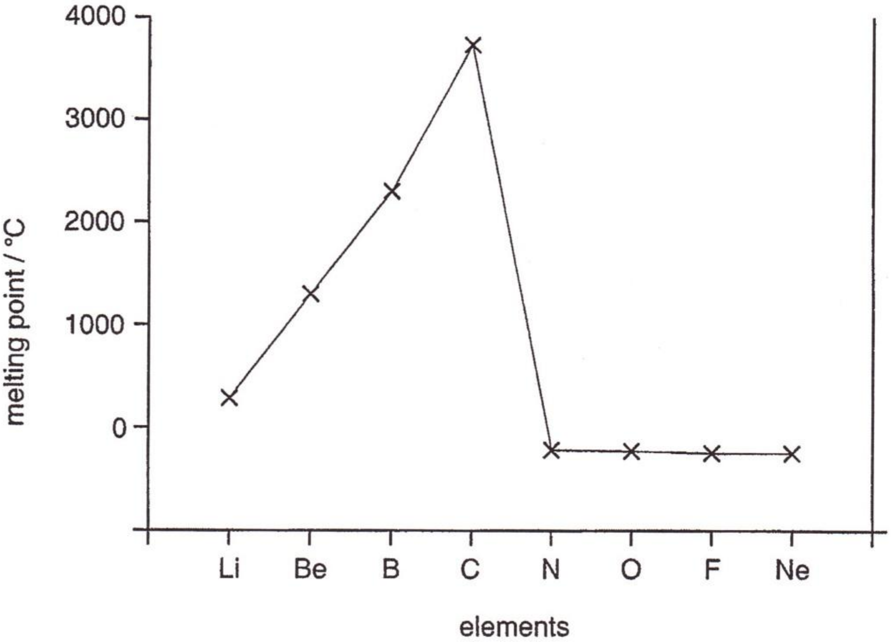
(ii) Predict the time taken for the reaction to finish if iron(III) chloride was used as a catalyst. [1]

....

[Total: 9]

Question 4.

This information is about the elements in **Period 2** of the Periodic Table.



element	electrical conductivity at room temperature and pressure
Li	good
Be	good
B	poor
C	good
N	does not conduct
O	does not conduct
F	does not conduct
Ne	does not conduct

(a) **(i)** Use the information to describe the trends in melting point and electrical conductivity across Period 2.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(ii) How does the data show that the first four elements in Period 2 are solids at room temperature?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(iii) Explain why the last four elements in Period 2 do not conduct electricity. [5]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(b) **(i)** How does the melting point of carbon compare to the other elements in the Period?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(ii) Does the electrical conductivity of carbon fit the general pattern across the Period? Justify your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(iii) There are two forms of carbon, diamond and graphite. Which form of carbon does the data refer to? Explain your answer with reference to the structure of the substance that you have chosen. [4]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(c) Draw a sketched graph to show how atomic number changes across Period 2. [1]

(d) An element in Period 3 has the following properties.

melting point / °C	98
electrical conductivity	good

Use the information given in this question to suggest the element that this data is most likely to refer to. Explain your answer. [2]

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

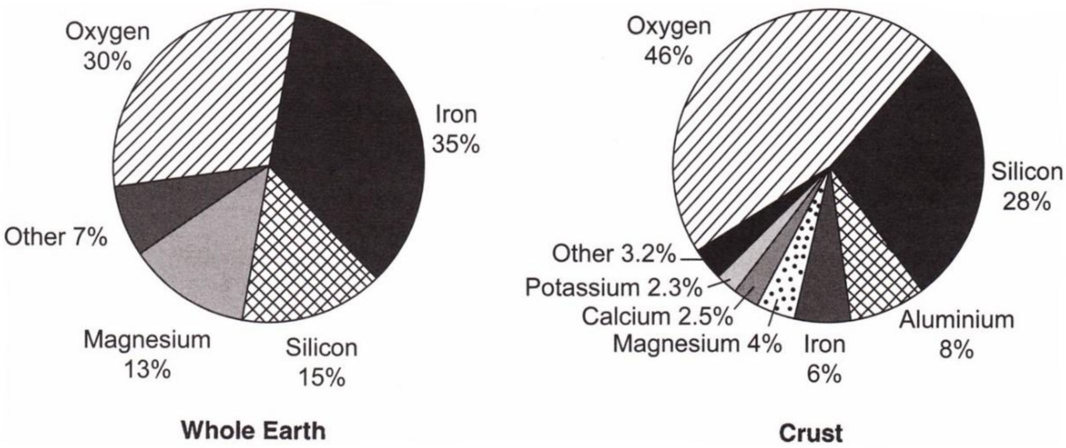
……………………………………………………………………………………………...

[Total: 12]

Question 5.

Read the information about the elements and compounds in the Earth.

The Earth's crust is the thin outer layer of the Earth. The pie charts show a comparison of the percentages of elements in the whole Earth and in the Earth's crust.



In the Earth's crust, silicon and oxygen are the most abundant elements. Rocks such as quartz are made of covalently bonded compounds of silicon and oxygen. Typically, quartz contains 46.7 % silicon and 53.3 % oxygen by mass.

Some rocks such as feldspars contain ionic silicate compounds. These contain metal ions ionically bonded to silicate ions. Examples of naturally occurring silicates are shown in the table below.

name of silicate compound	**formula**
forsterite	Mg_2SiO_4
phenacite	Be_2SiO_4
anorthite	$CaAl_2Si_2O_8$
microcline	$KAlSi_3O_8$

The formulae of the silicate compounds are not simple. Some silicate compounds contain one type of metal ion, others contain more than one. All silicate ions contain silicon and oxygen, but the numbers of the atoms and the charges on the ions vary. For example,

- **phenacite** (Be_2SiO_4) contains only **Be^{2+}** metal ions. The formula of its silicate ion is **SiO_4^{4-}**.
- **microcline** ($KAlSi_3O_8$) contains **K^+** & **Al^{3+}** metal ions. The formula of its silicate ion is **$Si_3O_8^{4-}$**.

(a) Scientists believe that the centre of the Earth is made from an inner core made mainly of iron. What evidence from the pie charts supports this idea? [2]

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(b) **(i)** Use the information to work out the **empirical formula** and hence the **name** of the main compound in quartz. [3]

(ii) There are other compounds of oxygen found in the Earth's crust as well as quartz. Explain how the pie chart information shows this. [1]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(c) Give the formulae and charges of the ions present in anorthite. [2]

……………………………………………………………………………………………...

……………………………………………………………………………………………...

(d) Beryllium and silicon can both be extracted from the mineral phenacite.

Show by calculation that 1 kg of phenacite contains a larger mass of silicon than beryllium but a larger number of moles of beryllium atoms than silicon atoms. [4]

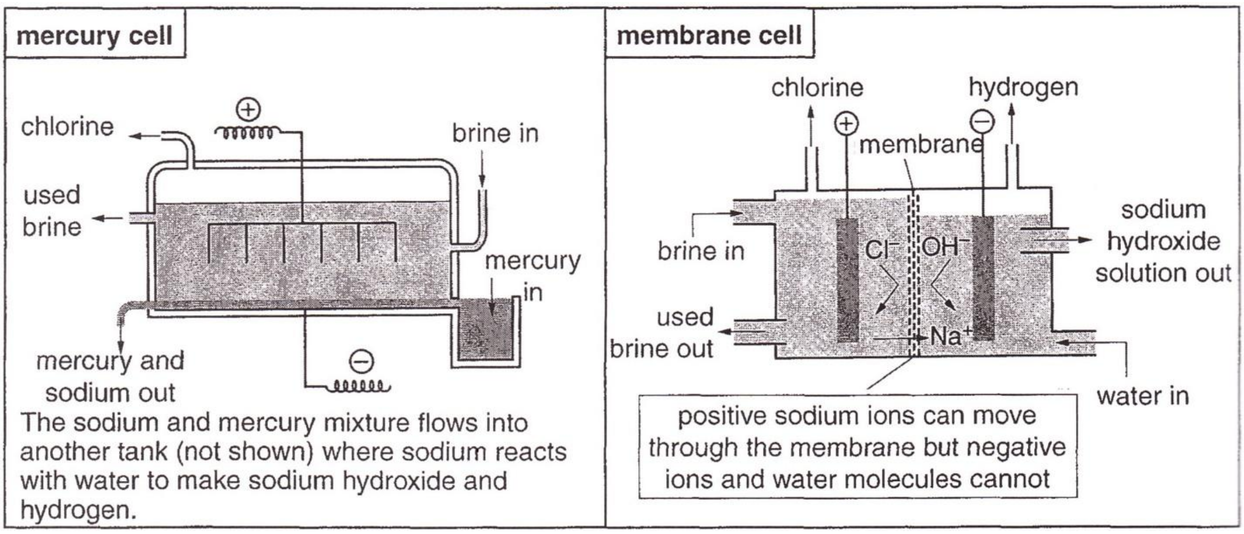
[Total: 12]

Question 6.

