



West Spring Secondary School Preliminary Examination 2022

CHEMISTRY

6092/02

Paper 2

SECONDARY 4 EXPRESS

Name _____ () Date **26 August 2022**

Class _____ Duration **1 hour 45 minutes**

Additional materials: Laminated Periodic Table

READ THESE INSTRUCTIONS FIRST

Write your index number, class and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Section A

Answer **all** questions in the spaces provided.

Section B

Answer all **three** questions, the last question is in the form either/or.

Answer **all** questions in the spaces provided.

The number of marks is given in brackets [] at the end of each question or part question.

A copy of the Periodic Table is provided separately.

The use of an approved scientific calculator is expected, where appropriate.

FOR EXAMINER'S USE	
Section A	/ 50
Section B	/ 30
Total	/ 80

This document consists of **20** printed pages including the cover page.

Setter: Mdm Sharena

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

- A1** Choose from the following reactions/processes to fill in the blanks. Each reaction/process may be used once, more than once or not at all.

Precipitation	Displacement	Reduction	Decomposition
Neutralisation	Combustion	Oxidation	Dissociation

- (a) When potassium hydroxide and carbonic acid reacts, occurs. [1]
- (b) Iron undergoes during rusting. [1]
- (c) Copper(II) carbonate undergoes to form copper(II) oxide and carbon dioxide. [1]
- (d) Copper(II) oxide can undergo to form copper, by reacting with hydrogen. [1]
- (e) Methane undergoes when it reacts with air to produce carbon dioxide and water vapour. [1]

[Total: 5]

- A2** Chromatography can be used to separate components of a mixture.

A student used paper chromatography to analyse a black food colouring.

The student placed spots of known food colours, A, B, C, D and E, and the black food colouring on a sheet of chromatography paper and carried out paper chromatography using ethanol as the solvent.

The results are shown on the chromatogram in Figure 2.1.

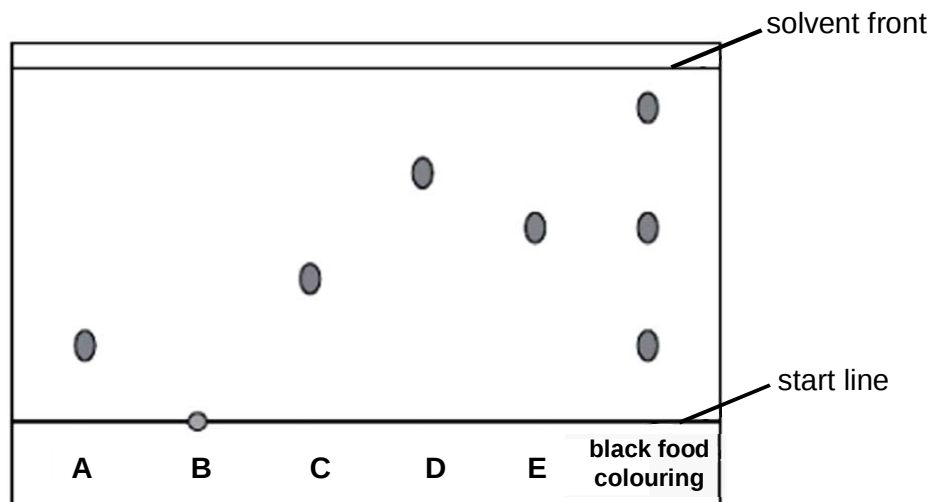


Fig. 2.1

- (a) Which of the known food colours is insoluble in ethanol? [1]
- (b) What does the chromatogram tell you about the composition of the black food colouring?

[2]
- (c) Table 2.1 gives the results of chromatography experiments that were carried out on some known food colours, using ethanol as the solvent.

Table 2.1

name of food colour	distance from start line to solvent front in mm	distance moved by food colour in mm	R _f value
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

Using Figure 2.1 and the information in Table 2.1, calculate the R_f value of food colour C to determine which of the food colours in the table could be food colour C?