Read the information about the industrial electrolysis of brine.

Industrial Electrolysis of Brine

Brine is a saturated solution of sodium chloride, containing about 25% by mass of sodium chloride. Electrolysis of brine produces chlorine, hydrogen and sodium hydroxide. Industrial electrolysis of brine used to be carried out in **mercury cells**, but it is now carried out in **membrane cells**. The diagrams below show how these two cells work.



mercury cell

The sodium and mercury mixture flows into another tank (not shown) where sodium reacts with water to make sodium hydroxide and hydrogen.

membrane cell

positive sodium ions can move through the membrane but negative ions and water molecules cannot

The membrane cell was a major breakthrough when it was developed because it allows sodium hydroxide and chlorine to be produced in the same cell. Without the membrane, the sodium hydroxide would not be pure because it would contain chloride ions. One other problem that the membrane cell solves is that it keeps the chlorine gas and hydroxide ions separate. Chlorine and hydroxide ions react together – this would reduce the amount of chlorine made and create more impurities in the sodium hydroxide.

The table shows some information about the two types of cells.

	mercury cell	**membrane cell**
overall energy consumption (kWh per tonne of chlorine) 1 tonne = 1 000 000 g	3360	2750
purity of sodium hydroxide	high purity	high purity
concentration of sodium hydroxide produced	50 % concentration	35 % concentration
other points	mercury is toxic and must be removed from the brine	low maintenance costs

(a) **(i)** In the membrane cell, it is important that negative ions do not pass through the membrane. Explain why. [3]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(ii) It is an advantage that negative ions do not pass through the membrane. Describe the **other** advantages of using the membrane cell instead of the mercury cell. [2]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(iii) Give one disadvantage of using the membrane cell instead of the mercury cell. [1]

……………………………………………………………………………………………

……………………………………………………………………………………………

(b) Calculate the energy consumption of the membrane cell **per mole** of chlorine gas produced. [2]

(c) **(i)** Write an equation for the overall reaction that happens in the membrane cell. [1]

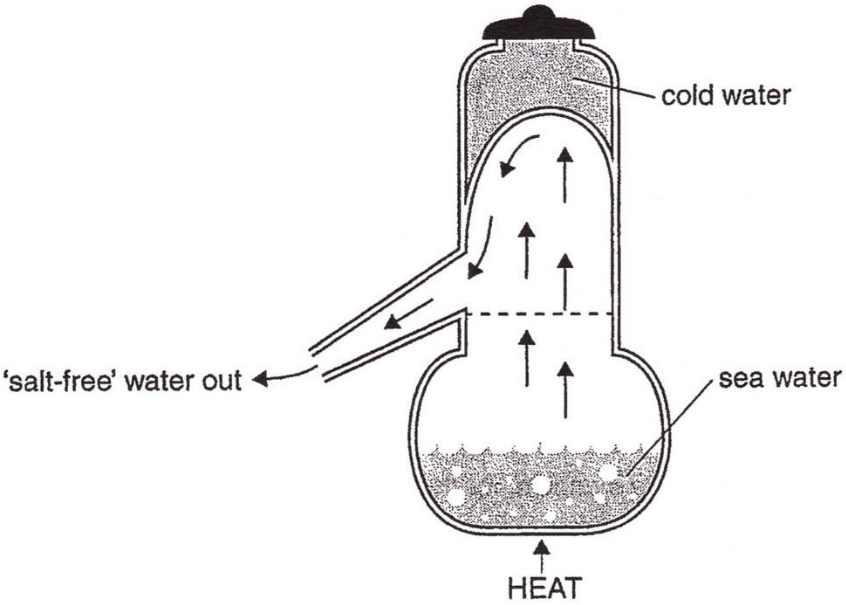
……………………………………………………………………………………………

(ii) Calculate the maximum mass of sodium hydroxide that can be produced from 1 tonne of saturated brine. [3]

[Total: 12]

Question 7.

Desalination is the process of converting sea water into drinking water. Older processes used a distillation method to desalinate the water, as shown in the diagram.



(a) Explain how this process produces salt-free water. [3]

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

(b) The salt-free water is tested to check that it does not contain dissolved salts.

One way of doing this is to test for chloride ions.

Outline how this test is carried out and what the results should show. [3]

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

(c) Removal of salt is only one stage of the process of producing drinking water from sea water. Other stages involve,

1. Removing solid particles of suspended substances such as fine sand.

2. Adding substances to kill bacteria that may enter the water during its distribution.

Suggest, in outline, how these processes could be carried out, and whether they should happen before or after distillation. [3]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(d) A newer process involves using a membrane to remove salt from the sea water.

Cold sea water is pumped through the membrane under pressure.

Suggest why this process has a lower energy demand than the distillation process. [1]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

[Total: 10]

Question 8.

The History of Chemical Formulae

The idea that chemical compounds could be represented by formulae was developed in the first part of the nineteenth century.

A French Chemist called Joseph Proust developed the Law of Constant Composition in the early 1800s. He noticed that if different masses of metals were heated in air to constant mass, the increase in the mass was proportional to the mass of each metal used. His law states that,

> "All samples of a particular chemical compound have the same elemental composition by mass."

Proust collected data about the change in mass when the metals iron, lead and mercury were heated in air to constant mass.

He used the data to calculate the percentage composition by mass of the metal oxides.

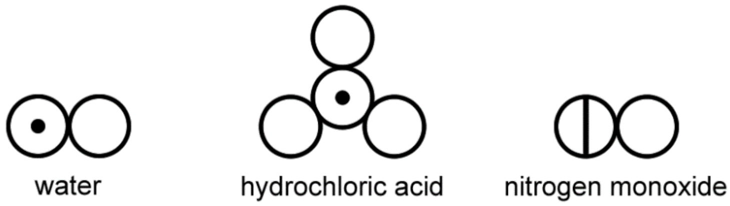
Table 1 shows some data from an experiment to find the increase in mass when iron, lead and mercury are heated.

Table 1

metal	mass of metal before heating / g	mass of metal after heating / g
iron	20.0	28.6
	30.0	42.7
lead	25.0	26.9
	30.0	32.3
mercury	25.0	27.0
	40.0	41.6

The Law of Constant Composition does not work for all metals because different oxides may be formed under different conditions.

John Dalton was a British chemist who worked a few years later than Proust. He realised that the Law of Constant Composition could be explained if all compounds contained small particles of each element. This was the beginning of atomic theory. Dalton developed symbols and used them to represent elements and compounds.



Some of our modern formulae for compounds show that Dalton's formulae were not always correct.

(a) Use the data from the experiment in **Table 1** for this question.

(i) Use calculations to decide whether iron and mercury obey the Law of Constant Composition when they are heated in air.

Show your working. [3]

……………………………………………………………………………………………

……………………………………………………………………………………………

(ii) Lead is a metal in Group 14 of the Periodic Table. Lead forms two common oxides, lead(II) oxide and lead(IV) oxide.

Which oxide was formed when lead was heated in this experiment?

Calculate the empirical formula of the oxide formed to support your answer. [3]

……………………………………………………………………………………………

……………………………………………………………………………………………

(b) **(i)** Describe how Dalton's formulae for water, hydrochloric acid and nitrogen monoxide compare to their modern formulae. [4]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

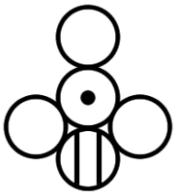
……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(ii) This is Dalton's formula for a common metal salt.



This formula of the salt does not agree with its modern formula.

Suggest the name of the salt based upon the modern formula. Explain your reasoning. [2]

Name: ………………………………………………………………………………………

Reason: ………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

[Total: 12]

Question 9.

Properties of Hydrocarbons

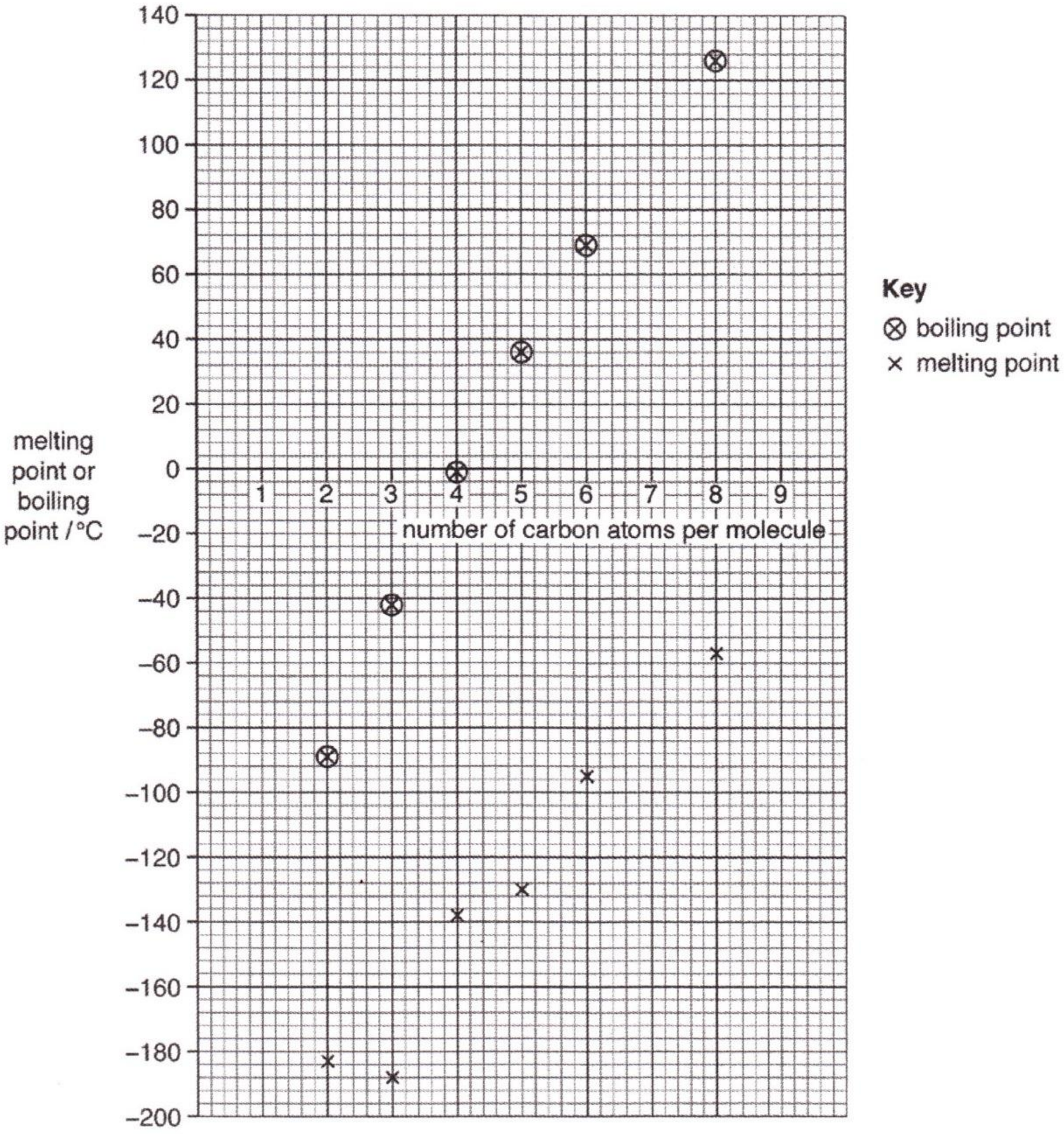
Table 1 shows the melting points and boiling points of some alkanes.

Table 1

name of alkane	formula	melting point / °C	boiling point / °C
ethane	C_2H_6	–183	–89
propane	C_3H_8	–188	–42
butane	C_4H_{10}	–138	–1
pentane	C_5H_{12}	–130	36
hexane	C_6H_{14}	–95	69
octane	C_8H_{18}	–57	126

Graph 1 shows the melting points and boiling points of some alkanes plotted against the number of carbon atoms in each alkane molecule.

Graph 1



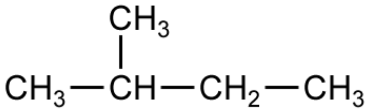
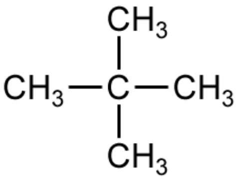
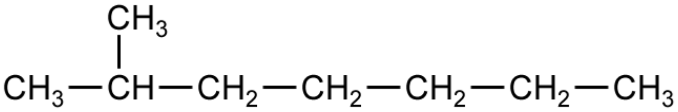
The flashpoint of a compound is the minimum temperature at which that compound gives off enough vapour to burn in air. The flashpoint is important to consider when hydrocarbons are blended to make fuels such as petrol. Compounds with lower flashpoints evaporate and burn more easily at lower temperatures and usually burn more smoothly in the car engine.

In a petrol refinery, isomerisation is used to convert straight chain alkanes into branched chain alkanes for use as fuels. The flashpoints of some straight chain and branched chain alkanes are shown in **Table 2** and **Table 3**.

Table 2 Shows the flashpoints of some straight chain alkanes.

name of alkane	**formula**	**flashpoint / °C**
propane	C_3H_8	–104
butane	C_4H_{10}	–71
pentane	C_5H_{12}	–49
hexane	C_6H_{14}	–23
heptane	C_7H_{16}	–4
octane	C_8H_{18}	13

Table 3 Shows the flashpoints of some branched chain alkanes.

	number of carbon atoms in molecule	**formula**	**flashpoint / °C**
branched alkane 1	5	 $CH_3-CH(CH_3)-CH_2-CH_3$	–57
branched alkane 2	5	 $CH_3-C(CH_3)_2-CH_3$	–65
branched alkane 3	8	 $CH_3-CH(CH_3)-CH_2-CH_2-CH_2-CH_2-CH_3$	4

(a) What trends are shown by the data in **Table 1** and **Graph 1**? [1]

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(b) One of the alkanes appears to have a melting point that is different from the expected value. Name the alkane and explain your choice. [1]

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(c) Heptane has the formula C_7H_{16}.

Predict the melting point and boiling point of heptane. [1]

melting point: ……………………… °C boiling point: ……………………… °C

(d) The boiling points and flashpoints of straight chain alkanes both follow similar trends.

Describe these trends. [1]

……………………………………………………………………………………………...

……………………………………………………………………………………………...

(e) How is the flashpoint of a straight chain alkane affected by isomerism?

Use evidence from the information to explain your reasoning. [4]

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

(f) Petrol contains straight chain octane. Other compounds are added to improve the performance of the fuel.

In cold countries, *winter blend* petrol is sold.

Winter blend petrol contains increased amounts of compounds that include pentane and branched chain alkane 2.

(i) Explain how and why this mixture works better than pure octane alone. [2]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(ii) Petrol tanks are not air tight.

Winter blend petrol is **not** sold in very hot weather conditions because it leads to an increased loss of petrol from the petrol tank.

Explain how and why the petrol is lost. [2]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

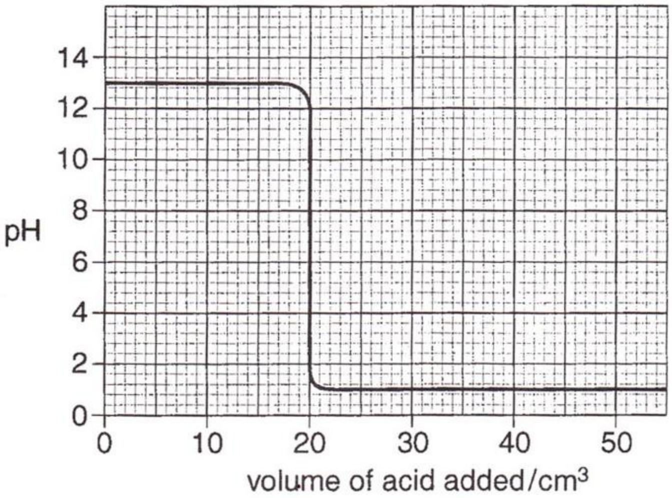
[Total: 12]

Question 10.

Read the information about some titration experiments.

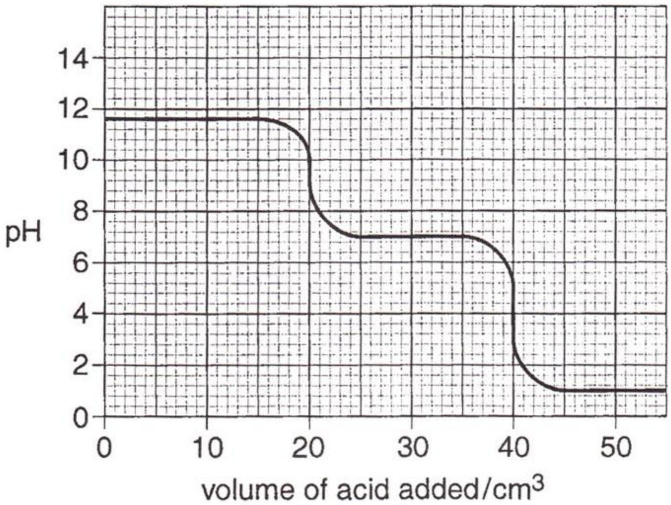
A pH probe attached to a computer measures pH changes during some titration experiments. In **Experiment 1**, 0.1 mol dm^{-3} hydrochloric acid was added from a burette to 25.0 cm^3 of dilute sodium hydroxide. The pH probe measured the pH during the experiment. **Graph 1** shows the results.