Use the formula,

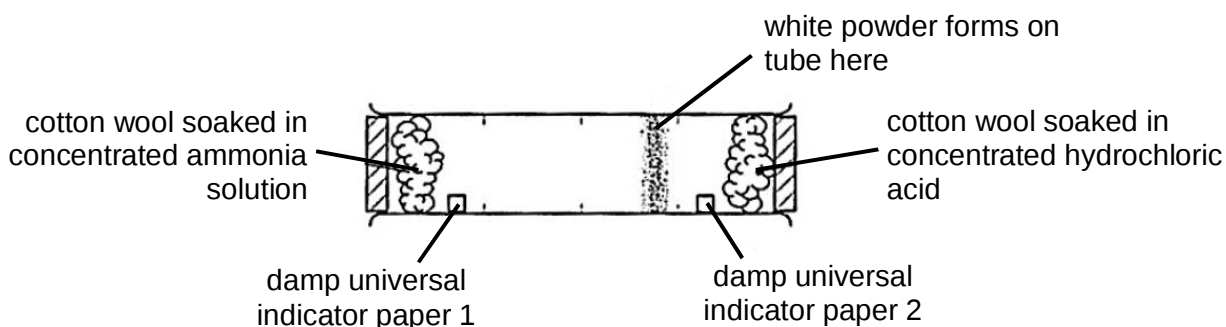
$$R_f \text{ value} = \frac{\text{distance travelled by food colour C}}{\text{distance travelled by the solvent}}$$

Food colour C is

[2]

[Total: 5]

- A3** An experiment was set up to investigate the movement of gaseous ammonia and gaseous hydrogen chloride.



- (a) The white powder forms on the tube due to the reaction between gaseous ammonia and gaseous hydrogen chloride to produce solid ammonium chloride.

Insert the correct symbol in the equation to show that this reaction is reversible.



- (b) The tube contains two pieces of Universal Indicator paper.

Complete Table 3.1 to show the colours and pH values of each piece of paper at the end of the experiment.

Table 3.1

Universal Indicator paper	colour	pH
1		
2		

[2]

- (c) Explain why the white powder does not form at the centre of the tube.

.....

.....

.....

.....[3]

[Total: 6]

A4 Strontium-88 has three other isotopes.

Figure 4.1 is the mass spectrum that shows the relative abundance of each isotope.

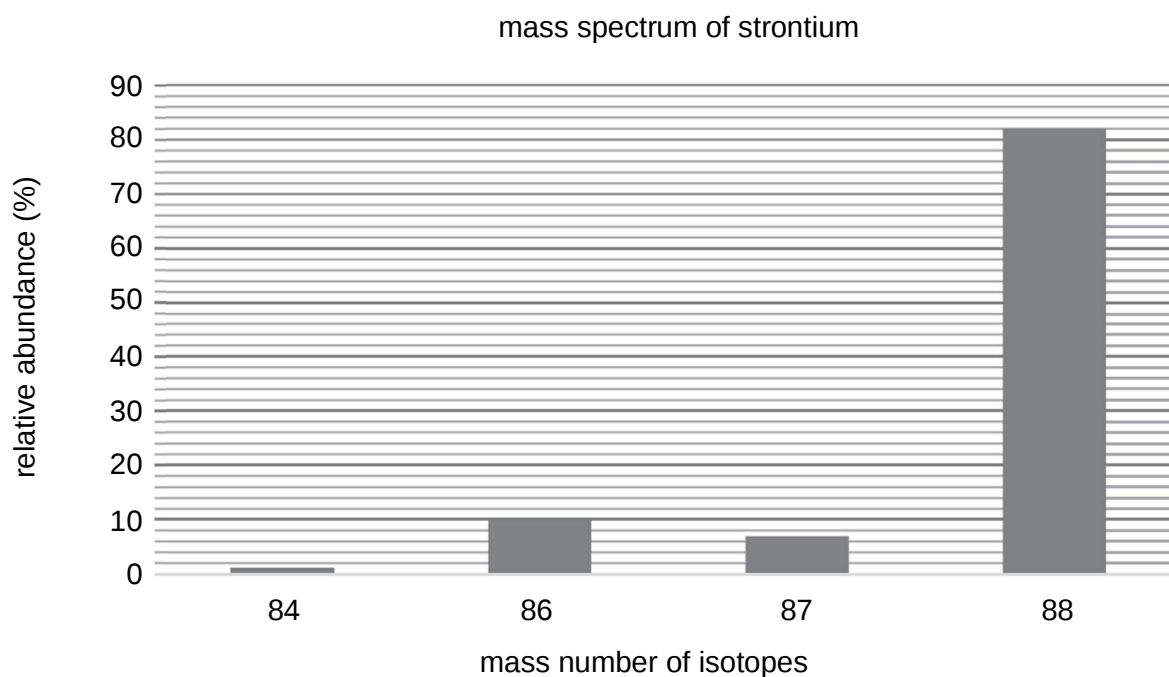


Fig. 4.1

(a) Calculate the relative atomic mass of strontium.