Graph 1.



In **Experiment 2**, 0.1 mol dm^{-3} hydrochloric acid was added from a burette to 25.0 cm^3 of dilute sodium carbonate. **Graph 2** shows the results.

Graph 2.



The reaction between sodium carbonate and hydrochloric acid happens in two stages.
Stage 1: Sodium carbonate reacts with dilute hydrochloric acid to form sodium hydrogencarbonate ($NaHCO_3$) and a neutral salt.
Stage 2: Sodium hydrogencarbonate undergoes a further reaction with hydrochloric acid.

(a) Use the information to calculate the concentration of sodium hydroxide used in **Experiment 1**. [3]

(b) A third experiment was carried out. A solution of sodium hydroxide of the same concentration as that used in **Experiment 1** was used. This time, dilute hydrochloric acid of a concentration of 0.2 mol dm^{-3} was added from a burette.

On **Graph 1** for **Experiment 1**, sketch the graph you would expect from this experiment. [2]

(c) What is the pH of sodium hydrogencarbonate? [1]

………………………………………………………………………………………………...

(d) What is the name and formula of the neutral salt formed in **Experiment 2** by the first stage of the reaction between sodium carbonate and hydrochloric acid? [1]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(e) Sodium carbonate is described as a weak alkali, but sodium hydroxide is described as a strong alkali. Use information from **Graph 1** and **Graph 2** to explain why. [2]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(f) Methyl orange is an indicator. It is red in solutions below pH 3, and orange in solutions above pH 4.

Explain why using a pH probe is better than using methyl orange for titrating sodium carbonate solution. [1]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

[Total: 10]

Question 11.

Choosing and Using De-icers

In some countries, winter temperatures fall below 0 °C and ice forms on roads. This causes accidents because vehicles slide on the slippery surface. De-icers are mixtures of chemical compounds that are spread on the roads to melt the ice.

The most commonly used de-icer is sodium chloride. It is used because it is very inexpensive. Calcium chloride is also used in smaller areas such as paths and car parks.

Effect of the Mass of De-icer Used

A scientist wanted to find out if mixtures containing a higher mass of de-icer have lower freezing points. She made solutions by adding different masses of sodium chloride to 100 cm^3 samples of water at room temperature. She then measured the freezing point of each solution. She repeated the experiment with different masses of calcium chloride. **Table 1** and **Table 2** show her results.

Table 1

mass of sodium chloride added / g	freezing point / °C
10	–8
20	–20
30	–15
40	does not fully dissolve

Table 2

mass of calcium chloride added / g	freezing point / °C
10	–9
20	–20
30	–45
40	+12

More About the Chemistry of De-icers

The surface of the ice has a very thin layer of water. The de-icer dissolves in this layer of water and lowers its freezing point. This stops the water from freezing.

Some de-icers dissolve exothermically. This helps to melt the solid ice under the layer of water and allows the de-icer to work deeper in the ice.

The enthalpy change that happens during dissolving is the enthalpy change of solution, ΔH_{sol}.

During very cold conditions, there may be very little liquid water for the de-icer to dissolve in. Some de-icers attract water vapour from the air and can use this to form a solution on the surface of the ice. De-icers that act in this way are known as hygroscopic.

Table 3 shows some information about some commonly used de-icers.

Table 3

compound	lowest effective temperature* / °C	ΔH_{sol} in kJ / mol	hygroscopic	other information
NaC*l*	–7	+3.9	no	speeds up corrosion of metals, harmful to plants
$CaCl_2$	–32	–82.9	yes	speeds up corrosion of metals, harmful to plants
$MgCl_2$	–18	–155	yes	speeds up corrosion of metals, harmful to plants
KC*l*	–4	+17.2	no	speeds up corrosion of metals, harmful to plants
CH_4N_2O (urea)	–4	+15.0	no	low toxicity

(a) Use the data to estimate the number of moles of sodium chloride that dissolve in 1 dm^3 of water. [1]

(b) What are the similarities and differences in the results of the scientist's experiment for sodium chloride and calcium chloride? [3]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(c) Some of de-icers are effective at much lower temperatures than others. Identify **two** factors that determine which de-icers are more effective at very low temperatures. Explain your answers. [3]

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

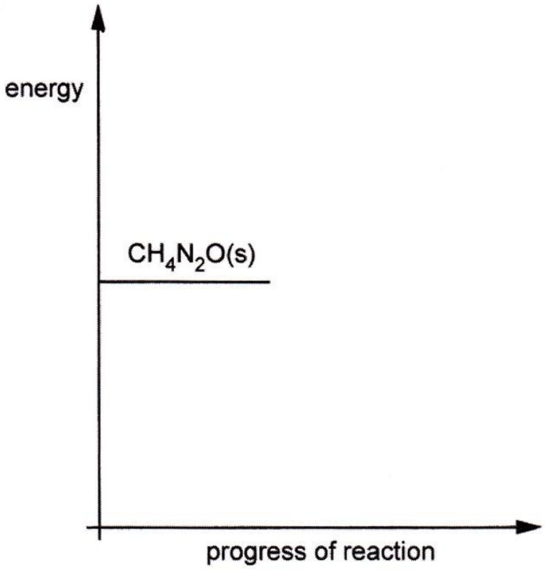
…………………………………………………………………………………………………...

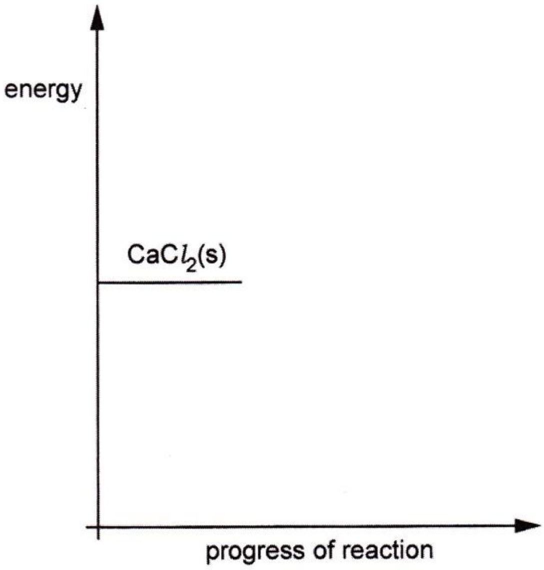
…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

(d) **(i)** Complete the energy level diagrams to show the products and energy changes of solution when urea, CH_4N_2O, and calcium chloride, $CaCl_2$, dissolve in water. [3]





(ii) Suggest one benefit of using urea rather than calcium chloride as a de-icer. [1]

………………………………………………………………………………………………

………………………………………………………………………………………………

(e) Some of the de-icers are harmful to plants. This is because they contain a high concentration of a particular ion. Which ion in these de-icers is most likely to be harmful to plants at high concentrations? Explain your reasoning. [1]

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

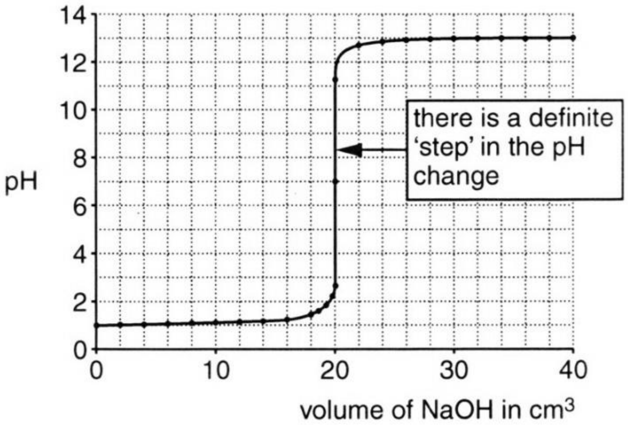
[Total: 12]

Question 12.

pH Changes During a Titration. A pH meter and a data logger are used to monitor the pH changes during a series of titrations. In each titration, 0.1 mol/dm^3 sodium hydroxide, NaOH, is added from a burette into a solution of a different dilute acid. During the titrations, the pH does not change smoothly. The data logger gives a graph for each titration.

titration 1:

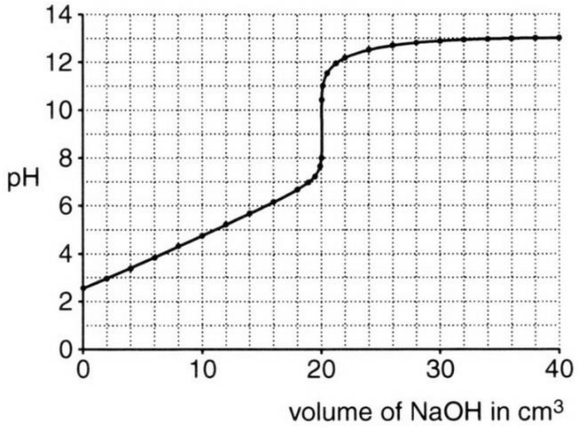
0.1 mol/dm^3 sodium hydroxide added to 20.0 cm^3 0.1 mol/dm^3 hydrochloric acid (HC*l*)



titration 2:

0.1 mol/dm^3 sodium hydroxide added to 20.0 cm^3 0.1 mol/dm^3 ethanoic acid (CH_3COOH)

Ethanoic acid is a weak acid. The shape of the graph is different from **titration 1**.

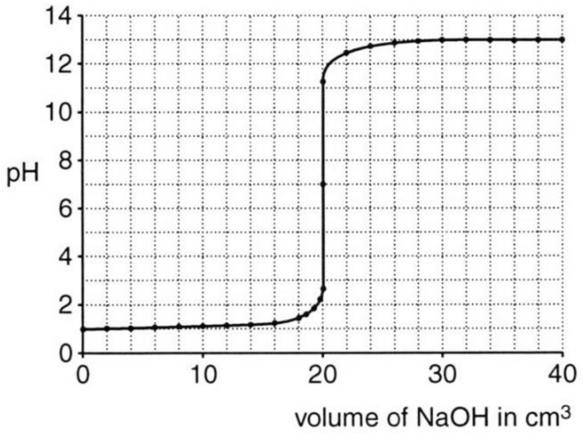


titration 3:

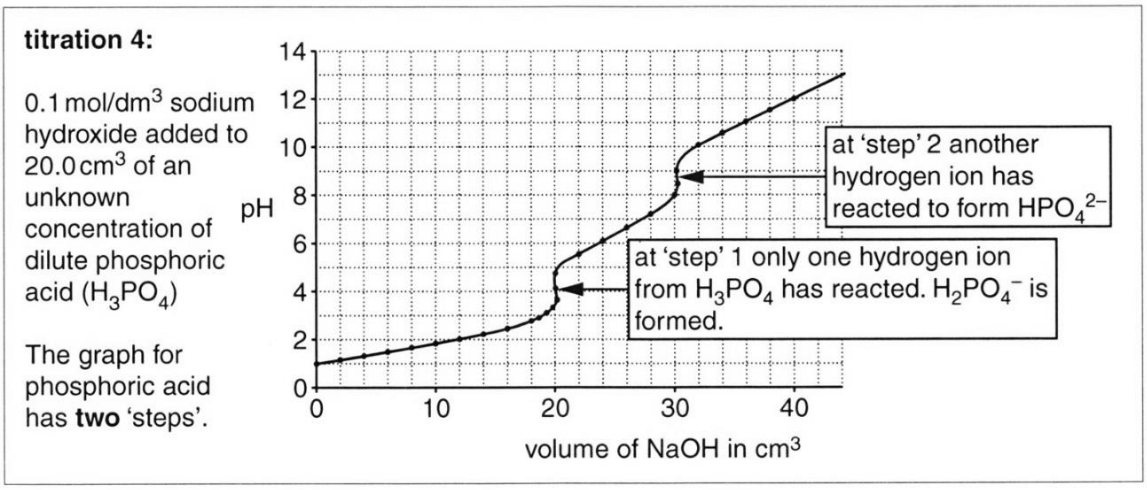
0.1 mol/dm^3 sodium hydroxide added to 20.0 cm^3 of an unknown concentration of dilute sulfuric acid (H_2SO_4)

Sulfuric acid is a strong acid. The ionisation of sulfuric acid can be shown by two equations.

1. $H_2SO_4 \rightarrow H^+ + HSO_4^-$
2. $HSO_4^- \rightarrow H^+ + SO_4^{2-}$



H_2SO_4 and HSO_4^- are both strong acids. Therefore they are both neutralised at the same point in the titration, which means that there is still only a single 'step' on the graph.



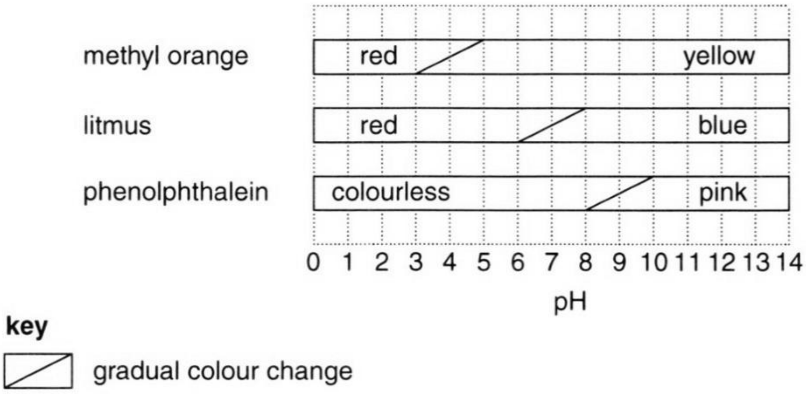
There appear to be three hydrogen atoms in phosphoric acid that may ionise. In practice, only the first two hydrogen atoms form ions. At the end of the titration, HPO_4^{2-} ions are left.

Endpoints and Indicators

An indicator can also be used to see when a 'step' happens in the pH change.

The **endpoint** of each titration happens when the indicator changes colour.

The diagram shows the colours of some indicators at different pH values. In between the colours, most indicators change colour gradually over a range of pH values.



The best indicator for a titration gives a distinct colour change when a 'step' occurs.

For a titration between a strong acid and a strong alkali, every indicator in the diagram would give an accurate titration volume.

(a) The information does not give the concentration of sulfuric acid used in **titration 3**. What is the concentration? Explain your reasoning in words or by means of a calculation. [2]

Concentration ……………………… mol/dm^3

Reasoning …………………………………………………………………………………..........

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

(b) Hydrochloric acid is a strong acid; ethanoic acid is a weak acid.

(i) What is the difference between a strong acid and a weak acid? [1]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………….......

(ii) Identify **two** differences between the pH graphs for **titration 1** and **titration 2**. [2]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(c) **(i)** Write equations to show how phosphoric acid produces the hydrogen ions involved in the two 'steps' on the pH graph in **titration 4**. [2]

- 'Step' 1:

……………………………………………………………………………………………………

- 'Step' 2:

……………………………………………………………………………………………………

(ii) Give the formula for the salt formed at the end of **titration 4**. [1]

……………………………………………………………………………………………………

(d) **(i)** Explain why any of the indicators in the diagram can be used to give an accurate titration volume when strong acids are titrated with dilute sodium hydroxide. [2]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(ii) Explain why methyl orange would **not** be suitable to use when titrating ethanoic acid with dilute sodium hydroxide. [1]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(iii) Suggest the best indicator to use when titrating ethanoic acid with dilute sodium hydroxide. [1]

……………………………………………………………………………………………………

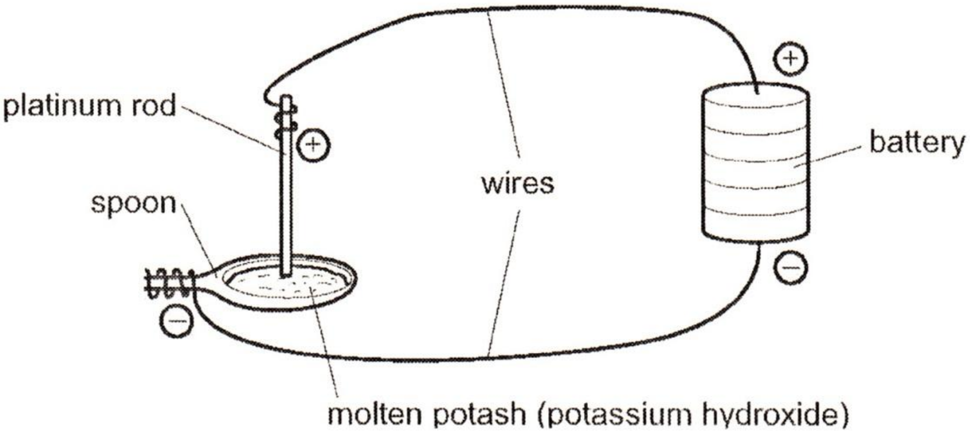
[Total: 12]

Question 13.

In the early nineteenth century, the first batteries had just been invented. Humphrey Davy was fascinated by batteries and used them to pass electricity through chemicals to see what changes happened. He quickly found out that solid compounds do not conduct electricity. He tried passing electricity through ‘potash’ (potassium hydroxide, KOH) dissolved in water. He was disappointed when only hydrogen and oxygen were made. He wrote,

“*I acted upon aqueous solutions of potash by the highest electrical power I could command, but in these cases, though there was a high intensity of action, the water of the solutions alone was affected, and hydrogen and oxygen were produced with much heat and violence*.”

Davy then tried passing electricity through hot, molten potassium hydroxide on a platinum spoon, as shown below.