Show your working clearly.

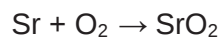
[2]

(b) 180 g of strontium-88 burns in oxygen to form 245 g of strontium peroxide.

Show that the empirical formula of strontium peroxide is SrO_2 .

[2]

- (c) The reaction between strontium and oxygen is a redox reaction.



Oxygen acts as an oxidising agent in the reaction.

Use ideas about oxidation state to explain that the statement is true.

.....

[2]

- (d) Strontium also forms strontium superoxide, $\text{Sr}(\text{O}_2)_2$, with oxygen.

Determine the formula for a superoxide ion.

.....[1]

[Total: 7]

A5 Astatine, At, is an element in Group VII of the Periodic Table.

It exists as diatomic molecules similar to the other elements in the same Group.

Two isotopes of astatine are known to exist : astatine-210 and astatine-211.

It reacts with calcium (Ca) to form the compound calcium astatide.

symbol	number of protons	number of neutrons	number of electrons
$^{85}_{210}\text{At}$			
$^{85}_{211}\text{At}$			

- (a) Complete the table above. [2]

- (b) Using astatine-210 and astatine-211 as examples, describe **one** similarity and **one** difference in terms of the particles in their nucleus.

.....

[2]

- (c) Draw the 'dot-and-cross' diagram for astatine.

Show outer electrons only.

[1]

- (d) Draw the "dot-and-cross" diagram of calcium astatide.

Show outer electrons only.

Hence, write the chemical formula of this compound.

Chemical formula of calcium astatide :

[3]

- (e) Suggest whether the melting and boiling point of calcium astatide will be higher or lower than that of astatine.

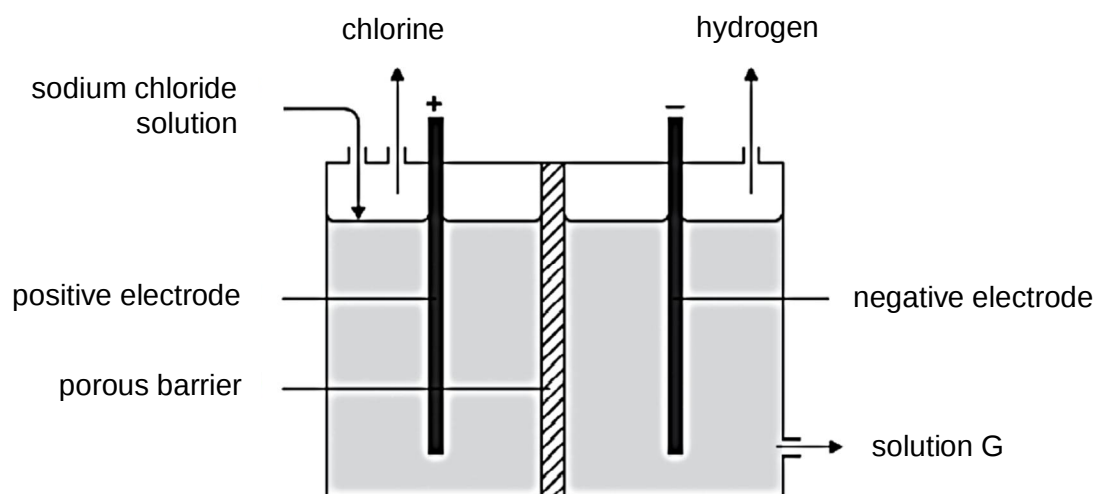
Explain your answer.

.....

[3]

[Total: 11]

- A6** The electrolysis of concentrated sodium chloride solution is an industrial process which produces three products: chlorine, hydrogen and solution G.



- (a)** Graphite electrodes are used in the electrolysis.