He was delighted when, “Small globules with a metallic lustre formed on the spoon. The hot drops of metal exploded in the air.” He had discovered potassium. This was the first element to be discovered by electrolysis.

(a) Humphrey Davy used a platinum spoon and rod as his electrodes.

(i) Why did Davy choose platinum and not iron for his electrodes? [1]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(ii) The same analysis can be carried out in a modern laboratory. What material could replace platinum for the electrodes in modern apparatus? [1]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(b) Humphrey Davy found that the products of the electrolysis of potash were different when he used a molten sample instead of an aqueous solution. Discuss the differences that he found. Your answer should include:

- A list of the ions used in each electrolysis.
- Ionic equations, with state symbols, for the changes at the electrodes.
- An explanation of why the products of each electrolysis are different. [8]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(c) Suggest a reason why chemists had not been able to extract potassium before Davy's time. [2]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

[Total: 12]

Question 14.

Compounds in Bleach

Bleaches are used to remove colour and to sterilise areas where hygiene is important. They are used in industry to bleach wood pulp for making paper, and flour for making bread. They are often used to sterilise areas such as bathrooms because they react with and break down organic molecules.

Manufacturing and Using Hypochlorite Bleaches

The most common compound used to make hypochlorite bleach is sodium hypochlorite, which is also known as sodium chlorate(I), $NaOCl$. The numeral in the name refers to the oxidation state of the chlorine in the compound. Pure sodium chlorate(I) is a very unstable solid at room temperature.

Sodium chlorate(I) is an oxidising bleach which is used to clean toilets and to kill bacteria in swimming pools. Human waste often contains ammonia. Sodium chlorate(I) reacts with ammonia by substituting a hydrogen atom with chlorine to form chloramine, NH_2Cl.

$$NH_3 + NaOCl \rightarrow \underset{\textbf{chloramine}}{NH_2Cl} + NaOH$$

Chloramine reacts with sodium chlorate(I), then the product formed reacts further with sodium chlorate(I) to form nitrogen trichloride. Compounds of nitrogen with chlorine are irritating and toxic to people.

Other Chlorine Based Bleaches

Sodium chlorate(I) is not the only hypochlorite bleach. All hypochlorite bleaches contain the chlorate(I) oxyanion. The oxyanion contains a covalent bond between the oxygen and chlorine atoms. Both atoms in the ion have a stable octet electron arrangement because the ion also has an overall negative charge.

$$[Cl - O]^-$$

chlorate(I) oxyanion

Calcium hypochlorite, which is also known as calcium chlorate(I), has two main advantages. Firstly, it is a stable solid, so it can be used to make powdered bleaching products for cleaning. Secondly, the percentage by mass of chlorate(I) ions in calcium chlorate(I) is greater than the percentage by mass of chlorate(I) ions in sodium chlorate(I).

A Different Type of Oxidising Bleach

Hydrogen peroxide, H_2O_2, is another compound which is used to make bleaches. It oxidises and breaks down compounds and produces water. Hydrogen peroxide is used to bleach hair and to sterilise wounds. Hydrogen peroxide is an unusual compound because the oxidation state of oxygen in the compound is –1.

H – O – O – H

structure of hydrogen peroxide

Sodium peroxide and calcium peroxide are also used as bleaches and disinfectants.

(a) Suggest reasons why the chlorate(I) ion is referred to as an 'oxyanion'. [1]

………………………………………………………………………………………………...

………………………………………………………………………………………………...

(b) **(i)** Write an equation for each of the two reactions which lead to the formation of nitrogen trichloride from chloramine. [1]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(ii) Deduce the oxidation states of nitrogen in each compound in these equations and hence show that sodium chlorate(I) acts as an oxidising agent. [3]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(c) Draw a 'dot-and-cross' diagram to show the arrangement of the outer shell electrons in a chlorate(I) oxyanion. [2]

(d) Show by calculation that the percentage by mass of chlorate(I) ions in calcium chlorate(I) is greater than the percentage by mass of chlorate(I) ions in sodium chlorate(I). [3]

(e) Deduce the formula for calcium peroxide. [1]

(f) Give a reason why hypochlorite bleaches can cause people to have adverse reactions but hydrogen peroxide bleaches are less likely to do so. [1]

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

[Total: 12]

Question 15.

Instrumental Techniques in Analysis

Flame Tests for Group 1 Elements

Flame tests were used in the 1850s. Robert Bunsen invented the Bunsen Burner and used it to show that many metals give characteristic colours when they are heated in the flame. The colour comes from light emitted by individual atoms when they become very hot. For example, sodium gives a very intense yellow-orange colour. The table shows the flame colours of Group 1 elements.

element	flame colour
lithium	red
sodium	yellow-orange
potassium	pale violet
rubidium	red-violet
caesium	blue-violet

Group 1 Element Emission Spectra

Bunsen realised that, in practice, it was difficult to use flame tests to identify elements in mixtures. In the 1860s, Bunsen worked with fellow scientist, Gustav Kirchhoff. They a spectroscope to split the colours of the flames into individual lines. They found that atoms of an element each gave a characteristic pattern of lines which is known as an emission spectrum. **Figure 1** shows the emission spectra of some Group 1 elements.

Emission spectra from elements can be used as a reference. They can be compared with the emission spectrum of a mixture so that individual elements in the mixture can be identified. This technique is used today to analyse light from stars to work out which elements are present in the star.

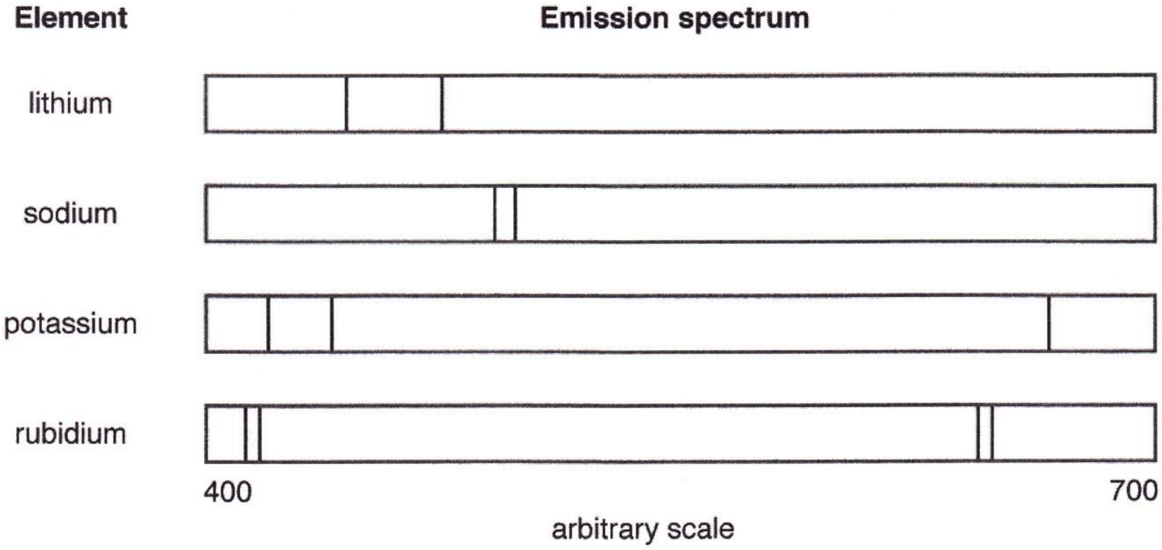


Figure 1.

Ion Chromatography of a Sample of Water

In the 1950s, ion chromatography was developed. This technique involves passing a sample through a chromatography column. Different ions travel through the column at different speeds. A detector is attached to the end of the column. The results are printed out as a graph.

The **retention time** is the time it takes each ion to travel through the column. Ions can be identified by their retention times. The position of the peaks show the retention time of each ion.

The **height** of each peak (relative intensity) is proportional to the **relative amount** of each ion in the sample.

Ion chromatography can be used to identify any ion, even those which contain multiple atoms, such as the sulfate ion.

The ion chromatography analyses of a sample of water from a natural source are shown in **Figure 2** and **Figure 3**.

Figure 2 shows the ion chromatogram of positive ions in a sample of the water.

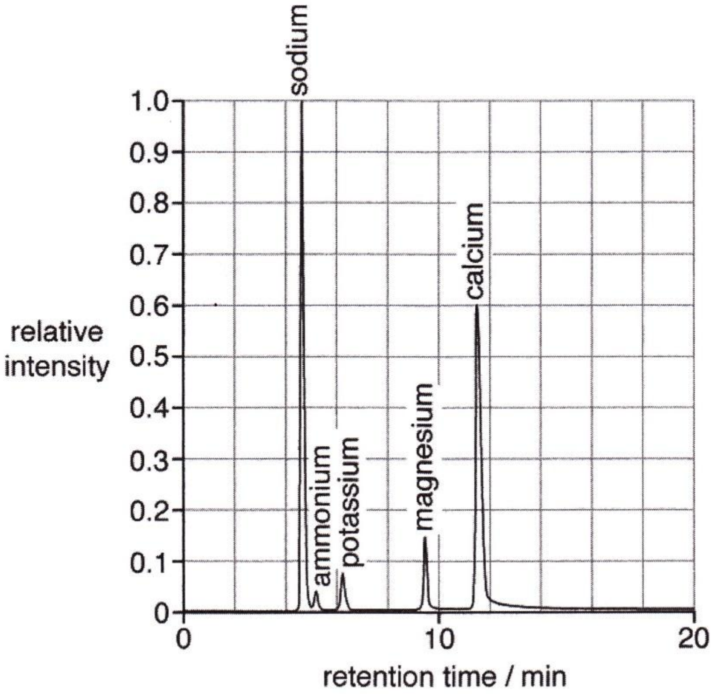


Figure 2.

Figure 3 shows the ion chromatogram of negative ions in a sample of water.

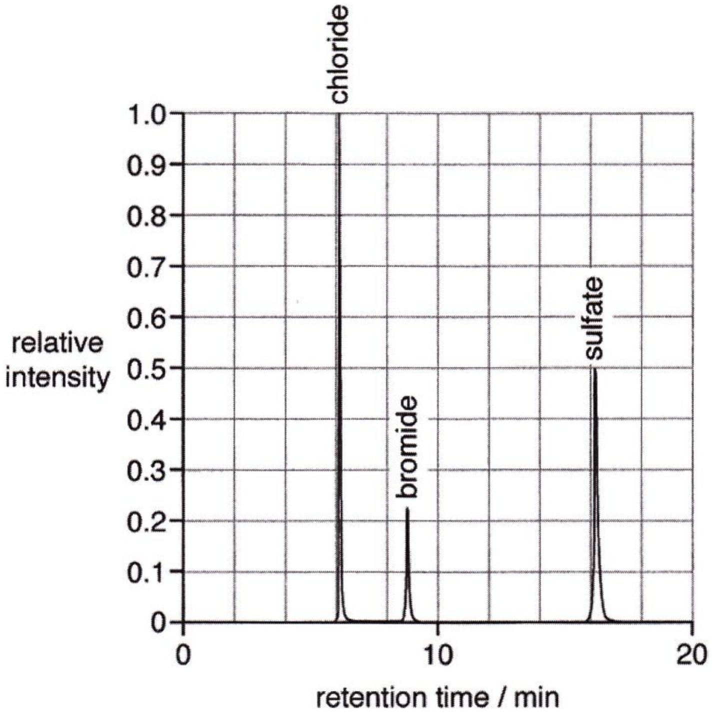


Figure 3.

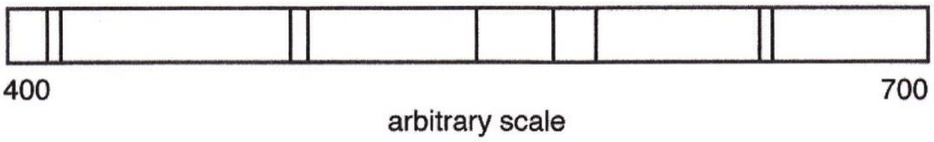
(a) Bunsen said that it is difficult to use flame tests to identify elements in mixtures. Explain why it is difficult to use flame tests to identify which Group 1 elements are in a mixture. [2]

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

(b) This is the emission spectrum from a mixture.



(i) What conclusions can you make about which Group 1 elements this mixture does and does not contain? Explain your reasoning. [3]

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(ii) What additional information would you need so that you could use the spectrum to identify **all** of the elements in the mixture? [1]

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(c) Further analysis of the same sample of water that was tested by **ion chromatography** was done.

(i) The sample was analysed to find out the concentration of sodium ions.

The first stage was to crystallise solid salts from the water.

Give the formulae of **three** different sodium salts which could crystallise from the water sample. [2]

Salt 1: ……………………………………………………………………………………..

Salt 2: ……………………………………………………………………………………..

Salt 3: ……………………………………………………………………………………..

(ii) The concentration of calcium ions in the water is 0.00420 mol dm^{-3}.

Calculate the concentration of magnesium ions and the concentration of sodium ions in the water. [2]

(d) A student comments that the ion chromatograms give more information about mixtures than the emission spectrum.

Give reasons to support her ideas. [2]

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

[Total: 12]

Question 16.

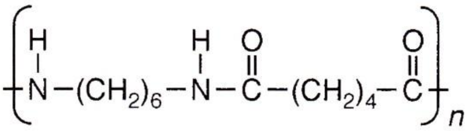
The Story of Nylon

Discovery, Naming and Properties

Wallace Carothers was an American research Chemist in the 1930s. He researched new synthetic polymers to replace silk. At the time, silk was needed in very large quantities for parachutes. He is most famous for developing the first ‘nylon’.

Carothers reacted together a diamine and a dicarboxylic acid to make a type of polyamide that we now call ‘nylon 6,6’.

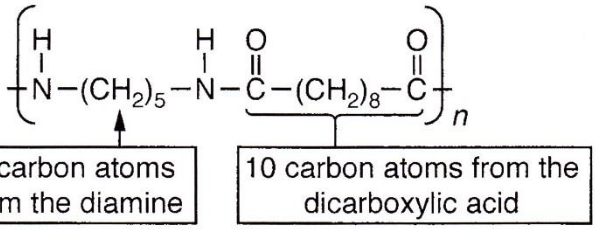
nylon 6,6



$\left[-NH-(CH_2)_6-NH-C(=O)-(CH_2)_4-C(=O)-\right]_n$

The numbers in the systematic names of each nylon refer to the number of carbon atoms from the diamine (the first number) and the dicarboxylic acid (the second number) which were used to make the nylon. For example, another type of nylon (nylon 5,10) was also made by Carothers. The structure of nylon 5,10 is shown below.

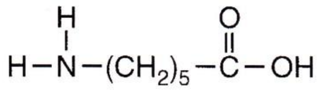
nylon 5,10



$\left[-NH-(CH_2)_5-NH-C(=O)-(CH_2)_8-C(=O)-\right]_n$

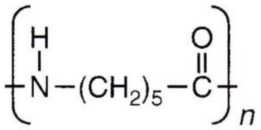
Later, nylon 6 was invented. This can be made from a single monomer that has an amine group at one end and a carboxylic acid group at the other end.

monomer of nylon 6



$H-NH-(CH_2)_5-C(=O)-OH$

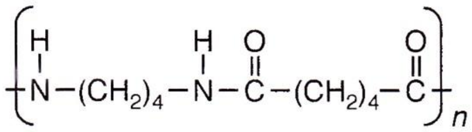
repeating unit of nylon 6



$\left[-NH-(CH_2)_5-C(=O)-\right]_n$

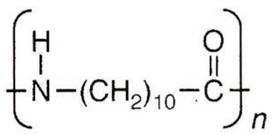
Other types of nylon were developed later.

repeating unit of nylon X



$\left[-NH-(CH_2)_4-NH-C(=O)-(CH_2)_4-C(=O)-\right]_n$

repeating unit of nylon Y



$\left[-NH-(CH_2)_{10}-C(=O)-\right]_n$

Different types of nylon are used for different purposes. One of the limits to their use is that they cannot be used in contact with solutions of strong acids because they react slowly with strong acids to form their original monomer molecules. Some uses of nylon are related to their melting points. For nylons made from two different monomers, the melting point is affected by the chain lengths of the diamine and the dicarboxylic acid used to make the nylon.

name of nylon	melting point / °C
nylon 6,6	269
nylon 6,10	220
nylon 6	220
nylon 4,6	275
nylon 6,12	218
nylon 11	190

Using Nylon

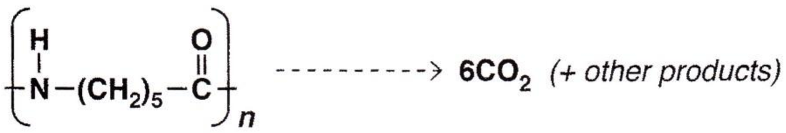
Nylons are useful because they are generally unreactive and can be made into very strong fibres. They are used to make clothing, fishing lines, ropes and machine parts. To be suitable for making fibres, the nylon chains must have a relative molecular mass of between 10 000 and 20 000. This length of molecule gives enough strength, but is still flexible enough to be spun into fibres easily.