Explain, in terms of bonding, why graphite conducts electricity.

.....

[2]

- (b)** Solution G is alkaline.

Name solution G and explain how it is produced in the electrolysis.

Solution G is

.....

[2]

[Total: 4]

A7 In the early 19th century, a chemist, Frederick Wohler, was the first to isolate aluminium metal.

At a high temperature, potassium was reacted with aluminium chloride to form potassium chloride and aluminium.

Today's chemists would classify this reaction as a redox reaction.

(a) Construct a balanced chemical equation for the reaction.

.....[1]

(b) Explain why this reaction is classified as a redox reaction, in terms of electron transfer.

.....

[3]

(c) Suggest if sodium can be used in place of potassium. Give a reason for your answer.

.....
[1]

[Total: 5]

A8 **(a)** Methanol, ethanol and propanol are organic compounds.

Table 8.1 shows the enthalpy change of combustion (ΔH) when 1 mole of each compound is completely burnt in oxygen.

Table 8.1

compound	molecular formula	boiling point / °C	ΔH / kJmol ⁻¹
methanol	CH ₄ O	65	– 700
ethanol	C ₂ H ₆ O	78	– 1350
propanol	C ₃ H ₈ O	97	– 2000

(i) State **two** pieces of evidence from the table which show that methanol, ethanol and propanol belong to the same homologous series of alcohols.

.....

[2]

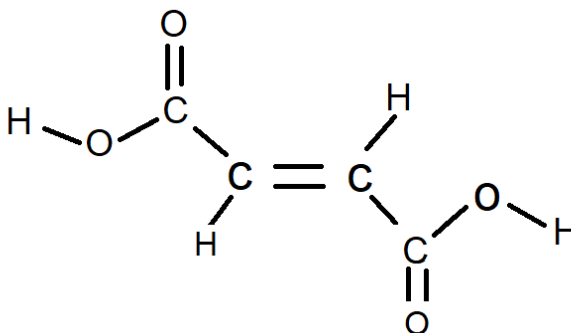
- (ii) Butanol is the fourth member of the alcohol homologous series.

Predict the amount of energy released when 1 mole of butanol is completely burnt, giving evidence in your answer.

.....
[1]

- (b) Fumaric acid is a colourless solid which can be extracted from plants.

The full structural formula of fumaric acid is shown below.



- (i) Describe how a sample of fumaric acid can be differentiated from ethanol.

.....

[2]

- (ii) Draw the structural formula of a repeating unit of the polymer which is made when fumaric acid reacts with ethane-1,2 diamine, $\text{H}_2\text{N}(\text{CH}_2)_2\text{NH}_2$.

Name the linkage formed.

Name of linkage =[2]

[Total: 7]

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 Solubility of Compounds

The solubility of a compound, at a certain temperature, is the maximum number of grams of the compound which dissolve in 100 grams of water at that temperature. The relationship between solubility and temperature can be expressed by a solubility curve. The solubility curves of some compounds are shown in Figure 9.1.

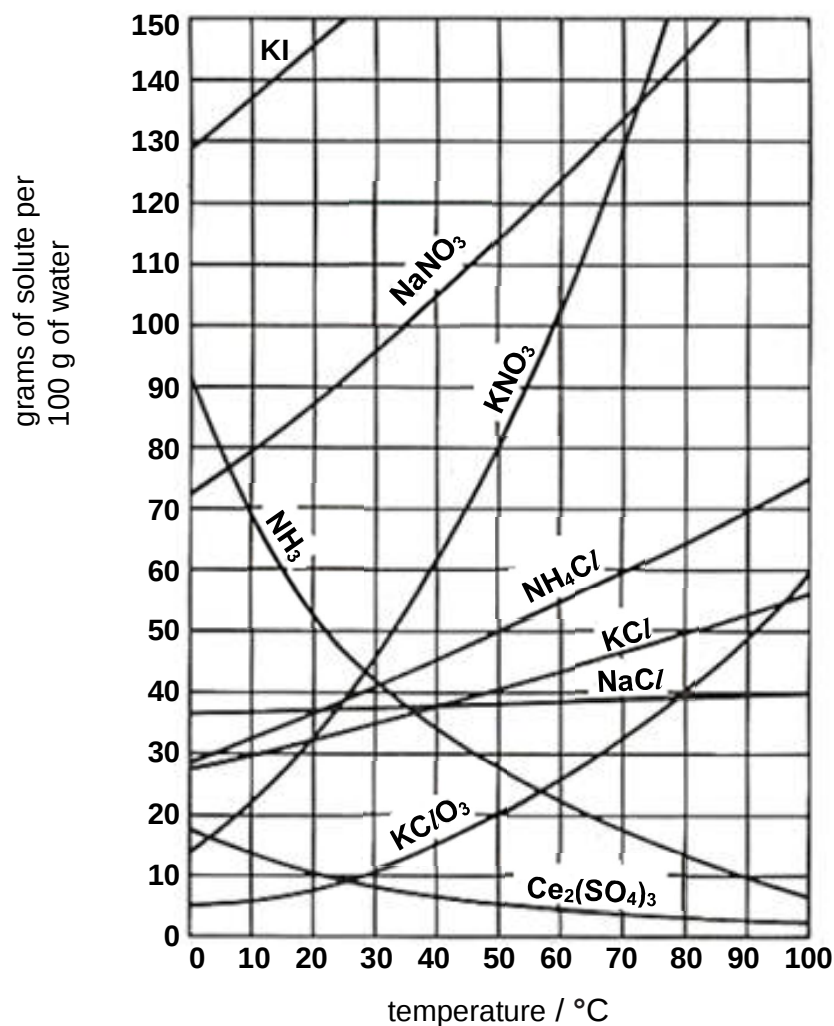


Fig. 9.1

Sparingly Soluble Ionic Compounds

The dissolving and precipitating of ionic compounds are phenomena that occur both within us and around us. For example, the dissolving of enamel on teeth in acidic solutions causes tooth decay; the precipitation of certain salts in our kidneys produces kidney stones; the precipitation of calcium carbonate from underground water forms stalactites and stalagmites inside caves. Although solids of ionic compounds are generally known to be soluble in water, some ionic solids have low solubility. Such ionic compounds are said to be sparingly soluble in water.

Ionic compounds such as sodium chloride, NaCl , are generally soluble in water. Some ionic solids such as silver chloride, AgCl , are only sparingly soluble (soluble to a small extent) in water.

The solubility of ionic compounds depends on two factors.

- 1 The forces of attraction between the water molecules and the ions of the solid;
- 2 The forces of attraction between the cations and anions of the solid.

If factor 1 is greater than factor 2, the ionic compound will dissolve in water.

Figure 9.2 shows what happens when sodium chloride dissolves in water.

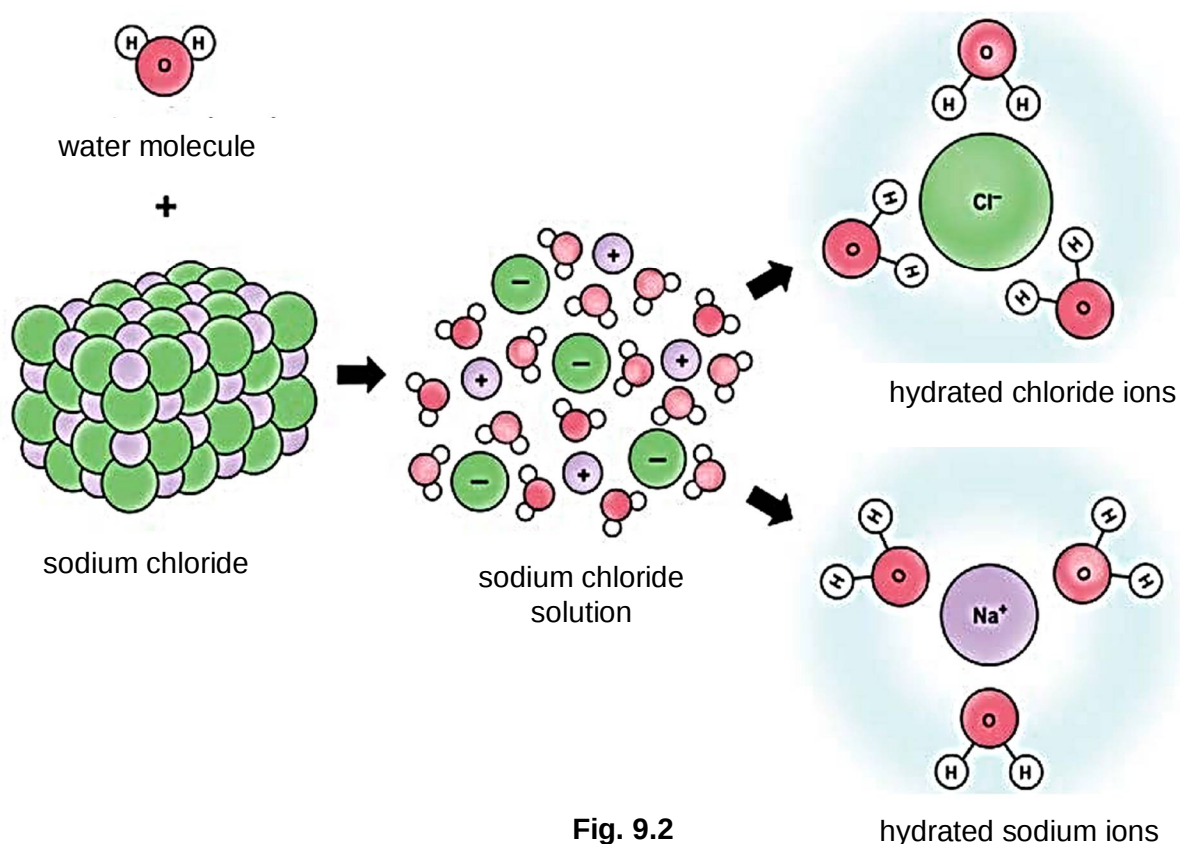


Fig. 9.2

The solubility of sparingly soluble ionic compounds can be estimated from its solubility product, K_{sp} , which is only affected by temperature. The higher the K_{sp} value, the more soluble the compound will be.

Table 9.1 below shows the K_{sp} values of some common ionic compounds.

Table 9.1

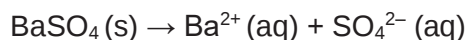
compound	chemical formula	K_{sp} (mol^2/dm^6) at 25°C
barium sulfate	BaSO_4	1×10^{-10}
calcium carbonate	CaCO_3	5×10^{-9}
calcium sulfate	CaSO_4	2×10^{-5}
silver chloride	AgCl	2×10^{-10}

Predicting Precipitation

By comparing the K_{sp} value and **ionic product** of a compound, we can predict whether precipitation of a certain compound will occur when two solutions are mixed together.

The **ionic product** is the product of the concentration of cation and anion present in the mixed solution.

For instance, when a sparingly soluble salt like barium sulfate dissolves in water, it dissociates into Ba^{2+} and SO_4^{2-} according to the equation below.



Ionic product = [concentration of Ba^{2+} ions in solution] x [concentration of SO_4^{2-} ions in solution]

Table 9.2 below shows whether precipitation will occur when comparing ionic product and K_{sp} of a compound.

Table 9.2

Types of solution	Outcome
ionic product = K_{sp}	No precipitation. Solution is saturated. No more solute can dissolve.
ionic product < K_{sp}	No precipitation. More solute can dissolve.
ionic product > K_{sp}	Precipitation occurs

- (a) (i) In Figure 9.1, why do the solubility curves not go beyond 100 °C?

.....[1]

- (ii) From the solubility curves in Figure 9.1, identify the compound which is the least soluble at 90°C.

.....[1]

- (iii) If 200 g of a saturated solution of potassium nitrate at 50 °C was evaporated to dryness, what mass of potassium nitrate would remain?

- (b) By comparing the two factors affecting solubility as described in the question, explain why sodium chloride is very soluble in water while silver chloride is only sparingly soluble.

.....

.....

.....

.....

.....

.....

.....

.....[2]

- (c) Sodium sulfate is another soluble ionic compound.

By referring to Figure 9.2, draw a similar diagram to the hydrated sodium ion or hydrated chloride ion to show a hydrated sulfate ion.

[1]

- (d) Predict the relationship between temperature and K_{sp} value of an ionic compound.

.....

.....[1]

- (e) 0.02 mol/dm^3 of calcium nitrate solution is added to the same volume of 0.005 mol/dm^3 sodium sulfate solution at 25°C .

- (i) Name the sparingly soluble compound that is formed.

.....[1]

- (ii) Using the information from Table 9.1 and Table 9.2, determine, by calculation of the ionic product in **part (e)(i)**, if precipitation will occur.

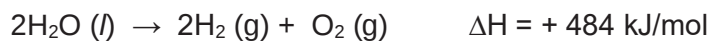
[2]

- (f) Without further addition of any reagent, suggest how the amount of solid precipitated out from a saturated solution can be increased.

.....[1]

[Total: 12]

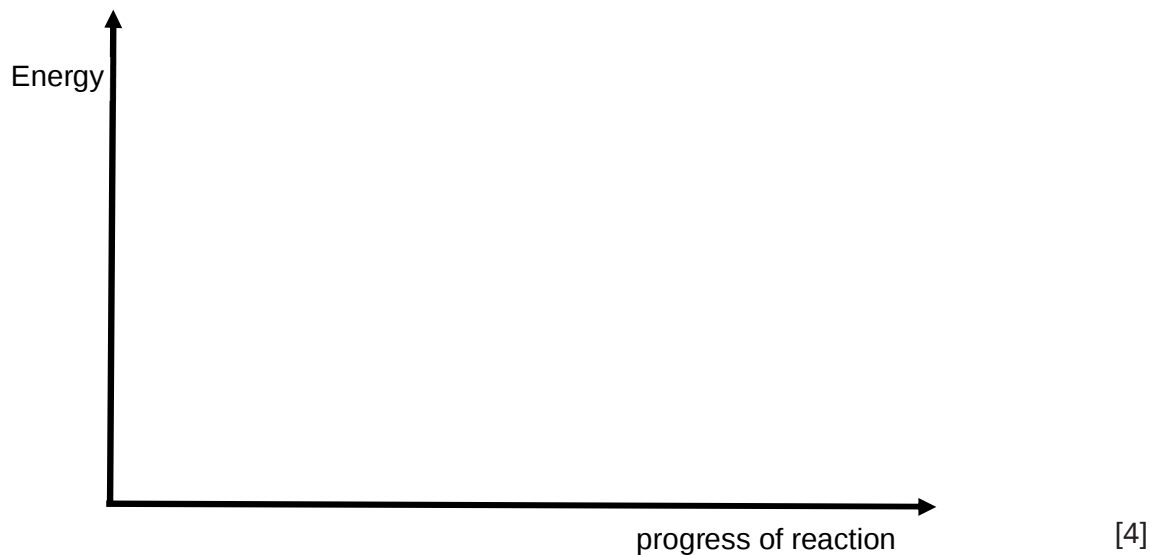
B10 Water can be broken down into hydrogen and oxygen by electrolysis. The equation is shown below.



(a) Complete the energy profile diagram for the electrolysis of water.

Your diagram should include :

- the reactants and products.
- the activation energy.
- the enthalpy change.



(b) Complete the table.

Fuel	enthalpy change when 1 mol of H ₂ is completely burned in kJ/mol	enthalpy change when 1 kg of H ₂ is completely burned in kJ/kg
Hydrogen, H ₂		

[2]

(c) Some people think hydrogen is a clean fuel.

Do you agree with the statement? Explain your answer.

.....

.....[2]

[Total: 8]

Either

B11 The rate of reaction between a metal and bromine can be studied using the apparatus in Figure 11.1.

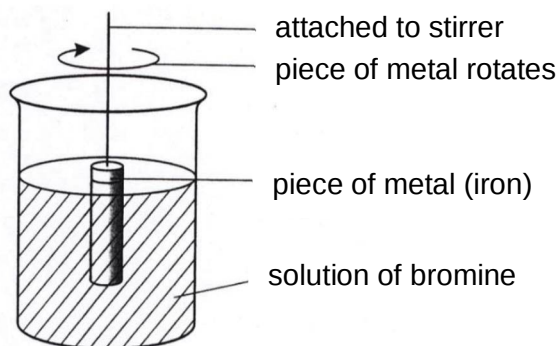


Fig. 11.1

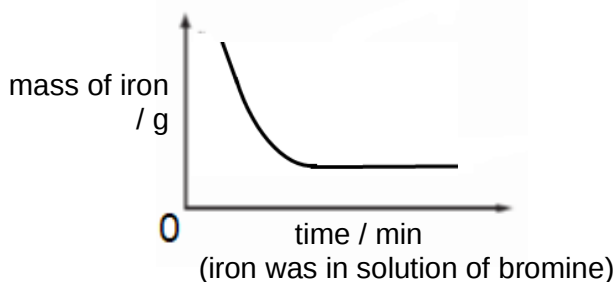
A cylindrical piece of iron, was weighed and placed in the solution as shown above.

The iron was removed at regular intervals and the stopwatch was paused.

The piece of iron was washed, dried, weighed and then placed in the solution again.

The stopwatch was restarted and the reaction continued.

The mass of iron was plotted against time. The graph shows the results obtained.



(a) Explain the shape of the graph.

.....

[3]

(b) How would the rate of reaction change if the cylindrical piece of iron was hammered to form a flat sheet of iron and placed in the bromine solution?

Explain your answer.

.....
[2]

- (c) The experiment was conducted using two solutions of bromine of equal volume but different concentration.

A piece of iron with equal mass was placed in each solution.

The mass of the iron was measured at one minute intervals.

Table 11.1 shows the loss in mass of the iron after one minute.

Table 11.1

experiment	concentration of bromine solution	loss in mass of iron after one minute
1	0.05 mol/dm ³	10 mg
2	0.10 mol/dm ³	20 mg

Explain, in terms of collisions between particles, the difference in the results obtained.

.....

[2]

- (d) Iron also reacts with iodine solution.

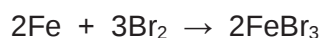
Predict the loss in mass of iron after one minute if 0.05 mol/dm³ of iodine solution of equal volume was used instead of bromine solution.

Suggest a reason for your answer.

Loss in mass of iron = mg

.....
[1]

- (e) Iron is heated with bromine gas to form iron(III) bromide.



Calculate the minimum mass of iron required to react completely with 12 dm³ of bromine gas.

[2]

[Total: 10]

Or

B11 One of the components in crude oil is undecane, $C_{11}H_{24}$.

This molecule may be broken down to give 2 molecules of butene and one other product.

The reaction is carried out in the oil refinery.

(a) What is the name of this type of reaction?

.....[1]

(b) Construct a balanced chemical equation for this reaction.

.....[1]

(c) Name the other product formed, besides butene.

.....[1]

(d) When the reaction is carried out, 1.00 mol of undecane gives 50.4 g of butene.

Calculate the percentage yield of butene.

[2]

(e) Butene can exist as 3 isomers. One isomer of butene is shown in Figure 11.1.

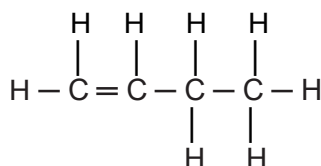


Fig. 11.1

Draw the structures of the other **two** isomers of butene.

[1]	[1]
-----	-----

- (f) The isomers of butene can undergo addition polymerisation.

Draw the structure of the polymer formed by any **one** of the isomers in **part (e)**, showing three repeating units.

[1]

- (g) Butanol is manufactured by the reaction between steam and butene.

Two isomers of butanol are formed at the same time.

These two isomers are miscible (can mix).

Suggest, with reason, a method suitable for separating the components of the mixture of products

method :

reason :

.....[2]

[Total: 10]

END OF PAPER

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Select elements from the list to answer the following questions.

You may use each element once, more than once or not at all.

aluminium

argon

carbon

copper

iodine

iron

lead

nitrogen

oxygen

sulfur

- (a) Which element has an ion which, in aqueous solution, reacts with aqueous sodium hydroxide to give a red-brown precipitate?

..... [1]

- (b) Which element has an atom with an electronic configuration with only five electron shells?

..... [1]

- (c) Which **two** elements form amphoteric oxides?

..... [1]

- (d) Which element is used as a catalyst in the Haber Process?

..... [1]

- (e) Which element provides an inert atmosphere in the manufacture of steel?

..... [1]

- (f) Which element produces ammonia when it is warmed with an aqueous mixture of sodium nitrate and sodium hydroxide?

..... [1]

[Total: 6]