Disposal of Nylon

All types of nylon are difficult to dispose of at the end of their useful life because they do not biodegrade easily. However, in the 1970s, a strain of bacteria was discovered that breaks down nylon. Nylon can also be disposed of by burning at a high temperature.
Both these methods of disposal give off carbon dioxide. This means that the disposal of nylon has a ‘carbon footprint’. The carbon footprint of nylon is the mass of carbon dioxide that is given off per kilogram of nylon.

carbon footprint = mass of carbon dioxide given off per kilogram of nylon

The carbon footprint can be calculated by considering the amount of carbon dioxide given off by each repeating unit of the nylon, for example, for nylon 6:



$$\left[-\overset{\overset{\displaystyle H}{|}}{N}-(CH_2)_5-\overset{\overset{\displaystyle O}{\|}}{C}- \right]_n \dashrightarrow 6CO_2 \text{ (+ other products)}$$

(a) Name **nylon X** and **nylon Y**. [3]

Nylon X: ....

Nylon Y: ....

(b) Give the structural formulae of the **two** products that form when nylon 5,10 is left in contact with strong acid. [2]

(c) A company wants to use nylon 6,6 to make fibres. Calculate the minimum number of repeating units which must be present in one chain of the nylon 6,6. [2]

(d) The article says "For nylons made from two different monomers, the melting point is affected by the chain lengths of the diamine and the dicarboxylic acid used to make the nylon".
How is the melting point of the nylon affected by the chain lengths of the diamine and the dicarboxylic acid used?
Explain your reasoning. [3]

Diamine: ……………………………………………………………………………………………..
………………………………………………………………………………………………………...
………………………………………………………………………………………………………...
Dicarboxylic acid: ………………………………………………………………………………...
………………………………………………………………………………………………………...
………………………………………………………………………………………………………...

(e) Calculate the carbon footprint of nylon 6. [2]

[Total: 12]

Question 17.

Acids and PH

Solutions of different acids of the same concentration (in mol/dm^3) have different properties. The concentration of hydrogen ions, the pH and the rate of reaction with metals and carbonates may be different, even when the initial concentration of the acid is the same.

Table 1 gives information about solutions of acids at different concentrations.

Table 1

name of acid	concentration of acid in mol/dm^3	concentration of hydrogen ions in solution in mol/dm^3	pH
hydrochloric acid	0.01	0.01	2.0
	0.10	0.10	1.0
	0.20	0.20	0.7
sulfuric acid	0.01	0.02	1.7
	0.02	0.04	1.4
ethanoic acid	0.01	0.0004	3.4
	0.05	0.0009	3.0
	0.10	0.0013	2.9

General Equations for Reactions of Acids

Some sources, such as textbooks and websites, represent the general formula of an acid as HA, where A is an anion. HA can be used to write general equations for the reactions of acids. For example, the reactions of acids with Group 2 metal hydroxides maybe written as:

equation 1 $2HA + M(OH)_2 \rightarrow MA_2 + 2H_2O$

And the reaction of acids with any metal can be written as

equation 2 $xHA + M \rightarrow MA_x + \frac{x}{2}H_2$

Where x is the value of the positive charge on the metal ion.

(a) **(i)** Which acids in **Table 1** fit the general formula HA and which do not? Explain your reasoning with reference to the ions present in each acid. [2]

....

....

....

....

....

(ii) Construct a general equation for the reaction of an acid with a Group 1 metal carbonate. Use HA as the general formula for an acid and M as the symbol for a Group 1 metal. [1]

....

(iii) Write a balanced chemical equation for the reaction of calcium with ethanoic acid.

Show, with reference to the value of x, why **equation 2** agrees with your equation. [2]

....

....

....

....

....

(b) **(i)** A student looks at the data in **Table 1** and suggests the following relationship.

$$\text{pH} \quad \propto \quad \frac{1}{\text{initial concentration of the acid}}$$

Use the data in **Table 1** to show that this relationship is incorrect. [2]

....

....

....

....

....

(ii) State and explain the factors that affect the pH of an acid using data from **Table 1**. [3]

....

....

....

....

....

(iii) Complete **Table 2**. Use the data in **Table 1** to help you. [2]

Table 2

name of acid	concentration of acid in mol/dm^3	concentration of hydrogen ions in solution in mol/dm^3	predicted pH
hydrochloric acid	0.04		
sulfuric acid	0.05		

[Total: 12]

Question 18.

Comparing vehicle fuels

Car manufacturers make cars which use a range of different fuels. Some fuels are renewable, which means that they do not rely on using finite resources such as fossil fuels, and some are 'carbon neutral', which means that their use does not lead to an overall increase in the amount of carbon in the atmosphere. Other factors that need to be taken into account are the energy output of the fuel and how easy it is to store in vehicles.

Ethanol in fuels

Ethanol fuels contain 93–96% ethanol. It is used mainly in countries such as Brazil where sugarcane can be grown in large quantities. The percentage of ethanol in the fuel is indicated by the name of the fuel. For example, E25 contains 25% ethanol by mass and E70 contains 70% ethanol by mass. In most other countries, standard petrol contains ethanol as an additive. Typically, standard petrol contains about 10% ethanol by mass and the rest is hydrocarbons. Ethanol is a useful additive to standard petrol because it increases the percentage of oxygen available for combustion.

Producing ethanol

Ethanol for use as a fuel for vehicles can be produced by either fermentation or by the catalytic addition of steam to ethene in an industrial process (see **Table 1.1**).

Table 1.1

process	raw materials	additional information
fermentation	sugar from sugarcane	reactions after fermentation produce ethanoic acid and ethyl ethanoate impurities separated by distillation or use of molecular sieves
catalytic addition of steam to ethene	ethene from cracking of naphtha from petroleum	conditions: • 300°C • 70 atm. Pressure • phosphoric(V) acid catalyst

Data about energy output

The enthalpy change of combustion is the energy given out when one mole of a pure compound burns. This can be used to compare the energy output of the main compounds in fuels, as shown in **Table 1.2**.

Table 1.2

type of fuel	main compound	enthalpy change of combustion of main compound in kJ/mol
LNG (liquified natural gas)	methane	–890
LPG (liquified petroleum gas)	butane	–2877
petrol	octane	–5470
ethanol fuel	ethanol	–1366

Fuels are mixtures of compounds and the enthalpy change of combustion does not take into account the state or the density of the fuel.

Comparing fuels

Gaseous fuels take up a lot of storage space in a vehicle, therefore they are compressed into a liquid state. Both the mass density and energy density (energy released per litre) of the fuels are important because they determine how far a vehicle can travel before needing to be refuelled. **Table 1.3** compares the mass density and energy density of some liquid fuels (1 L = 1000 cm^3).

Table 1.3

type of fuel	mass density in g/cm^3	energy density (energy released per litre in kJ/L
LNG (liquified natural gas)	0.45	22 200
LPG (liquified petroleum gas)	0.55	26 500
petrol	0.75	34 200
ethanol fuel	0.79	25 000

Energy densities of fuels can be approximated by calculations which use the enthalpy change of combustion of the main compound in the fuel and the mass density of the fuel. These calculated values differ from the values shown in **Table 1.3** because fuels are actually mixtures of compounds.

One way of comparing fuels is by using a GGE index. This compares the energy output of one litre of petrol to the energy output of one litre of the fuel. So, for example, a fuel with a GGE of 2.0 contains half as much energy per litre as one litre of petrol. Two litres of fuel would need to be carried in the vehicle to give the same energy output as one litre of petrol. This is more useful than looking at enthalpy change of combustion data because it takes into account the volume of fuel that can be stored in the car. Comparing ethanol fuel to petrol gives ethanol fuel a GGE of 1.4.

(a) The article identifies impurities in ethanol that is produced from sugarcane.

Describe how these impurities form. [2]

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(b) Some people think that ethanol is a 'carbon neutral' and renewable fuel.

Explain why people think this and explain how the information shows that this is incorrect.

[2]

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(c) **(i)** Calculate the percentage by mass of oxygen in E70 fuel. [2]

Percentage by mass of oxygen = …………………………

(ii) Suggest an advantage of increasing the percentage of oxygen in a fuel. [1]

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(d) Calculate the GGE of LPG (liquified petroleum gas).

Use your value to comment on how this affects the storage space needed for LPG fuel in vehicles compared to petrol vehicles. [2]

GGE of LPG = …………………………

Comment on storage space: ………………………………………………………………………

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

(e) An approximate value for the energy density of petrol can be estimated from the enthalpy change of combustion of octane, C_8H_{18}, and the mass density of petrol. This differs from the value shown in **Table 1.3**.

Calculate this approximate value. [3]

Approximate value for the energy density of petrol = ... kJ/L

[Total: 12]

- A copy of this assignment can be found online at:

http://www.nygh.sg/miscellaneous/sec_4_chem/database_questions.pdf

• Scan the QR code to view the answers to this assignment.		• Web page for answers: http://www.nygh.sg/ miscellaneous/ sec_4_chem/ database_answers.pdf

Periodic Table of the Chemical Elements (2017)

Key

atomic number
atomic symbol
name
relative atomic mass

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 A*l* aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 C*l* chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 T*l* thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 F*l* flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –