# Chemistry Paper 1 Required Practical Past exam questions

Name: _____

Class: _____

Date: _____

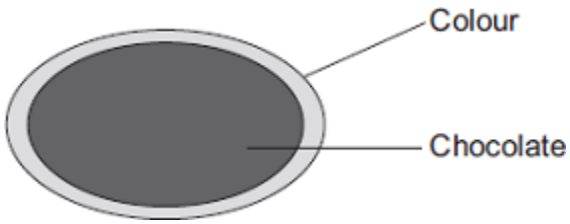
Time: **231 minutes**

Marks: **231 marks**

Comments:

**1** Colours are used to coat some chocolate sweets.

Some of these colours are given E-numbers.



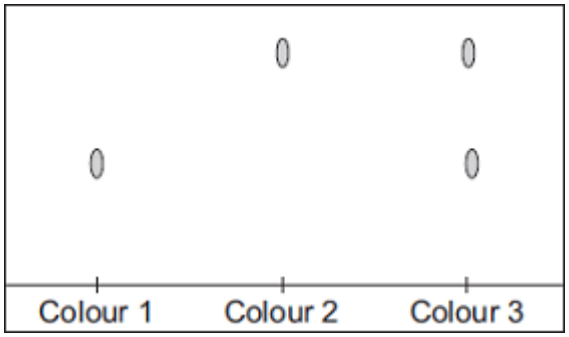

Use the correct word from the box to complete the sentence.

| | | |
|---|---|---|
| **additive** | **element** | **fuel** |

An E-number is used to identify a permitted food .....

**(1)**

(b) Chromatography was used to compare three of the colours used to coat the chocolate sweets.




What do these results tell you about these three colours?

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.....

.....

**(3)**

**(Total 4 marks)**

**2** This question is about salts.

(a) Salt (sodium chloride) is added to many types of food.

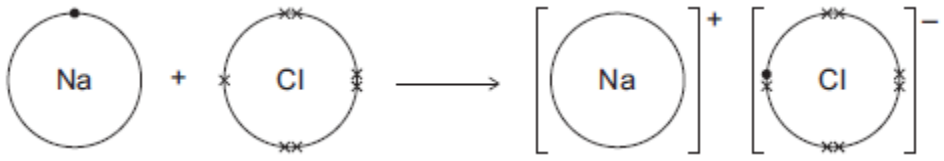
Sodium chloride is produced by reacting sodium with chlorine.

sodium + chlorine ⟶ sodium chloride

The diagram shows what happens to atoms of sodium and chlorine in this reaction.

The dots (•) and crosses (×) represent electrons.

Only the outer electrons are shown.




Describe, in terms of electrons, what happens when a sodium atom reacts with a chlorine atom to produce sodium chloride.

.....

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.....

**(3)**

(b) Lack of iodine can affect the learning ability of children.

One idea is that salt (sodium chloride) should have iodine added.

(i) Iodine consists of simple molecules.

What is a property of substances that have simple molecules?

Tick (✓) **one** box.

Have no overall electric charge ☐

Have high boiling points ☐

Have giant covalent structures ☐

**(1)**

(ii) Which one of the following questions cannot be answered by science alone?

Tick (✓) **one** box.

How much sodium chloride is in food? ☐

What harm does a lack of iodine do? ☐

Should iodine be added to salt in food? ☐

Give **one** reason why this question cannot be answered by science alone.

.....

.....

**(2)**

(c) A student produced the salt ammonium nitrate by adding an acid to ammonia solution.

(i) Name the acid used.

.....

**(1)**

(ii) Use the correct answer from the box to complete the sentence.

| **an acid** | **an alkali** | **a salt** |
|---|---|---|

Ammonia solution (ammonium hydroxide) is ..... .

**(1)**

(iii) The student added a few drops of a solution which changed colour when the reaction was complete.

Complete the sentence.

The solution added is an ..... .

**(1)**

(d) Farmers buy solid ammonium nitrate in poly(ethene) sacks.

(i) How is solid ammonium nitrate made from a solution of ammonium nitrate?

Tick (✓) **one** box.

Crystallisation ☐

Decomposition ☐

Electrolysis ☐

**(1)**

(ii) Why do farmers use ammonium nitrate on their fields?

.....

.....

**(1)**

(iii) The properties of poly(ethene) depend on the reaction conditions when it is made.

State **one** reaction condition that can be changed when making poly(ethene).

.....

.....

**(1)**

**(Total 12 marks)**

**3** Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

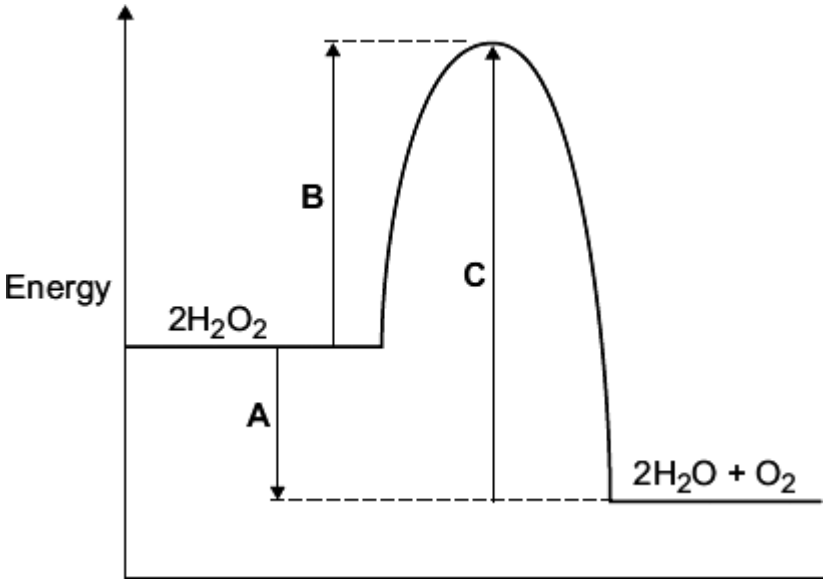
(a) In an *exothermic* reaction, energy is given out.

Draw a ring around the correct answer to complete the sentence.

| | |
|---|---|
| In an *exothermic* reaction, the temperature | goes down. |
| | goes up. |
| | stays the same. |

**(1)**

(b) The energy level diagram for this reaction is shown below.




The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

(i) Which energy change, **A**, **B** or **C**, is the activation energy?

**(1)**

(ii) Which energy change, **A**, **B** or **C**, shows that this reaction is exothermic?

**(1)**

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Draw a ring around the correct answer to complete each sentence.

Hydrogen peroxide decomposes quickly because

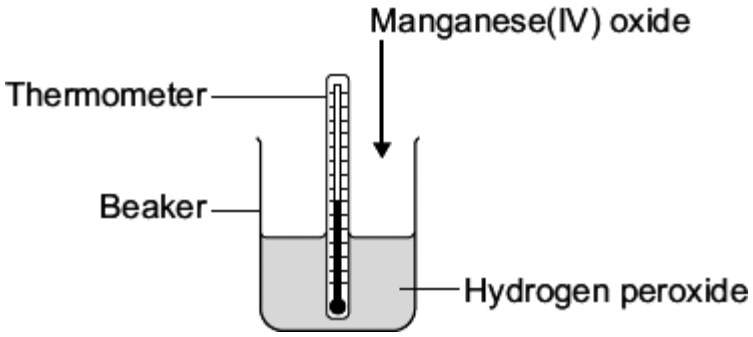
| | |
|---|---|
| manganese(IV) oxide is | a catalyst. |
| | an element. |
| | a solid. |

| | |
|---|---|
| The manganese(IV) oxide has lowered the | activation energy. |
| | boiling point. |
| | temperature. |

**(2)**

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.




The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide, stirred the mixture and recorded the highest temperature.

(i) Suggest why the student stirred the mixture before recording the highest temperature.

.....

.....

**(1)**

(ii) The biggest error in this experiment is heat loss.

Suggest how the student could change the apparatus so that less heat is lost.

.....

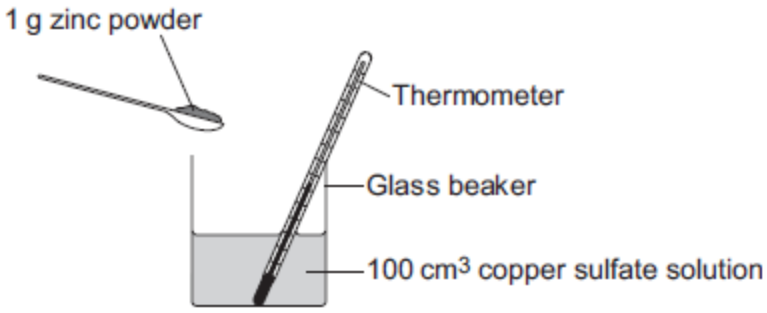
.....

**(1)**

**(Total 7 marks)**

**4** A student investigates the energy released when zinc powder reacts with copper sulfate solution.
The student uses the apparatus shown in **Figure 1**.

**Figure 1**




The student:

- measures 100 $cm^3$ copper sulfate solution into a beaker
- measures the temperature of the copper sulfate solution
- puts 1 g zinc powder into the beaker
- stirs the mixture with a thermometer
- measures the highest temperature.

The student's results were:

Starting temperature = 21 °C
Highest temperature = 32 °C

(a) (i) Calculate the change in temperature.

.....

Change in temperature = ..... °C

**(1)**

(ii) Calculate the energy released in the reaction.

Use the equation

energy released in J = volume of solution in $cm^3$ × 4.2 × temperature change in °C

.....

.....

Energy released = ..... J

**(2)**

(b) The reaction of zinc with copper sulfate is exothermic.

How can you tell from the student's results that the reaction is exothermic?

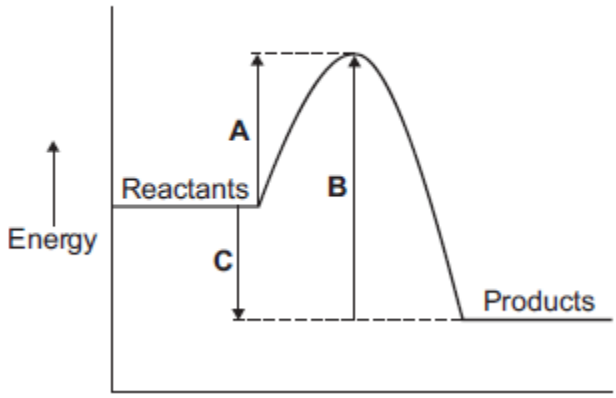
.....

.....

**(1)**

(c) The energy diagram for the reaction is shown in **Figure 2**.

**Figure 2**




(i) How can you tell from the energy diagram that the reaction is exothermic?

.....

.....

**(1)**

(ii) Which arrow shows the activation energy in **Figure 2**?

Tick (✓) **one** box.

**A** ☐

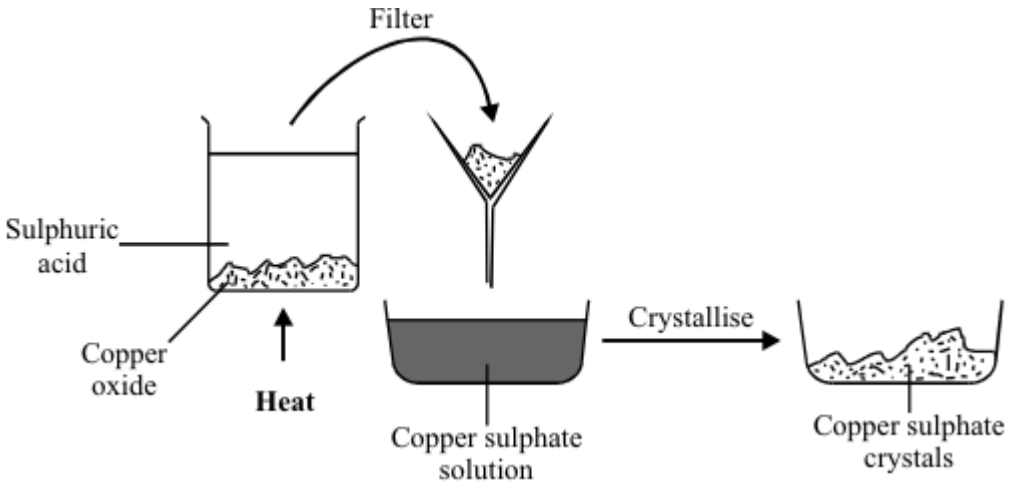
**B** ☐

**C** ☐

**(1)**

**(Total 6 marks)**

**5** (a) The diagram shows one way of making crystals of copper sulphate.




(i) Why was the solution filtered?

.....

**(1)**

(ii) How could you make the crystals form faster from the copper sulphate solution?

.....

**(1)**

(iii) The chemical equation is shown for this reaction.

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

In the chemical equation what does (aq) mean?

.....

**(1)**

(b) Blue copper sulphate crystals go white when warmed. How could you use the white copper sulphate as a test for water?


.....

.....

.....

**(2)**

**(Total 5 marks)**

**6** This question is about electrolysis.

(a) Metal spoons can be coated with silver.
This is called electroplating.

Suggest **one** reason why spoons are electroplated.

.....

.....

**(1)**

(b) When sodium chloride solution is electrolysed the products are hydrogen and chlorine.

(i) What is made from chlorine?

Tick (✓) **one** box.

Bleach ☐

Fertiliser ☐

Soap ☐

**(1)**

(ii) Sodium chloride solution contains two types of positive ions, hydrogen ions ($H^+$) and sodium ions ($Na^+$).

Why is hydrogen produced at the negative electrode and **not** sodium?

Tick (✓) **one** box.

Hydrogen is a gas. ☐

Hydrogen is less reactive than sodium. ☐

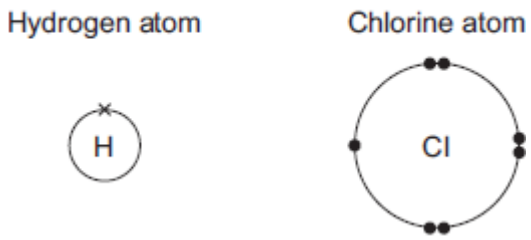
Hydrogen ions move faster than sodium ions. ☐

**(1)**

(iii) Hydrogen and chlorine can be used to produce hydrogen chloride.

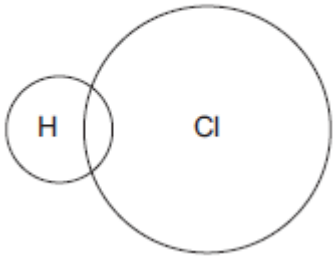
The diagrams in **Figure 1** show how the outer electrons are arranged in an atom of hydrogen and an atom of chlorine.

**Figure 1**




Complete **Figure 2** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

**Figure 2**




**(1)**

(iv) What is the type of bond in a molecule of hydrogen chloride?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

**(1)**

(v) Why is hydrogen chloride a gas at room temperature (20 °C)?

Tick (✓) **two** boxes.

Hydrogen chloride has a low boiling point. ☐

Hydrogen chloride has a high melting point. ☐

Hydrogen chloride is made of simple molecules. ☐

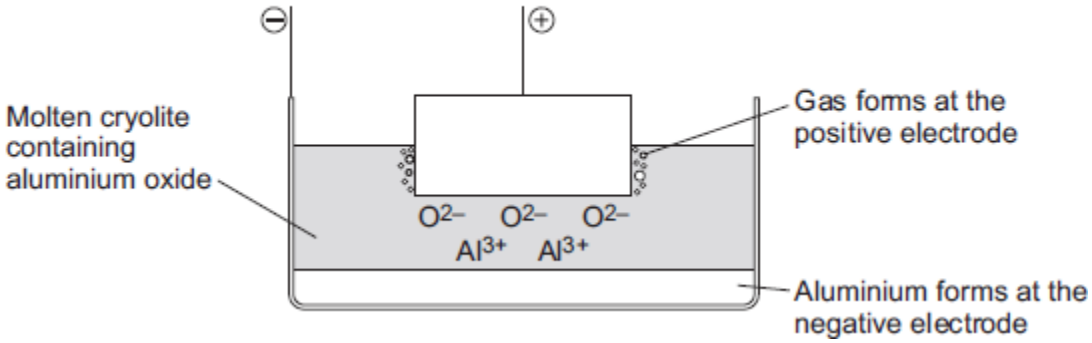
Hydrogen chloride does not conduct electricity. ☐

Hydrogen chloride has a giant structure. ☐

**(2)**

(c) Aluminium is produced by electrolysis of a molten mixture of aluminium oxide and cryolite. This is shown in **Figure 3**.

**Figure 3**




(i) Name a gas produced at the positive electrode.

.....

**(1)**

(ii) Aluminium ions move to the negative electrode.

Explain why.

.....

.....

.....

.....

**(2)**

(iii) At the negative electrode, the aluminium ions gain electrons to produce aluminium.

What is this type of reaction called?

Tick (✓) **one** box.

Combustion ☐

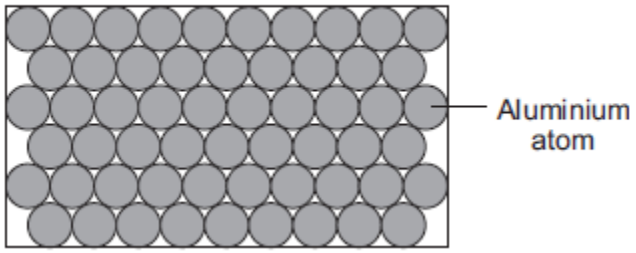
Oxidation ☐

Reduction ☐

**(1)**

(iv) Aluminium has layers of atoms, as shown in **Figure 4**.

**Figure 4**



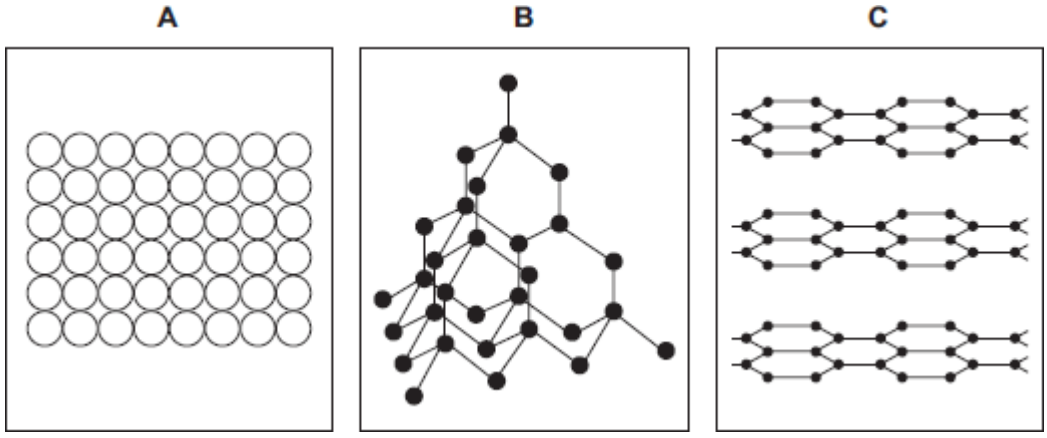

Complete the sentence.

Metals can be bent and shaped because the layers of atoms can .....

**(1)**

(d) Electrodes used in the production of aluminium are made from graphite.

(i) Which diagram, **A, B** or **C**, shows the structure of graphite?




The structure of graphite is shown in diagram ☐

**(1)**

(ii) The temperature for the electrolysis is 950 °C.

Use the correct answer from the box to complete the sentence.

| **cross links** | **a giant ionic lattice** | **strong covalent bonds** |
|---|---|---|

The graphite does not melt at 950 °C because

graphite has ..... .

**(1)**

**(Total 14 marks)**

**7** Some pollutants cause acid rain.

A student tested 25.0 $cm^3$ samples of three types of rainwater, **P, Q** and **R**.
The student titrated the samples with sodium hydroxide solution (an alkali).

The student recorded the volume of sodium hydroxide solution needed to neutralise the rainwater. The student's results are shown in **Table 1**.

**Table 1**

| | **Volume of sodium hydroxide needed to neutralise the rainwater in $cm^3$** | | | | |
|---|---|---|---|---|---|
| **Type of rainwater** | **Titration 1** | **Titration 2** | **Titration 3** | **Titration 4** | **Mean value** |
| **P** | 18.0 | 15.5 | 14.5 | 15.0 | 15.0 |
| **Q** | 13.0 | 10.0 | 11.0 | 10.5 | 10.5 |
| **R** | 23.0 | 19.5 | 18.5 | 19.0 | 19.0 |

(a) (i) The student calculated the mean value for rainwater **R** as 19.0 $cm^3$.

Show how the student calculated the mean value for rainwater **R**.

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.....

**(2)**

(ii) Write down **P, Q** and **R** in order of their acidity.

Most acidic .....

.....

Least acidic .....

**(2)**

(b) A second student repeated the experiment and recorded the results in **Table 2**.

**Table 2**

| | **Volume of sodium hydroxide needed to neutralise the rainwater in $cm^3$** | |
|---|---|---|
| **Type of rainwater** | **Titration 1** | **Titration 2** |
| **P** | 17 | 15 |
| **Q** | 11 | 9 |
| **R** | 20 | 18 |

Use **Table 1** and **Table 2** to suggest **two** improvements the second student could make to obtain more accurate results.

.....

.....

.....

.....

**(2)**

(c) The results of the two students show that the experiment is reproducible.

Give the reason why.

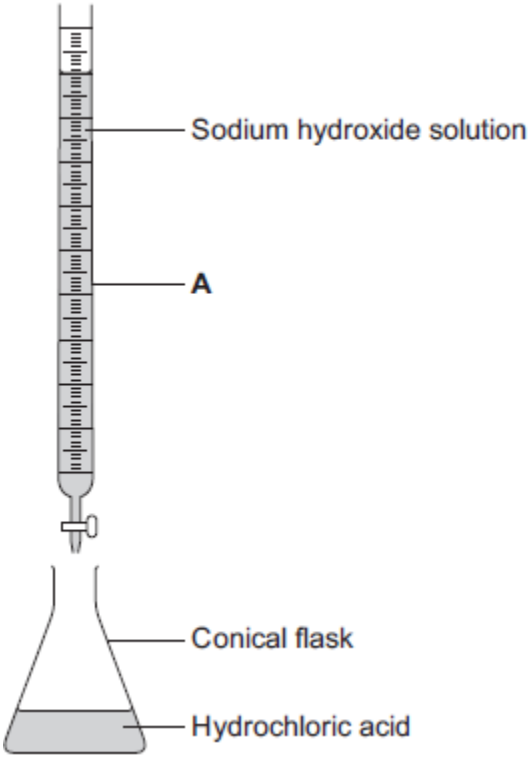
.....

.....

**(1)**

**(Total 7 marks)**

**8** (a) A student used the apparatus in the figure below to do a titration.




(i) What is the name of the piece of apparatus labelled **A**?

Draw a ring around the correct answer.

**burette** **measuring cylinder** **test tube**

**(1)**

(ii) What should the student add to the acid in the conical flask?

Draw a ring around the correct answer.

**catalyst** **indicator** **water**

**(1)**

(iii) What would the student see when the end point of the titration has been reached?

.....

**(1)**

(b) The student does the titration three times.

(i) State **one** variable that the student needs to keep the same to make it a fair test.

.....

**(1)**

(ii) The student's results are shown in the table below.

| Titration | Volume of sodium hydroxide solution added in $cm^3$ |
|---|---|
| **1** | 22.40 |
| **2** | 22.20 |
| **3** | 22.30 |

Calculate the mean volume of sodium hydroxide solution added.

..... $cm^3$

**(1)**

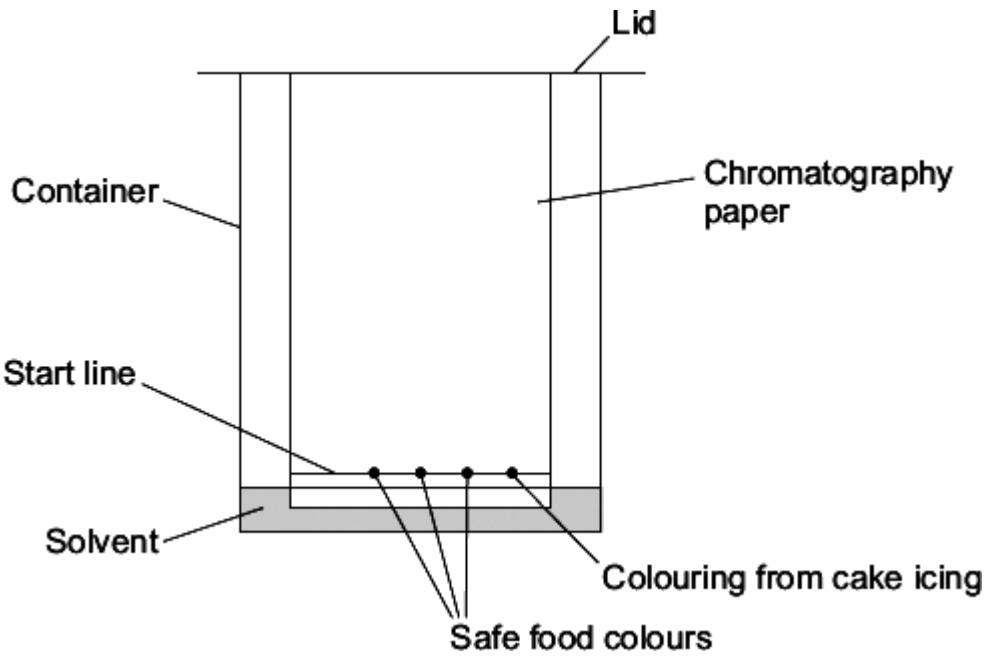
**(Total 5 marks)**

**9** Icing on cakes is tested to check that safe colours were used when they were made.

By Megan Chromik [CC-BY-SA-2.0], via Wikimedia Commons

Paper chromatography is one method of testing which colours are in cake icing.

(a) The diagram shows an experiment a student did.




(i) Suggest why there is a lid on the container.

.....

.....

**(1)**

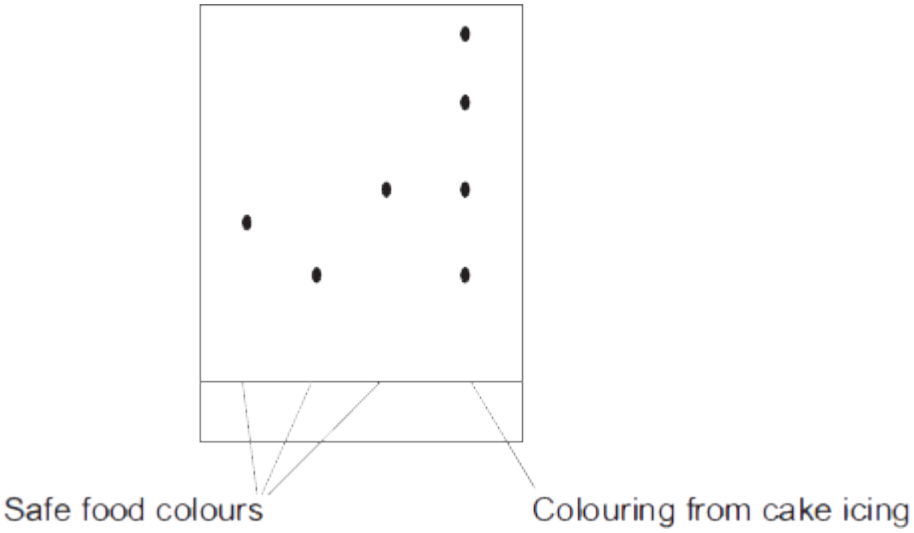
(ii) The start line should be drawn in pencil **not** in ink.
Suggest why.

.....

.....

**(1)**

(b) The diagram shows the results of the paper chromatography experiment.




(i) How many different food colours were used in the colouring from the cake icing?

.....

**(1)**

(ii) Is the cake icing safe to eat?

Give a reason for your answer.

.....

.....

**(1)**

(c) Gas chromatography linked to mass spectroscopy is an example of an instrumental method. This method was used on a mixture of solvents.

(i) Give **two** advantages of gas chromatography compared with paper chromatography.

.....

.....

.....

.....

**(2)**

(ii) What does gas chromatography do to the mixture of solvents?

.....

.....

**(1)**

(iii) What information does mass spectroscopy give?

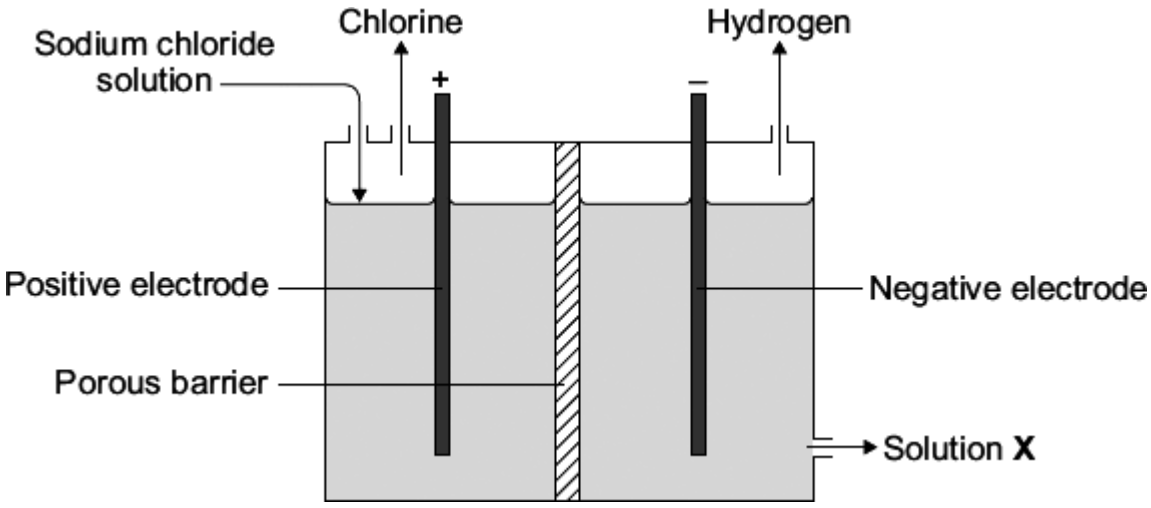
.....

.....

**(1)**

**(Total 8 marks)**

**10** The electrolysis of sodium chloride solution is an industrial process.




(a) Why do chloride ions move to the positive electrode?

.....

**(1)**

(b) Sodium chloride solution contains two types of positive ions, sodium ions ($Na^+$) and hydrogen ions ($H^+$).

Tick (✓) the reason why hydrogen is produced at the negative electrode and **not** sodium.

| Reason | Tick (✓) |
|---|---|
| Hydrogen is a gas. | |
| Hydrogen is less reactive than sodium. | |
| Hydrogen is a non-metal. | |
| Hydrogen ions travel faster than sodium ions. | |

**(1)**

(c) Solution **X** is alkaline.

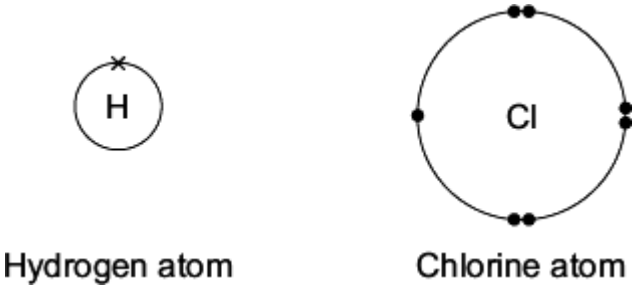
Which ion makes solution **X** alkaline?

.....

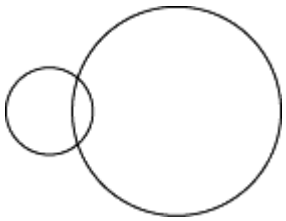
**(1)**

(d) Electrolysis of sodium chloride solution produces hydrogen and chlorine.
The hydrogen and chlorine can be used to make hydrogen chloride.

(i) The diagrams show how the outer electrons are arranged in atoms of hydrogen and chlorine.




Complete the diagram to show how the electrons are arranged in a molecule of hydrogen chloride (HCl).



**(1)**

(ii) Name the type of bond between the hydrogen and the chlorine atoms in a molecule of hydrogen chloride.

.....

**(1)**

(iii) Some hydrogen chloride was bubbled into water. This made a solution with a pH of 1.

Which ion gave the solution a pH of 1?

.....

**(1)**

**(Total 6 marks)**

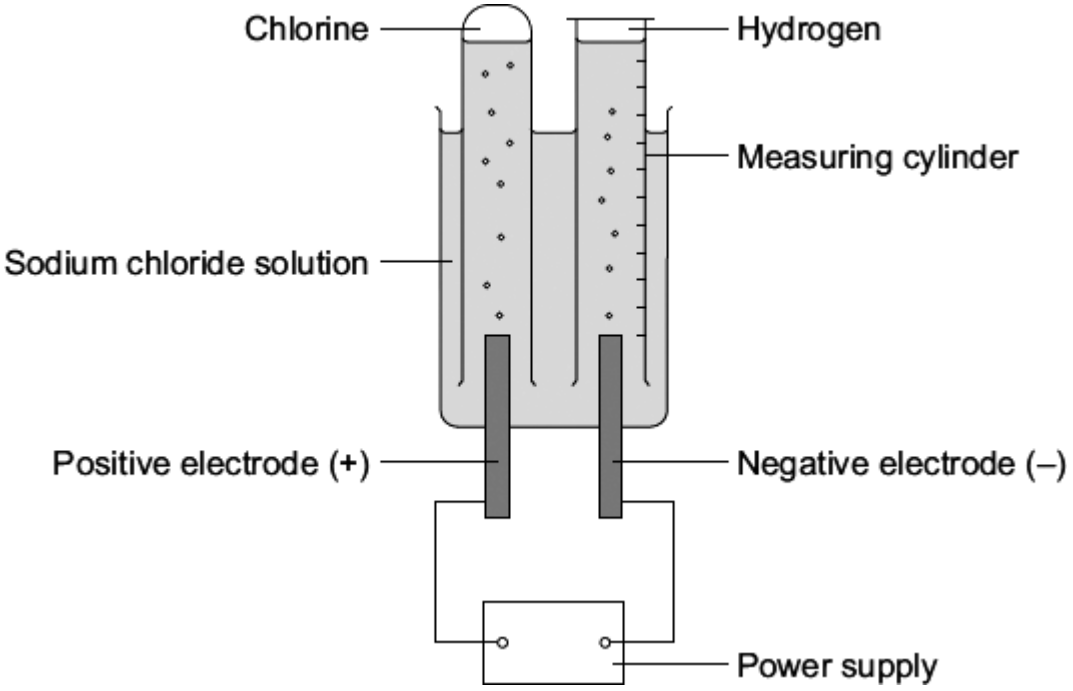
**11** A student investigated the electrolysis of sodium chloride solution.

Five sodium chloride solutions were made. Each solution had a different concentration.

To make each solution the student:

- weighed the amount of sodium chloride needed
- dissolved it in water
- added more water until the total volume was one cubic decimetre (1 $dm^3$).

The solutions were placed one at a time in the apparatus shown below.




The student measured the volume of hydrogen gas produced in ten minutes.

The results are shown on the graph below.

(a) Sodium chloride does not conduct electricity when it is solid.

Explain, in terms of ions, why sodium chloride solution conducts electricity.

.....

.....

**(1)**

(b) Chlorine is produced at the positive electrode.

Why are chloride ions attracted to the positive electrode?

.....

**(1)**

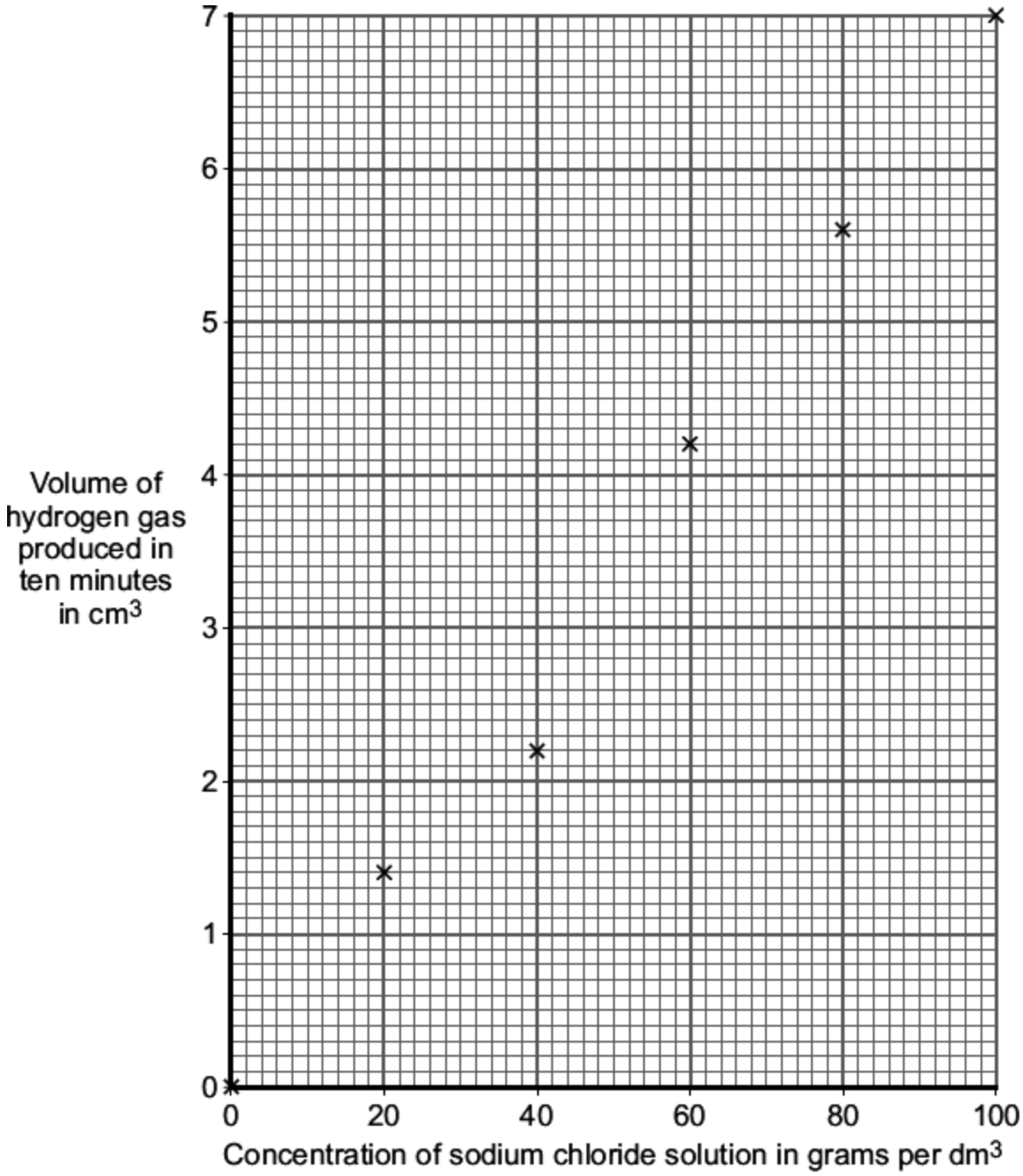
(c) The solution left at the end of each experiment contains sodium hydroxide.

Draw a ring around **one** number which could be the pH of this solution.

**2** **5** **7** **13**

**(1)**

(d) The results for the experiment above are shown on the graph.




(i) Draw a line of best fit on the graph.

**(1)**

(ii) The result for one concentration is anomalous.
Which result is anomalous?

The result at concentration ..... grams per $dm^3$

**(1)**

(iii) Suggest **two** possible causes of this anomalous result.

1 .....

.....

2 .....

.....

**(2)**

(iv) Suggest how the student could check the reliability of the results.

.....

.....

**(1)**

(iv) How did an increase in the concentration of the sodium chloride solution affect the volume of hydrogen gas produced in ten minutes?

.....

.....

**(1)**

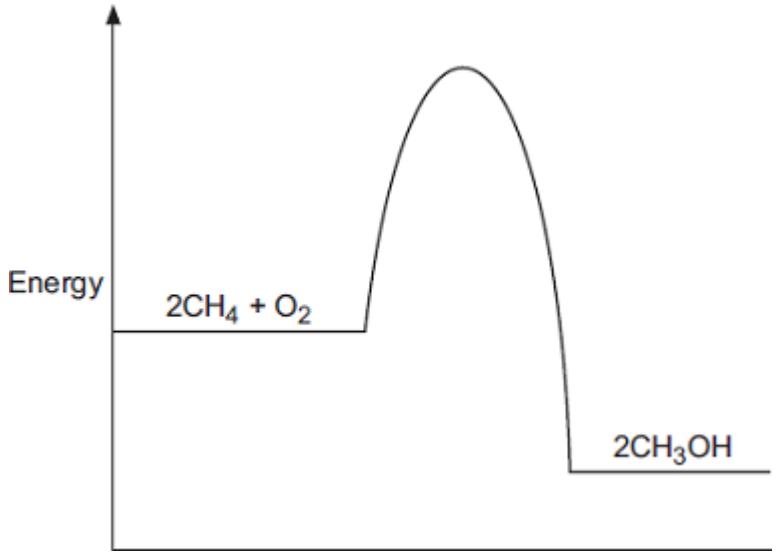
**(Total 9 marks)**

**12** Methanol ($CH_3OH$) can be made by reacting methane ($CH_4$) and oxygen ($O_2$).
The reaction is exothermic.

The equation for the reaction is:

$$2\,CH_4 + O_2 \longrightarrow 2\,CH_3OH$$

(a) The energy level diagram for this reaction is given below.




(i) How does the diagram show that this reaction is exothermic?

.....

.....

.....

**(1)**

(ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

.....

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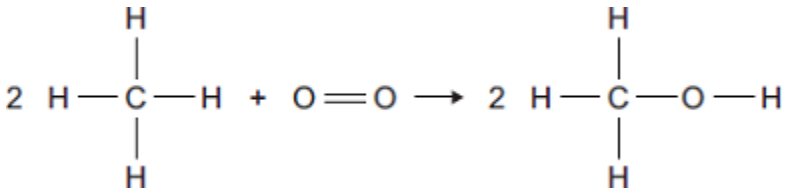
**(1)**

(b) The equation can also be written showing the structural formulae of the reactants and the product.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

| Bond | Bond energy in kJ |
|---|---|
| C — H | 435 |
| O ═ O | 497 |
| C — O | 336 |
| O — H | 464 |

.....

.....

.....

.....

Energy change = ..... kJ

**(3)**

(iii) In terms of the bond energies, why is this an exothermic reaction?

.....

.....

**(1)**

**(Total 6 marks)**

**13** The label shows the ingredients in a drink called Cola.

**Cola**

Ingredients:

Carbonated water
Sugar
Colouring
Phosphoric acid
Flavouring
Caffeine

(a) (i) The pH of carbonated water is 4.5.

The pH of Cola is 2.9.

Name the ingredient on the label that lowers the pH of Cola to 2.9.

.....

**(1)**

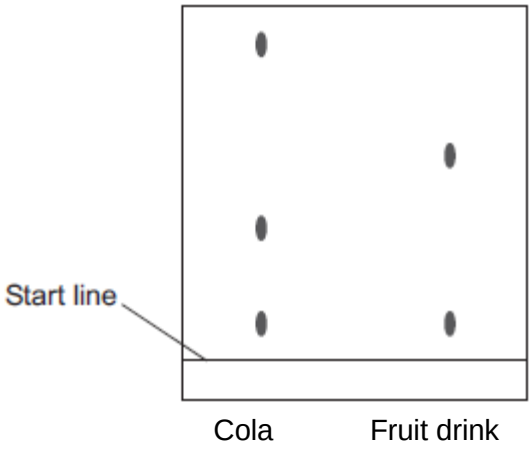
(ii) Which ion causes the pH to be 2.9?

.....

**(1)**

(b) A student investigated the food colouring in Cola and in a fruit drink using paper chromatography.

The chromatogram in the figure below shows the student's results.




(i) Complete the sentence.

The start line should be drawn with a ruler and ..... .

Give a reason for your answer.

.....

.....

**(2)**

(ii) Suggest **three** conclusions you can make from the student's results.

.....

.....

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**(3)**

(c) Caffeine can be separated from the other compounds in the drink by gas chromatography.

Why do different compounds separate in a gas chromatography column?

.....

.....

**(1)**

(d) Caffeine is a stimulant.

Large amounts of caffeine can be harmful.

(i) Only **one** of the questions in the table **can** be answered by science alone.

Tick (✓) **one** question.

| **Question** | **Tick** (✓) |
|---|---|
| Should caffeine be an ingredient in drinks? | |
| Is there caffeine in a certain brand of drink? | |
| How much caffeine should people drink? | |

**(1)**

(ii) Give **two** reasons why the other questions **cannot** be answered by science alone.

Reason 1 .....

.....

Reason 2 .....

.....

**(2)**

**(Total 11 marks)**

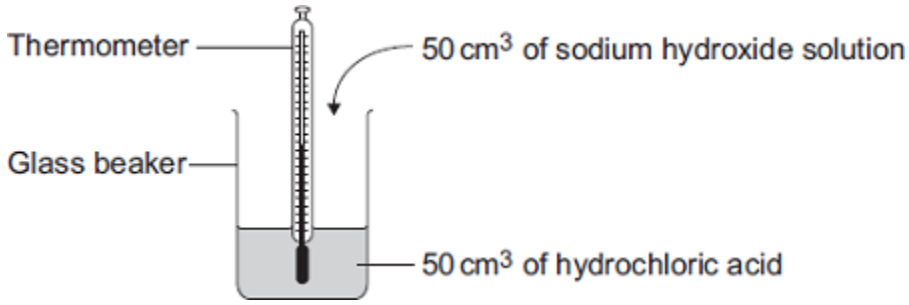
**14** Read the information about energy changes and then answer the questions.

A student did an experiment to find the energy change when hydrochloric acid reacts with sodium hydroxide.

The equation which represents the reaction is:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

The student used the apparatus shown in the diagram.




The student placed 50 $cm^3$ of hydrochloric acid in a glass beaker and measured the initial temperature.

The student then quickly added 50 $cm^3$ of sodium hydroxide solution and stirred the mixture with the thermometer. The highest temperature was recorded.

The student repeated the experiment, and calculated the temperature change each time.

| | **Experiment 1** | **Experiment 2** | **Experiment 3** | **Experiment 4** |
|---|---|---|---|---|
| Initial temperature in °C | 19.0 | 22.0 | 19.2 | 19.0 |
| Highest temperature in °C | 26.2 | 29.0 | 26.0 | 23.5 |
| Temperature change in °C | 7.2 | 7.0 | 6.8 | 4.5 |

(a) The biggest error in this experiment is heat loss.

Suggest how the apparatus could be modified to reduce heat loss.

.....

.....

**(1)**

(b) Suggest why it is important to mix the chemicals thoroughly.

.....

**(1)**

(c) Which **one** of these experiments was probably done on a different day to the others?

Give a reason for your answer.

.....

**(1)**

(d) Suggest why experiment **4** should **not** be used to calculate the average temperature change.

.....

.....

**(1)**

(e) Calculate the average temperature change from the first three experiments.

.....

Answer = ..... °C

**(1)**

(f) Use the following equation to calculate the energy change for this reaction.

Energy change in joules = 100 × 4.2 × average temperature change

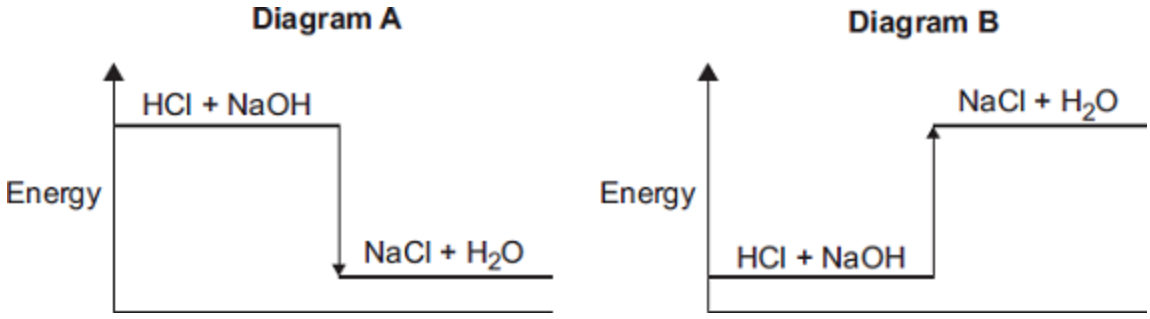
.....

Answer = ..... J

**(1)**

(g) Which **one** of these energy level diagrams represents the energy change for this reaction?

Give a reason for your answer.




.....

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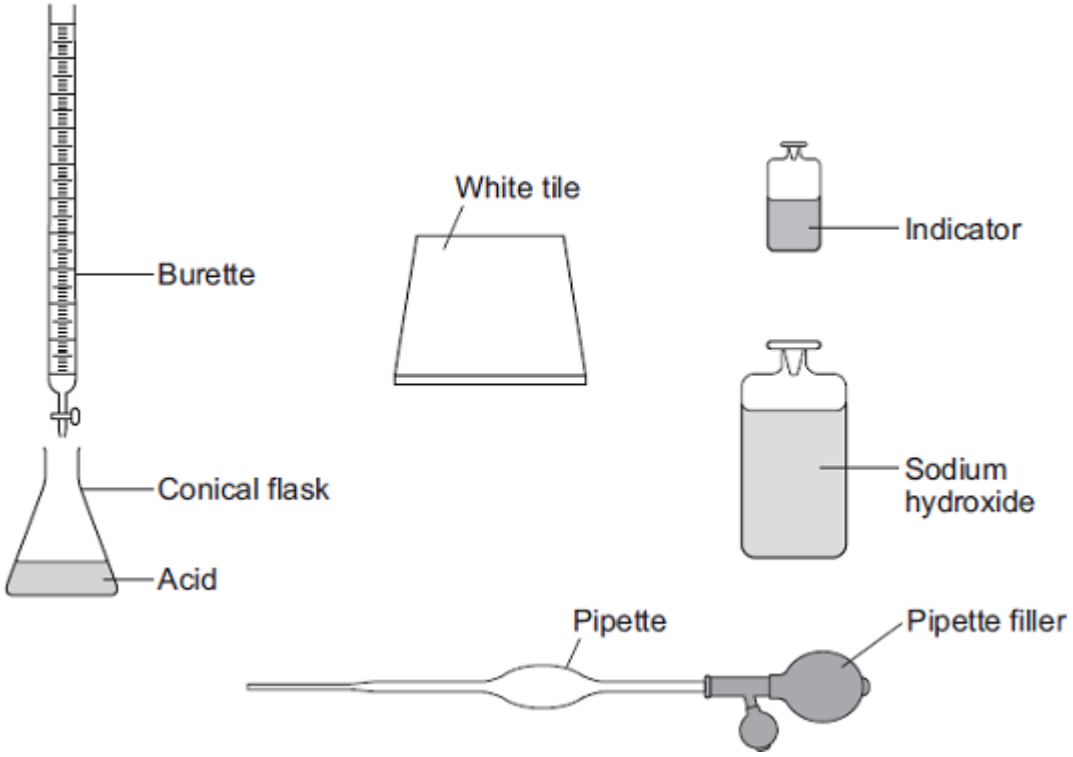
**(1)**

**(Total 7 marks)**

**15** *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

A student used the equipment shown to do a titration.



Describe how the student should use this equipment to find the volume of sodium hydroxide solution that reacts with a known volume of acid.
Include any measurements the student should make.

Do **not** describe how to do any calculations.

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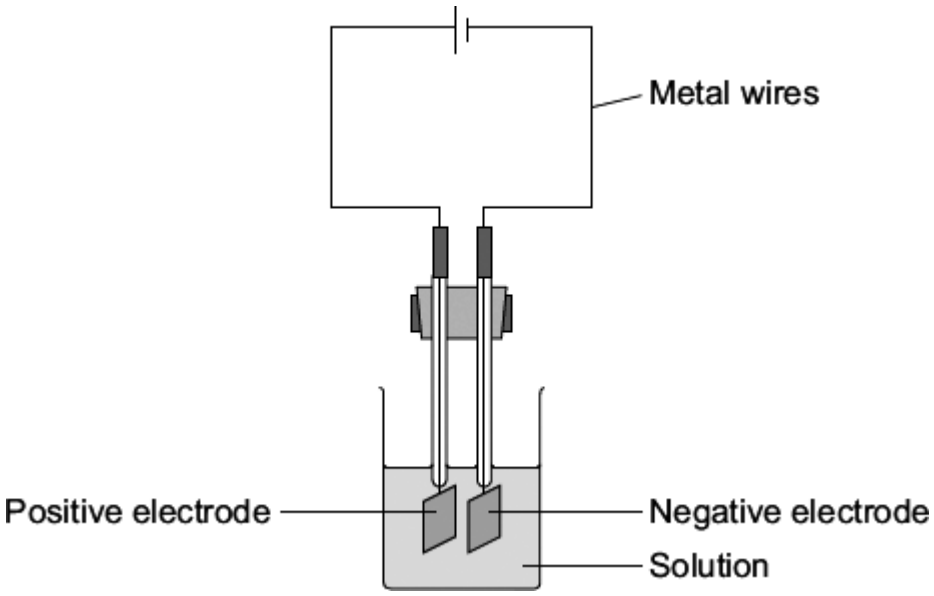
**(Total 6 marks)**

**16** The diagram shows apparatus used by a student to investigate electrolysis.




The student was given a solution by the teacher. The solution contained a mixture of ionic compounds.

(a) Name the particles which carry the electric current through:

(i) the metal wires .....

**(1)**

(ii) the solution. .....

**(1)**

(b) The table shows the ions in the solution.

| Positive ions in the solution | Negative ions in the solution |
|---|---|
| Zinc ion ($Zn^{2+}$) | Chloride ion ($Cl^{-}$) |
| Iron(III) ion ($Fe^{3+}$) | Hydroxide ion ($OH^{-}$) |
| Hydrogen ion ($H^{+}$) | Nitrate ion ($NO_3^{-}$) |
| Copper(II) ion ($Cu^{2+}$) | Sulfate ion ($SO_4^{2-}$) |

The reactivity series on the Data Sheet may help you to answer this question.

(i) Which element is most likely to be formed at the negative electrode?

.....

**(1)**

(ii) Explain, as fully as you can, why you have chosen this element.

.....

.....

.....

.....

**(2)**

(c) The electrolysis of sodium chloride solution is an industrial process.

(i) The reaction at one of the electrodes can be represented by the equation shown below.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

The chloride ions ($Cl^-$) are oxidised.

Explain why.

.....

.....

**(1)**

(ii) The reaction at the other electrode can be represented by an equation.

Complete and balance the equation for the reaction at the other electrode.

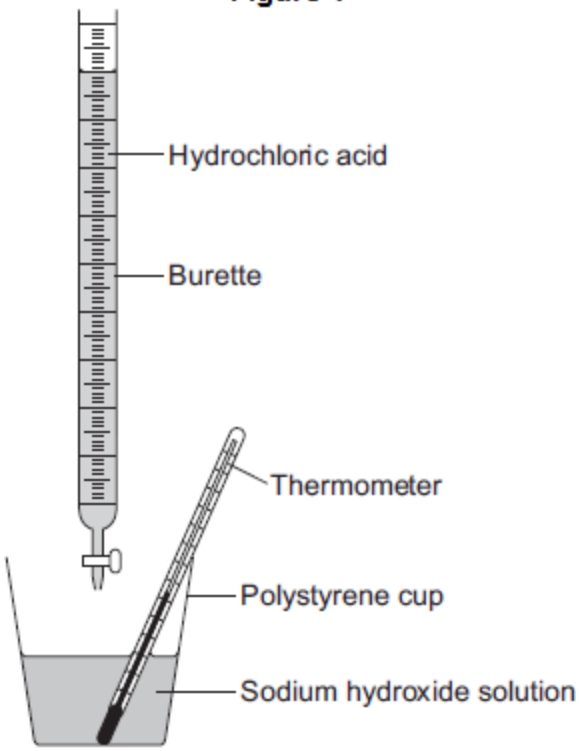
$$H^+ \rightarrow H_2$$

**(1)**

**(Total 7 marks)**

**17** A student investigates the energy released when hydrochloric acid completely neutralises sodium hydroxide solution.
The student uses the apparatus shown in **Figure 1**.

**Figure 1**




The student:

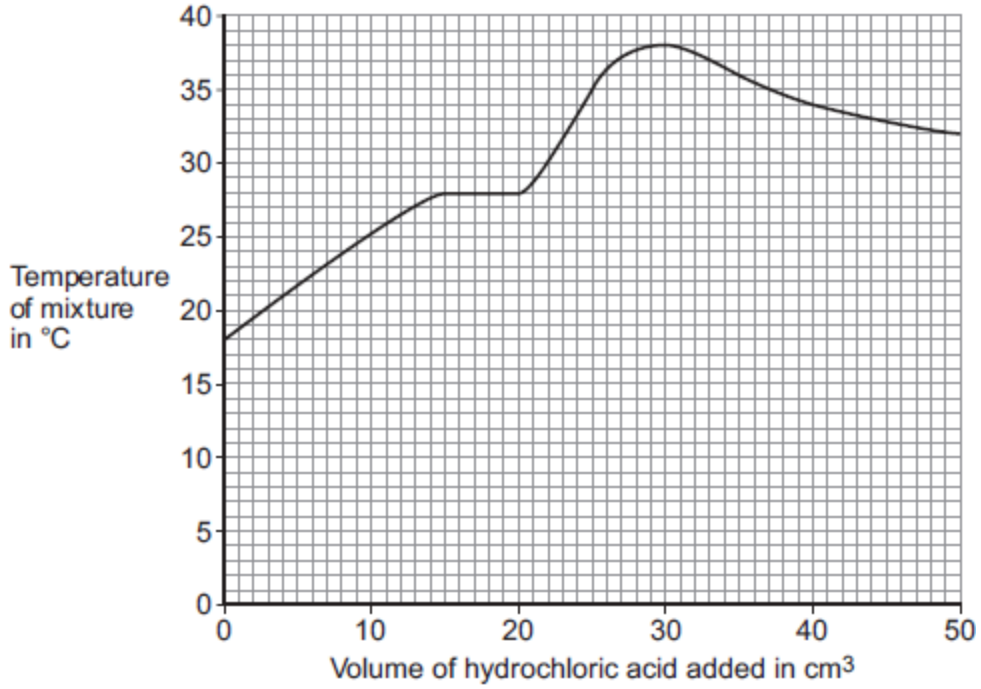
- measures 25 $cm^3$ sodium hydroxide solution into a polystyrene cup
- fills a burette with hydrochloric acid
- measures the temperature of the sodium hydroxide solution
- adds 5 $cm^3$ hydrochloric acid to the sodium hydroxide solution in the polystyrene cup
- stirs the mixture and measures the highest temperature of the mixture
- continues to add 5 $cm^3$ portions of hydrochloric acid, stirring and measuring the highest temperature of the mixture after each addition.

(a) The student has plotted a graph of the results.

The graph line has been incorrectly drawn by including an anomalous result.

The graph is shown in **Figure 2**.

**Figure 2**




(i) Suggest a cause for the anomalous result when 20 $cm^3$ of hydrochloric acid is added.

.....

.....

**(1)**

(ii) Suggest the true value of the temperature of the anomalous point.

Temperature = ..... °C

**(1)**

(iii) What was the **total** volume of the mixture when the maximum temperature was reached?

.....

Total volume of the mixture = ..... $cm^3$

**(1)**

(iv) Calculate the overall temperature increase in this experiment.

.....

Overall temperature increase = ..... °C

**(1)**

(v) Use your answers to (iii) and (iv) and the equation to calculate the energy released in the reaction. Give the unit.

Assume the volume in $cm^3$ is equivalent to the mass of solution in grams.

Equation: $Q = mc\Delta T$

where:
Q = energy released
m = mass of solution (g)
c = 4.2 (J per g per °C)
ΔT = change in temperature (°C)

.....

.....

Energy released = ..... Unit = .....

**(2)**

(b) The student did the experiment again, starting with 50 $cm^3$ of sodium hydroxide solution instead of 25 $cm^3$.

Explain why this would make no difference to the overall temperature increase.

.....

.....

.....

.....

**(2)**

**(Total 8 marks)**

**18** A student carried out a titration to find the concentration of a solution of sulphuric acid. 25.0 $cm^3$ of the sulphuric acid solution was neutralised exactly by 34.0 $cm^3$ of a potassium hydroxide solution of concentration 2.0 $mol/dm^3$. The equation for the reaction is:

$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$

(a) Describe the experimental procedure for the titration carried out by the student.

.....

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.....

**(4)**

(b) Calculate the number of moles of potassium hydroxide used.

.....

Number of moles = .....

**(2)**

(c) Calculate the concentration of the sulphuric acid in mol/$dm^3$.

.....

.....

.....

.....

Concentration = ..... mol/$dm^3$

**(3)**

**(Total 9 marks)**

**19** Insoluble salts can be made by mixing solutions of two soluble salts.

(a) A student mixed sodium carbonate solution and copper sulfate solution.

This produced a precipitate of copper carbonate and a solution of sodium sulfate.

(i) Write the correct state symbols from the box in the spaces in the chemical equation.

| | | | |
|---|---|---|---|
| **aq** | **g** | **l** | **s** |

$Na_2CO_3$(aq) + $CuSO_4$(aq) ⟶ $CuCO_3$ (.....) + $Na_2SO_4$ (.....)

**(2)**

(ii) What process could the student use to separate the precipitate of copper carbonate from the mixture?

Tick (✓) **one** box.

Chromatography ☐

Distillation ☐

Filtration ☐

**(1)**

(iii) The student washed the copper carbonate he obtained with water.

Name **one** substance removed from the copper carbonate by washing it with water.

.....

**(1)**

(b) A student mixed some salt solutions.

His observations are shown the table.

| Mixture | Salt solution 1 | Salt solution 2 | Observations |
|---|---|---|---|
| **A** | Sodium carbonate | Cobalt sulfate | Pink precipitate<br>Colourless solution |
| **B** | Copper sulfate | Lead nitrate | White precipitate<br>Blue solution |
| **C** | Sodium sulfate | Manganese nitrate | No precipitate<br>Very pale pink solution |

- All sodium salts are soluble.
- All nitrate salts are soluble.

(i) Name the **insoluble** salt made in mixture **B**.

.....

**(1)**

(ii) Name one **soluble** salt made by the student.

.....

**(1)**

(iii) What colour is cobalt carbonate?

.....

**(1)**

(c) Barium sulfate is an insoluble salt.

Barium sulfate can be made by adding barium hydroxide solution to dilute sulfuric acid.

The balanced chemical equation for the reaction is:

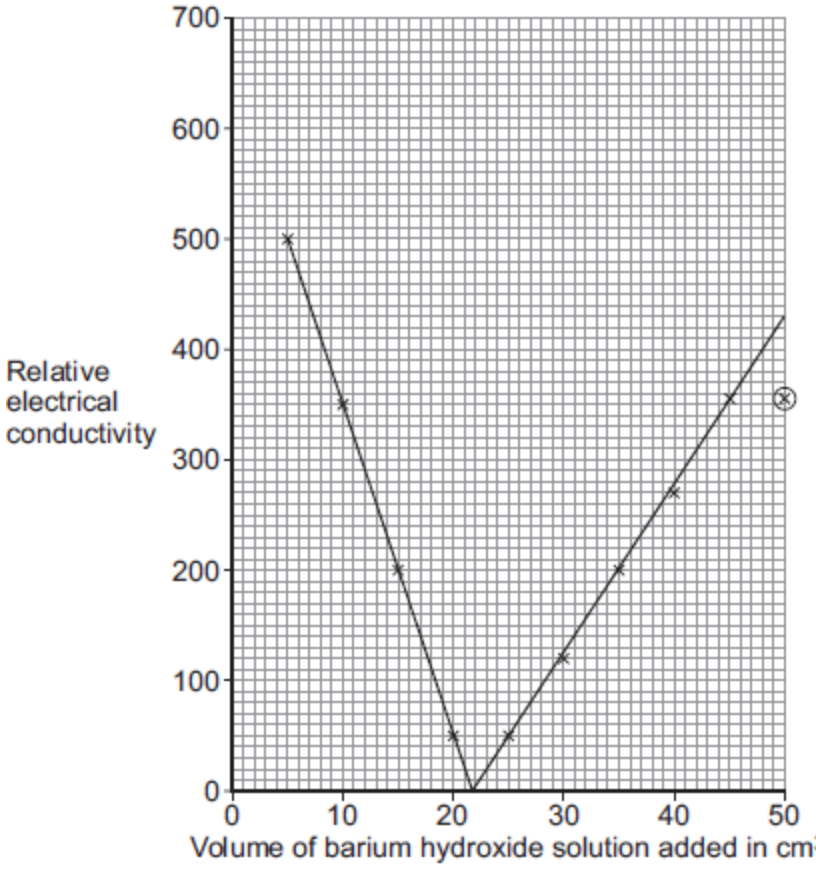
$$H_2SO_4(aq) + Ba(OH)_2(aq) \longrightarrow BaSO_4(s) + 2\,H_2O(l)$$

A student investigated how the electrical conductivity of dilute sulfuric acid changed as barium hydroxide solution was added.

This is the method she used.

Step 1 Place 25.0 $cm^3$ of dilute sulfuric acid in a conical flask.
Step 2 Add 5.0 $cm^3$ of barium hydroxide solution.
Step 3 Stir the mixture.
Step 4 Use a conductivity meter to measure the electrical conductivity of the mixture.
Step 5 Repeat Step 2, Step 3 and Step 4 until 50 $cm^3$ of barium hydroxide solution have been added.

The student's results are shown on the graph.




(i) The ringed point on the graph is anomalous.

What could have happened to cause the anomalous point?

Tick (✓) **one** box.

No more barium hydroxide solution was added. ☐

Too much barium hydroxide solution was added. ☐

Too much dilute sulfuric acid was used. ☐

**(1)**

(ii) Use the graph to estimate the relative electrical conductivity of the dilute sulfuric acid before any barium hydroxide solution was added.

Show your working on the graph.

Relative electrical conductivity = .....

**(2)**

(iii) Explain why dilute sulfuric acid conducts electricity.

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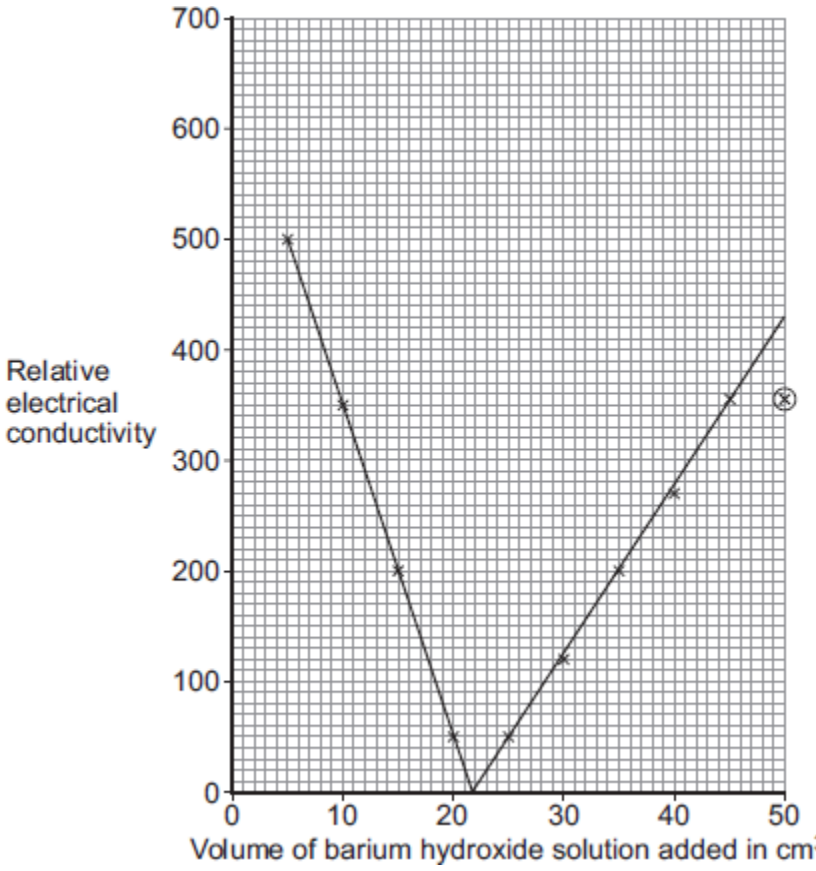
**(2)**

(d) The graph has been reprinted here to help you to answer the questions.




(i) What was the volume of barium hydroxide solution added when the relative electrical conductivity of the mixture was zero?

Volume of barium hydroxide solution = ..... $cm^3$

**(1)**

(ii) Suggest why the relative electrical conductivity became zero.

.....

.....

.....

**(1)**

(e) The student did another experiment using the same solutions as she used before.

She used the same volume (25.0 $cm^3$) of dilute sulfuric acid in the conical flask.

She then added an unknown volume of barium hydroxide solution.

She found that the relative electrical conductivity of the mixture was 260.

This is the student's conclusion:

**13 $cm^3$ of barium hydroxide solution must have been added**.

(i) Why may the student's conclusion **not** be correct?

.....

.....

**(1)**

(ii) The student said that she could check whether she was correct by adding something to the mixture.

What could she add to the mixture? How would this tell her whether she was correct?

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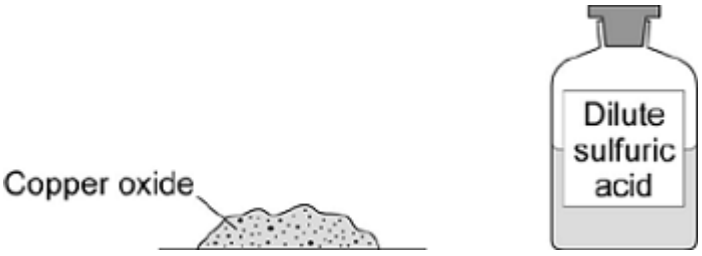
**(3)**

**(Total 18 marks)**

**20** (a) Copper sulfate crystals can be made from copper oxide and dilute sulfuric acid.




*In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

Give a method for making copper sulfate crystals from copper oxide and dilute sulfuric acid.

You should include:

- the names of the pieces of apparatus used
- the purpose of each step
- appropriate safety precautions.

.....

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**(6)**

(b) If crystals of hydrated copper(II) sulfate are dried by heating them strongly, they decompose to give a white solid.

The equation for this decomposition is:

$$CuSO_4.\ 5H_2O \rightleftharpoons CuSO_4 + 5H_2O$$

(i) Give the name of the white solid formed.

.....

**(1)**

(ii) Dilute sulfuric acid was added to the white solid.
What colour would the white solid turn?
Explain your answer.

.....

.....

.....

.....

**(2)**

**(Total 9 marks)**

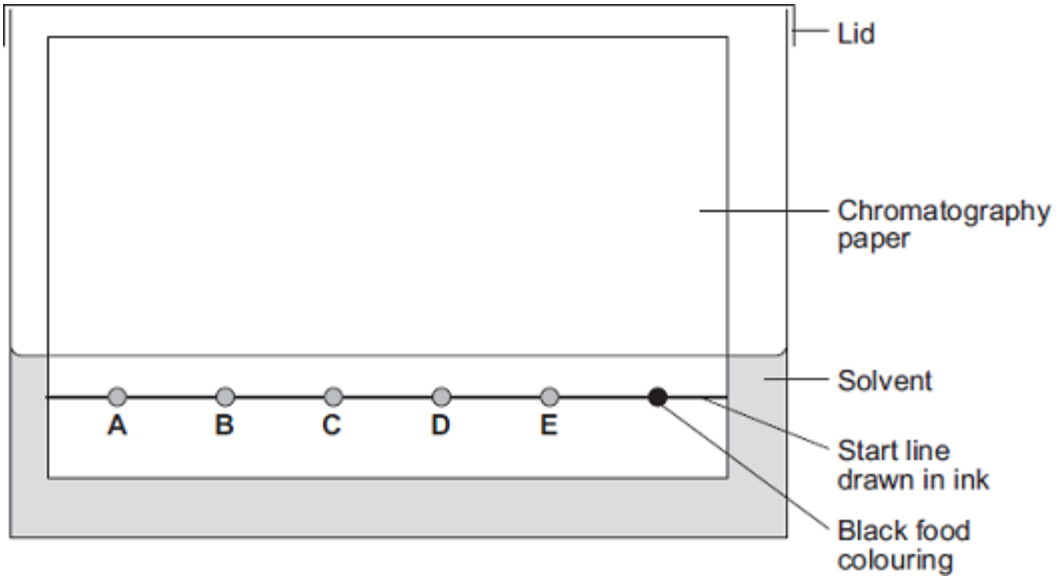
**21** Chromatography can be used to separate components of a mixture.

(a) 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.

The student set up the apparatus as shown in **Diagram 1**.

**Diagram 1**




The student made **two** errors in setting up the apparatus.
Identify the **two** errors and describe the problem each error would cause.

.....

.....

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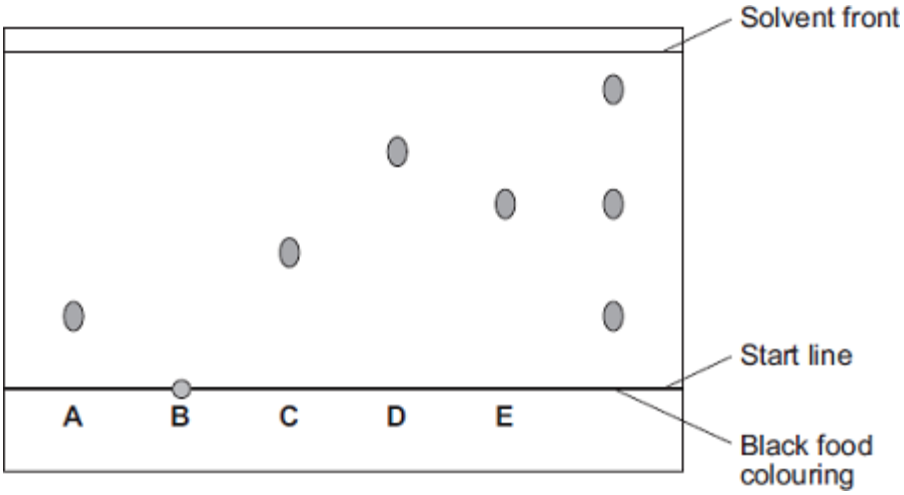
**(4)**

(b) A different student set up the apparatus without making any errors.

The chromatogram in **Diagram 2** shows the student's results.

**Diagram 2**




(i) What do the results tell you about the composition of the black food colouring?

.....

.....

.....

**(2)**

(ii) Use **Diagram 2** to complete **Table 1**.

**Table 1**

| | **Distance in mm** |
|---|---|
| Distance from start line to solvent front | ..... |
| Distance moved by food colour **C** | ..... |

**(2)**

(iii) Use your answers in part **(b) (ii)** to calculate the $R_f$ value for food colour **C**.

.....

.....

$R_f$ value = .....

**(1)**

(c) **Table 2** gives the results of chromatography experiments that were carried out on some known food colours, using the same solvent as the students.

**Table 2**

| 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 |

Which of the food colours in **Table 2** could be food colour **C** from the chromatogram?

Give the reason for your answer.

.....

.....

.....

**(2)**

(d) Two types of chromatography are gas chromatography and paper chromatography.

Give **one** advantage of gas chromatography compared with paper chromatography.

.....

.....

**(1)**

**(Total 12 marks)**

**22** Calcium chloride ($CaCl_2$) is a soluble salt.

Calcium chloride can be made by reacting dilute hydrochloric acid with either solid calcium oxide or solid calcium carbonate.

(a) Name the type of reaction that takes place when dilute hydrochloric acid reacts with calcium oxide.

.....

**(1)**

(b) Write a balanced symbol equation for the reaction of dilute hydrochloric acid with calcium oxide.

.....

**(2)**

(c) A student added solid calcium oxide to dilute hydrochloric acid in a beaker.

The student added solid calcium carbonate to dilute hydrochloric acid in another beaker.

Describe **one** difference between the two reactions that the student would **see**.

.....

.....

**(1)**

(d) Describe how crystals of calcium chloride can be made from calcium carbonate and dilute hydrochloric acid.

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**(4)**

(e) A student dissolved some crystals of a salt in water.

The student added sodium hydroxide solution to the salt solution.

The student added sodium hydroxide solution until it was in excess.

(i) Describe what the student would **see** if the salt contained calcium ions.

.....

.....

.....

**(2)**

(ii) Why does the result you have described in part (e)(i) **not** prove that the salt contains calcium ions?

.....

.....

**(1)**

(iii) Describe an additional test the student could do that would prove the salt contains calcium ions.

.....

.....

.....

**(2)**

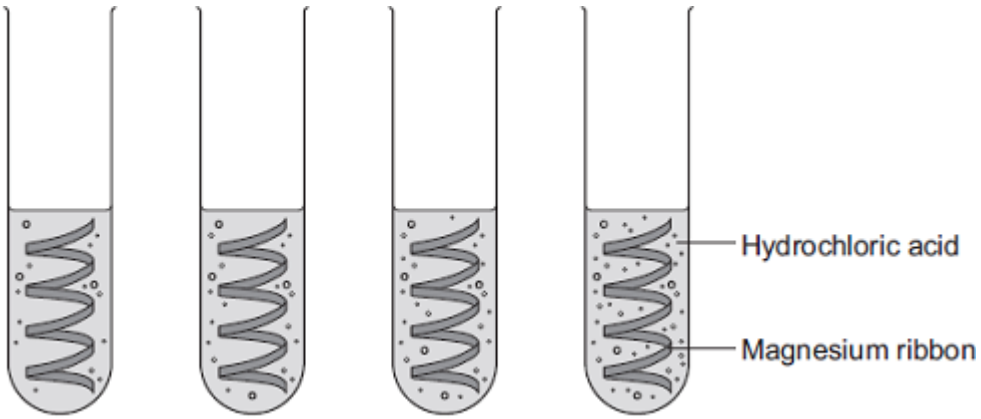
**(Total 13 marks)**

**23** A student investigated the rate of reaction of magnesium and hydrochloric acid.

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

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.




| Concentration of hydrochloric acid in moles per $dm^3$ | 0.5 | 1.0 | 1.5 | 2.0 |
|---|---|---|---|---|

(a) The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1 .....

2 .....

**(2)**

(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

.....

.....

.....

.....

**(2)**

(ii) Explain why increasing the temperature would increase the rate of reaction.

.....

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**(3)**

(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per $dm^3$.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 $cm^3$ of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per $dm^3$ sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

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**(4)**

(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

The student found that 27.20 $cm^3$ of 0.100 moles per $dm^3$ sodium hydroxide neutralised 5.00 $cm^3$ of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per $dm^3$.

Give your answer to three significant figures.

.....

.....

.....

.....

.....

.....

Concentration of hydrochloric acid = ..... moles per $dm^3$

**(3)**

**(Total 14 marks)**

**24** Dilute nitric acid reacts with potassium hydroxide solution.

The equation for the reaction is:

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

A student investigated the temperature change in this reaction.

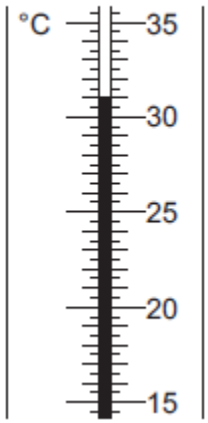
This is the method the student used.

Step 1 Put 25 $cm^3$ of dilute nitric acid in a polystyrene cup.
Step 2 Use a thermometer to measure the temperature of the dilute nitric acid.
Step 3 Use a burette to add 4 $cm^3$ of potassium hydroxide solution to the dilute nitric acid and stir the mixture.
Step 4 Use a thermometer to measure the highest temperature of the mixture.
Step 5 Repeat steps 3 and 4 until 40 $cm^3$ of potassium hydroxide solution have been added.

The dilute nitric acid and the potassium hydroxide solution were both at room temperature.

(a) **Figure 1** shows part of the thermometer after some potassium hydroxide solution had been added to the dilute nitric acid.

**Figure 1**




What is the temperature shown on the thermometer?

The temperature shown is ..... °C

**(1)**

(b) Errors are possible in this experiment.

(i) Suggest **two** causes of random error in the experiment.

.....

.....

.....

.....

**(2)**

(ii) Another student used a glass beaker instead of a polystyrene cup.

This caused a systematic error.

Why does using a glass beaker instead of a polystyrene cup cause a systematic error?

.....

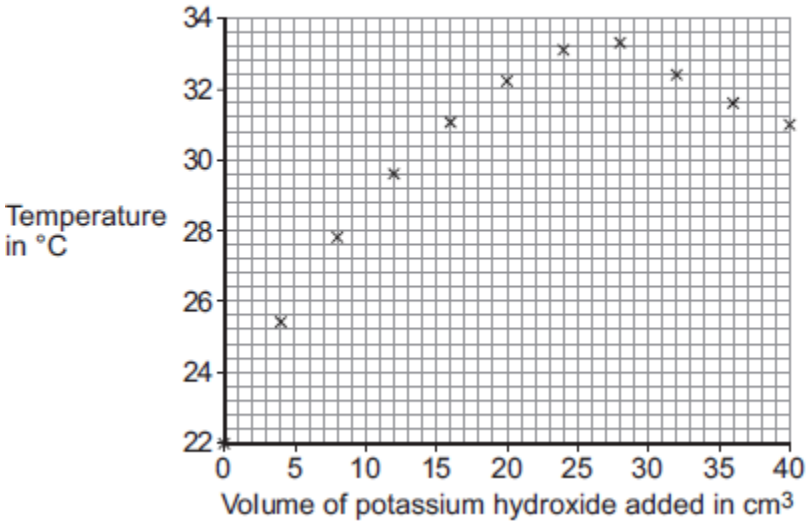
.....

.....

**(1)**

(c) The results of the student using the polystyrene cup are shown in **Figure 2**.

**Figure 2**




(i) How do the results in **Figure 2** show that the reaction between dilute nitric acid and potassium hydroxide solution is exothermic?

.....

.....

**(1)**

(ii) Explain why the temperature readings decrease between 28 $cm^3$ and 40 $cm^3$ of potassium hydroxide solution added.

.....

.....

.....

**(2)**

(iii) It is difficult to use the data in **Figure 2** to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

Suggest further experimental work that the student should do to make it easier to find the exact volume of potassium hydroxide solution that would give the maximum temperature

.....

.....

.....

.....

**(2)**

(d) The student did further experimental work and found that 31.0 $cm^3$ of potassium hydroxide solution neutralised 25.0 $cm^3$ of dilute nitric acid.

The concentration of the dilute nitric acid was 2.0 moles per $dm^3$.

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

Calculate the concentration of the potassium hydroxide solution in moles per $dm^3$.

.....

.....

.....

.....

.....

.....

Concentration = ..... moles per $dm^3$

**(3)**

(e) The student repeated the original experiment using 25 $cm^3$ of dilute nitric acid in a polystyrene cup and potassium hydroxide solution that was twice the original concentration.

She found that:

- a smaller volume of potassium hydroxide solution was required to reach the maximum temperature
- the maximum temperature recorded was higher.

Explain why the maximum temperature recorded was higher.

.....

.....

.....

.....

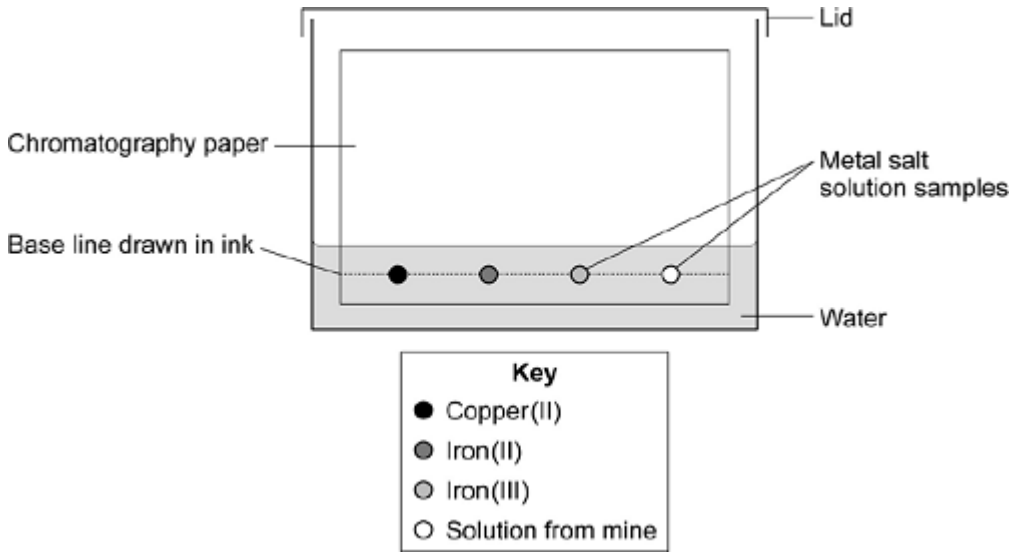
**(2)**

**(Total 14 marks)**

**25** A student analysed a sample of water from a disused mine to find out which metal ions were in the water.

He used paper chromatography of the sample of water from the mine and of solutions containing known metal ions.

He set the apparatus up as shown in the diagram.



(a) Give **one** error the student made in the way he set up his apparatus.
Explain the problem this error would have caused.

.....

.....

.....

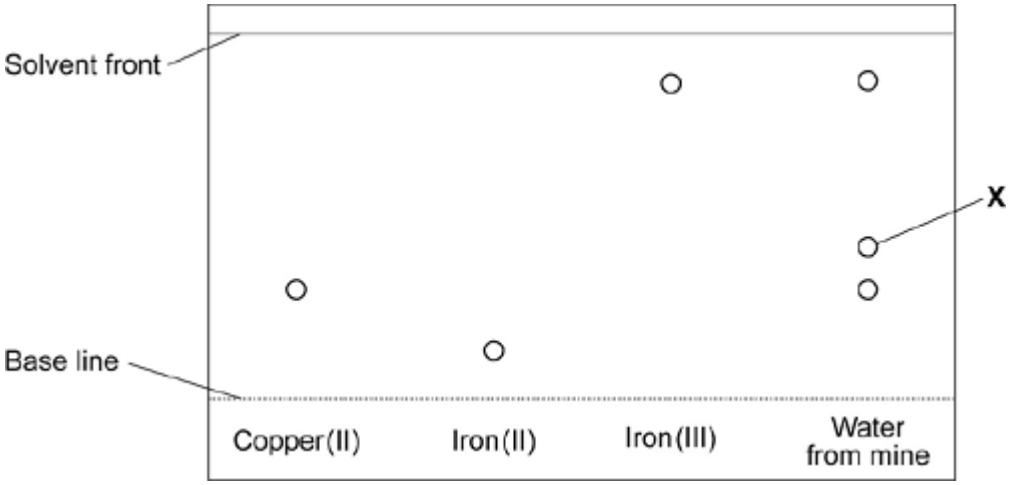
.....

**(2)**

(b) Another student repeated the experiment, but without making any errors.

After the water had soaked up the chromatography paper he sprayed it with a dilute solution of sodium hydroxide. Coloured spots appeared on the paper.

The results he obtained are shown in the diagram.




(i) Identify **two** of the metal ions in the sample of water from the mine.

.....

**(1)**

(ii) State the colour of the spot formed from the iron(III) ions.

.....

**(1)**

(iii) Give the formula of the iron(III) compound responsible for the colour you stated in (b)(ii).

**(1)**

(c) Spots obtained by chromatography can be compared by their $R_f$ values.

(i) Use the diagram of the results to help you to complete the table.

Include the units.

| | |
|---|---|
| distance moved by spot **X** from base line | ..... |
| distance moved by solvent from base line | ..... |

**(2)**

(ii) Use the values you recorded in the table to calculate the $R_f$ value for spot **X**.

.....

.....

$R_f$ value = .....

**(1)**

(d) Paper chromatography of a mixture using water as the solvent gave a spot with an $R_f$ value of 0.54.

The data in the table below was used to identify the substance that caused the spot.

| **Substance** | **$R_f$ value when the solvent is:** | | |
|---|---|---|---|
| | **Water** | **Ethanol** | **Propanone** |
| **A** | 0.72 | 0.54 | 0.00 |
| **B** | 0.53 | 0.62 | 0.84 |
| **C** | 0.04 | 0.16 | 0.54 |
| **D** | 0.55 | 0.45 | 0.31 |

(i) Use the data in the table to suggest **two** possible identities for the substance that caused the spot with an $R_f$ of 0.54.

.....

.....

**(1)**

(ii) Describe a further chromatography experiment that should be carried out to confirm which one of the substances you have identified in (d)(i) actually caused the spot.
Explain why you chose this experiment.

.....

.....

.....

.....

.....

**(2)**

**(Total 11 marks)**

**1** (a) additive

**1**

(b) colour 3 is a mixture of colours 1 and 2

any **two** from:

*accept E-number or additive instead of colour*

*ignore comments about height / level*

**1**

- colour 1 is made up of only one colour / dye
- colour 2 is made up of only one colour / dye
- colour 3 is made up of two colours / dyes
  **or**
  more colours (than colours 1 and 2)

**2**

**[4]**

**2** (a) sodium loses (electron)

*sharing / covalent / metallic = max 2*

**1**

chlorine gains (electron)

**1**

1 **or** an (electron)

**1**

(b) (i) Have no overall electric charge

**1**

(ii) Should iodine be added to salt?

**1**

reason

any **one** from:

- cannot be done by experiment
  *accept difficult to get / not enough evidence*
- based on opinion / view
  *allow must be done by survey*
- ethical **or** economic issue.

**1**

(c) (i) nitric (acid)

1

(ii) an alkali

1

(iii) indicator

*accept any named acid base indicator*

1

(d) (i) Crystallisation

1

(ii) fertiliser

*allow to help crops grow*

1

(iii) any **one** from:

- pressure

  *allow concentration*
- temperature

  *ignore heat*
- catalyst.

1

**[12]**

**3**

(a) goes up

1

(b) (i) B

1

(ii) A

1

(iii) a catalyst

1

activation energy

1

(c) (i) eg (ensures) complete reaction

*allow spread heat / energy*

**or** even heating

*allow mixes properly or mix them together or to get correct temperature*

*ignore dissolves*

1

(ii) lid (on beaker)

*accept cover beaker*

**or**

insulate (beaker) / use a plastic cup

**1**

**[7]**

**4** (a) (i) 11

**1**

(ii) 4620 (J)

*correct answer gains **2** marks with or without working*

*allow 4.62kJ for **2** marks*

*if answer is incorrect:*

*100 × 4.2 × 11 gains **1** mark*

***or***

*100 × 4.2 × (their temp. rise) gains **1** mark*

***or***

*100 × 4.2 × (their temp. rise) correctly calculated gains **2** marks*

**2**

(b) the temperature increases

*allow gets hotter*

*allow heat / energy is given off*

**1**

(c) (i) (energy of) products lower than (energy of) reactants

*allow converse*

*allow arrow C points downwards*

**1**

(ii) A

**1**

**[6]**

**5** (a) (i) to remove or separate copper oxide

*accept to remove or separate*

*unreacted or excess base*

*accept to remove or separate insoluble solids*

**1**

(ii) heat (the solution)

*accept heat the water*

*accept evaporate the water*

***rapid** cooling/cool to lower temperature*

*accept boil the water or solution*

***not** increase surface area, put in draught*

***not** increase the temperature*

**1**

(iii) aqueous

*accept in water*

*accept solution*

***not** soluble in water*

**1**

(b) add water/liquid/solution

**1**

colour changes to blue

**1**

**[5]**

**6**

(a) any **one** from:

- protection / improve lifespan
- improve appearance.

**1**

(b) (i) Bleach

**1**

(ii) Hydrogen is less reactive than sodium

**1**

(iii) 1 bonding pair of electrons 6 unbonded electrons on Cl

*accept dot, cross or e or − or any combination*

**1**

(iv) Covalent

**1**

(v) Hydrogen chloride has a low boiling point.

**1**

Hydrogen chloride is made of simple molecules.

**1**

(c) (i) oxygen

*accept carbon dioxide*

**1**

(ii) aluminium ions are positive

**1**

so are attracted (to the negative electrode)

*allow opposites attract*

**1**

(iii) Reduction

**1**

(iv) slide

*allow move*

**1**

(d) (i) C

**1**

(ii) strong covalent bonds

**1**

**[14]**

**7**

(a) (i) (19.5 + 18.5 + 19.0) / 3

*allow (23.0 + 19.5 + 18.5 + 19.0) / 4 for **1** mark*

**2**

(ii) R P Q

*allow Q P R for **1** mark*

**2**

(b) any **two** from:

- repeat more times
- calculate a mean
- measure to one decimal place.

**2**

(c) both students get similar results / similar pattern

**1**

**[7]**

**8** (a) (i) burette

**1**

(ii) indicator

**1**

(iii) colour change

**1**

(b) (i) any **one** from:

- volume of (hydrochloric) acid

  *allow amount of (hydrochloric) acid*
- concentration of (hydrochloric) acid
- concentration of (sodium) hydroxide

  *allow concentration of alkali*

**1**

(ii) 22.3(0)

**1**

**[5]**

**9** (a) (i) prevent evaporation of solvent

*allow prevent loss of solvent*

*allow to support the (chromatography) paper*

**1**

(ii) ink dissolves in the solvent

*allow ink 'runs' / spreads* ***or*** *pencil does not 'run' / spread*

*allow ink would affect the result / mixes with colours*

**or**

carbon / graphite does not dissolve in the solvent

*accept pencil for carbon / graphite*

**1**

(b) (i) 4

**1**

(ii) *no mark for 'no / don't know'* ,

*ignore numbers*

any **one** from:

- because not all colours match
- not all colours are safe
- some colours could be unsafe
- some colours travelled higher (than safe colours)

**1**

(c) (i) any **two** from:

*ignore reliable / precise*

- rapid / quick
- accurate
- sensitive **or** detects very small quantities

*accept small sample*

**2**

(ii) separates

**1**

(iii) identifies solvents / compounds / substances

*accept (relative) molecular mass*

*accept formula mass*

*accept $M_r$*

*accept relative mass*

*accept molecular ion peak*

**1**

**[8]**

**10** (a) any **one** from:

- they are negative / anions

*allow $Cl^-$*

*ignore atoms / chlorine*

*do **not** accept chloride ions are negative electrodes*

- they are attracted
- they are oppositely charged

**1**

(b) hydrogen is less reactive than sodium

**1**

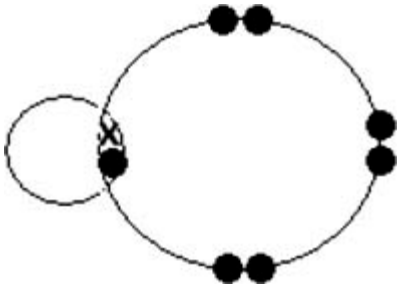
(c) hydroxide (ions) / $OH^-$

*ignore OH*

*do **not** accept NaOH / sodium hydroxide*

**1**

(d) (i)



*allow any combination of dots or crosses*

*ignore chemical symbols*

**1**

(ii) covalent

*allow close spelling errors*

*apply list principle*

**1**

(iii) hydrogen (ion) / $H^+$

*ignore (aq) / H*

*do not accept hydrochloric acid / HCl*

*apply list principle*

**1**

**[6]**

**11** (a) the ions can move / travel / flow /are free

*accept particles / they for ions*

*allow delocalised ions*

**or**

*ignore delocalised / free electrons*

*ignore references to collisions*

*accept converse with reference to solid*

the ions carry the charge / current

*ignore ions carry electricity*

**1**

(b) any **one** from:

- because they are negative / anion

  *allow $Cl^-$*

  *ignore chlorine*

- opposite charges / attract

**1**

(c) 13

**1**

(d) (i) reasonable attempt at straight line which misses the anomalous point

*must touch all five crosses*

*do **not** allow multiple lines*

**1**

(ii) 40

*ignore 2.2*

**1**

(iii) any **two** sensible errors from:

*ignore systematic / human / apparatus / zero /experimental / random / measurement / reading errors unless qualified*

- gas escapes
- weighing error

  *allow NaCl not measured correctly*
- error in measuring (volume / amount) of hydrogen
- error in measuring (volume / amount) of water

  *allow error in measuring volume / scale for **1** mark if neither hydrogen or water mentioned*
- incorrect concentration

  *allow NaCl not fully dissolved **or** spilled **or** impure*
- timing error
- change in voltage / current

  *allow faulty power supply*
- change in temperature
- recording / plotting error

**2**

(iv) any **one** from:

*ignore 'do more tests'*

- repeat the experiment
- results compared with results from /other students / other groups / other laboratories / internet / literature.
- results compared with another method

**1**

(v) increases owtte

*allow directly proportional or positive correlation*

*allow rate / it is faster / quicker*

**1**

**[9]**

**12** (a) (i) energy / heat of products less than energy of reactants

*allow converse*

*allow products are lower than reactants*

*allow more energy / heat given out than taken in*

*allow methanol is lower*

*allow energy / heat is given out / lost*

*allow ΔH is negative*

**1**

(ii) lowers / less activation energy

*allow lowers energy needed for reaction*
***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

**1**

(b) (i) (8 × 435) + 497 = 3977

*accept: bonds broken: (2 × 435) + 497 = 1367*

**1**

(6 × 435) + (2 × 336) + (2 × 464) = 4210

*bonds made: (2 × 336) + (2 × 464) = 1600*

**1**

3977 – 4210 = (–) 233

*energy change:*

*1367 – 1600 = (–) 233*

*ignore sign*

*allow ecf*

*correct answer (233) = **3** marks with or without working*

**1**

(ii) energy released forming (new) bonds is greater than energy needed to break (existing) bonds

*allow converse*

*do **not** accept energy needed to form (new) bonds greater than energy needed to break (existing) bonds*

**1**

**[6]**

**13** (a) (i) (phosphoric) acid

*allow phosphoric*

**1**

(ii) $H^+$ / hydrogen (ion)

*if ion symbol given, charge must be correct*

**1**

(b) (i) pencil

**1**

so it will not run / smudge / *dissolve*

*ignore pencil will not interfere with / affect the results*

**or**

because ink would run / smudge / *dissolve*

*ignore ink will interfere with / affect the results*

**1**

(ii) any **three** from:

*reference to spots / dots = max **2***

*allow colouring for colour*

- *3* colours in Cola

*allow more colours in cola **or** fewer colours in fruit drink*

- *2* colours in Fruit drink
- one of the colours is the same
- two of the colours in Cola are different
- one of the colours in Fruit drink is different

*allow some of the colours in the drinks are different*

- *one of the colours in Cola is the most soluble*

*accept one of the colours in Cola has the highest $R_f$ value*

**3**

(c) different substances travel at different speeds **or** have different retention times

*accept different attraction to solid*

*ignore properties of compounds*

**1**

(d) (i) Is there caffeine in a certain brand of drink?

**1**

(ii) any **two** from:

- cannot be done by experiment
- based on opinion / *lifestyle choice*
- ethical, *social* or economic issue

*accept caffeine has different effects on different people*

**2**

**[11]**

**14**

(a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

*any sensible modification to reduce heat loss*

*ignore prevent draughts*

*ignore references to gas loss*

*ignore bomb calorimeter*

**1**

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

*'so they react' is insufficient for the mark*

*accept increase chances of (successful) collisions / collision rate increase*

*do **not** accept rate of reaction increase / make reaction faster*

**1**

(c) experiment 2 **and**
different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher temperature*

*do **not** accept temperature change / results higher*

**1**

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*

*'results are different' is insufficient*

**1**

(e) 7 / 7.0

**1**

(f) (100 × 4.2 × 7) = 2940

*ecf from (e)*

**1**

(g) diagram A **and**
reaction exothermic / heat evolved / Δ H is negative / temperature rises

*accept energy is lost (to the surroundings)*

*accept energy of products lower than reactants*

*allow arrow goes downwards*

**1**

**[7]**

**15** Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

**0 marks**
No relevant content.

**Level 1 (1-2 marks)**
There is a simple description of using some of the equipment.

**Level 2 (3-4 marks)**
There is a description of an experimental method involving a measurement, **or** including addition of alkali to acid (or vice versa).

**Level 3 (5-6 marks)**
There is a description of a titration that would allow a successful result to be obtained.

**Examples of chemistry points made in the response could include:**

- acid in (conical) flask
- volume of acid measured using pipette
- indicator in (conical) flask
- sodium hydroxide in burette
- white tile under flask
- slow addition
- swirling
- colour change
- volume of sodium hydroxide added

**Extra information**

- allow acid in the burette to be added to sodium hydroxide in the (conical) flask
- allow any specified indicator

colour change need not be specified

**[6]**

**16** (a) (i) electron(s)

*allow free / delocalised / negative electrons*

*do **not** accept additional particles*

**1**

(ii) ion(s)

*allow named ions from table*

*ignore positive or negative*

*do **not** accept additional particles*

**1**

(b) (i) copper

*accept Cu*

*do **not** accept $Cu^{2+}$*

**1**

(ii) it is / they are positive (ions)

*accept formula of positive ion*

**1**

and it is the least reactive

**1**

(c) (i) loss of electron(s)

*ignore numbers*

**1**

(ii) $\mathbf{2H^+} + \mathbf{2e^-} \rightarrow H_2$

*accept correct multiples / fractions*

*accept e / $e^-$*

*allow $\mathbf{2H^+} \rightarrow H_2 - \mathbf{2e^-}$*

**1**

**[7]**

**17** (a) (i) any **one** from:

- incorrect measurement of temperature or volume
- incorrect recording of temperature
- failure to stir
- heat loss

*ignore faulty equipment*

**1**

(ii) 32 - 33

**1**

(iii) 55

**1**

(iv) 20

**1**

(v) 4620

*allow 4.62 kJ for **2 marks***

**1**

J / joules

*allow kJ if evidence of dividing by 1000*

*mark independently, but if a numerical answer has been divided by 1000 must be kJ.*

*allow ecf from their answers to (iii) and (iv)*

**1**

(b) twice as much energy released

**1**

but twice as much water to heat

*allow more energy released but more water to heat for **2 marks***

*if no other mark awarded, allow twice the amount of hydrochloric acid used for **1 mark***

**1**

**[8]**

**18** (a) any four from:

- sulphuric acid measure by pipette

  ***or** diagram*
- potassium hydroxide in burette

  ***or** diagram*
- if solutions reversed, award
- note initial reading
- use of indicator
- note final reading **or** amount used

**4**

(b) $\frac{34 \times 2}{1000}$

**1**

= 0.068

**1**

(c) ½ or 0.5 moles $H_2SO_4$ react with 1 mole KOH

**1**

moles $H_2SO_4$ in 25.0 $cm^3$ = 0.068 × 0.5

**1**

$\therefore$ moles $H_2SO_4$ in 1 $dm^3$ = $\frac{0.068 \times 0.5 \times 1000}{25}$ = 1.36 mol/$dm^3$

**1**

**[9]**

**19** (a) (i) s

*this order only*

1

aq

1

(ii) Filtration

1

(iii) sodium carbonate **or** copper sulfate **or** sodium sulfate

*accept correct formulae*

1

(b) (i) lead sulfate

*accept correct formula*

1

(ii) sodium sulfate **or** copper nitrate **or** sodium nitrate **or** manganese sulfate

*accept correct formula*

1

(iii) (very pale) pink

1

(c) (i) No more barium hydroxide solution was added

1

(ii) correct extrapolation shown on graph

1

640

*correct answer with no extrapolation shown gains **1** mark*

1

(iii) contains ions

1

which are able to move

*second mark dependent on having ions*

1

(d) (i) 21.5 ($cm^3$)

*accept 21 to 22*

1

(ii) no dissolved (ionic) substance **or** ions cannot move **or** liquid is water **or** no ions in solution

1

(e) (i) could have added 39 $cm^3$ **or** another volume gives the same conductivity

**1**

(ii) add (more) barium hydroxide

**1**

a small volume

*if specified the volume must be less than 26 $cm^3$*

**1**

if she is correct this will cause the conductivity to drop
**or**
allow add a named indicator
correct acid colour for this indicator
some acid remains in solution

**1**

**[18]**

**20** (a) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response.

**0 marks**
No relevant content

**Level 1 (1–2 marks)**
There is a basic method, which includes some of the apparatus,and there is some attempt at explaining some of the steps. The method does not necessarily allow the procedure to be completed successfully by another person.There may be an attempt at identifying safety precautions but these may be inappropriate or incomplete.

**Level 2 (3–4 marks)**
There is a clear description of the method, which includes most of the apparatus needed, and an explanation of the various steps in the procedure. The method could be followed by another person. There is some attempt at identifying some, but not necessarily all, of the safety precautions needed.

**Level 3 (5–6 marks)**
There is a clear, balanced and detailed description of the method, which correctly names the apparatus needed and explains the purpose of each step.This method could easily be followed by another person. There is a comprehensive list of appropriate safety precautions.

**examples of chemistry points made in the response**

***extra information***

- heat the sulfuric acid in a beaker and add the copper oxide with stirring
  *the underlined words are needed to gain each point*
- because heating and stirring speed up the reaction
- until the copper oxide is in excess
- which means that the reaction has gone to completion
- filter the mixture
  **or**
  pour the mixture through a funnel and filter paper
  **or**
  leave the mixture to stand and decant / pour off the excess liquid
- to remove the excess / unreacted copper oxide
- put the solution in an evaporating basin
- heat it gently so that (some of) the water evaporates
- when a saturated solution is formed or when crystals start to form, stop heating
- leave the solution to cool so that crystallisation can occur.

**examples of the safety points made in the response**

- wear safety goggles – to protect eyes because sulfuric acid is corrosive / an irritant / harmful
- care when heating – to protect against burns
- wash hands after the preparation – copper sulfate is harmful / a sensitiser
- care when handling glass apparatus – to protect against cuts
- do not add copper oxide to boiling acid as it may boil over

**6**

(b) (i) anhydrous copper sulfate

*do not accept 'dehydrated'*

**1**

(ii) it (turns) blue

**1**

because (dilute sulfuric acid) contains water **or** because (dilute sulfuric acid) rehydrates the crystals or because hydrated copper sulfate is formed

*owtte*

*ignore references to forming a solution / dissolving*

**1**

**[9]**

**21** (a) start line drawn in ink

**1**

so it will run / dissolve in the solvent / split up

*allow mixes with the spots*

**1**

spots under solvent **or** solvent above spots / start line

**1**

so they will mix with solvent **or** wash off paper **or** colour the solvent **or** dissolve in the solvent

**1**

(b) (i) contains **A** and **E**

**1**

and one other (unknown substance)

*if no other marks awarded, an answer saying it is made up of three colours gains **1** mark*

**1**

(ii) 45 or 46

*allow any value from 45 to 46*

**1**

18

*allow any value from 16 to 20*

*award **1** mark if numbers correct but in cm*

**1**

(iii) 0.40

*allow ecf from **(b)(ii)***

*ignore units*

**1**

(c) fast red

*allow ecf from **(b)(iii)***

**1**

has same $R_f$ value

*allow none of them, as none has the same $R_f$ value for **2** marks*

**1**

(d) any **one** from:

- more accurate
- more sensitive
- uses small quantities of samples
- quicker / faster / more rapid
- can link to mass spectrometer (MS)

**1**

**[12]**

**22** (a) neutralisation

*ignore reference to exothermic or endothermic*

**1**

(b) $2\ HCl + CaO \rightarrow CaCl_2 + H_2O$

*accept multiples and fractions*

formulae

*ignore state symbols*

**1**

balancing (dependent on first mark)

**1**

(c) (the carbonate has) fizzing / bubbles / effervescence

*ignore dissolving*

*ignore gas produced*

**1**

(d) add excess calcium carbonate to acid (and stir) / add $CaCO_3$ until fizzing stops

*ignore heating the acid*

*accept answer using calcium oxide in place of calcium carbonate*

**1**

(remove excess calcium carbonate by) filter(ing)

**1**

warm until a saturated solution forms / point of crystallisation / crystals start to form

*do **not** accept heat until all water gone*

**1**

leave to cool

*dependent on previous mark*

*If solution **not** heated allow leave to evaporate (1)*

*until crystals form (1)*

**1**

(e) (i) <u>white</u> precipitate / *solid* (forms)

**1**

insoluble in excess **or** remains **or** no (further) change in excess

*dependent on a precipitate / solid forming*

**1**

(ii) same result with magnesium (ions)

*do **not** accept reference to any other ion(s) that do not give a white precipitate*

*accept other named ions that do give a white precipitate*

**1**

(iii) flame test **or** description of flame test

**1**

gives a red flame

*accept brick red **or** orange-red **or** scarlet*

*do **not** accept crimson*

**1**

**[13]**

**23** (a) any **two** from:

- temperature (of the HCl)
- mass or length of the magnesium
- surface area of the magnesium
- volume of HCl

**2**

(b) (i) (a greater concentration has) more particles per unit volume

*allow particles are closer together*

**1**

therefore more collisions <u>per unit time</u> **or** more frequent collisions.

**1**

(ii) particles move faster

*allow particles have more (kinetic) energy*

**1**

therefore more collisions <u>per unit time</u> **or** more frequent collisions

**1**

collisions more energetic (therefore more collisions have energy greater than the activation energy) **or** more productive collisions

**1**

(c) (i) add (a few drops) of indicator to the acid in the conical flask

*allow any named indicator*

**1**

add NaOH (from the burette) until the indicator changes colour **or** add the NaOH dropwise

*candidate does not have to state a colour change but penalise an incorrect colour change.*

**1**

repeat the titration

**1**

calculate the **average** volume of NaOH **or** repeat until concordant results are obtained

1

(ii) **moles of NaOH**

0.10 × 0.0272 = 0.00272 moles

*correct answer with or without working gains **3** marks*

1

**Concentration of HCl**

0.00272 / 0.005 = 0.544

*allow ecf from mp1 to mp2*

1

correct number of significant figures

1

**[14]**

**24** (a) 31

1

(b) (i) any **two** from:
- incorrect reading of thermometer / temperature
- incorrect measurement of volume of acid
- incorrect measurement of volume of alkali (burette).

2

(ii) glass is a (heat) conductor **or** polystyrene is a (heat) insulator

*answer needs to convey idea that heat lost using glass **or** not lost using polystyrene*

*accept answers based on greater thermal capacity of glass (such as "glass absorbs more heat than polystyrene")*

1

(c) (i) temperature increases

1

(ii) no reaction takes place **or** all acid used up **or** potassium hydroxide in excess

1

cool / colder potassium hydroxide absorbs energy **or** lowers temperature

*ignore idea of heat energy being lost to surroundings*

1

(iii) take more readings

*ignore just "repeat"*

1

around the turning point **or** between 20 $cm^3$ and 32 $cm^3$

*accept smaller ranges as long as no lower than 20 $cm^3$ and no higher than 32 $cm^3$*

1

(d) 1.61 **or** 1.6(12903)

*correct answer with or without working scores **3***

*if answer incorrect, allow a maximum of **two** from:*

*moles nitric acid = (2 × 25 / 1000) = 0.05 for **1** mark*

*moles KOH = (moles nitric acid) = 0.05 for **1** mark*

*concentration KOH = 0.05 / 0.031*

*answer must be correctly rounded (1.62 is incorrect)*

**3**

(e) same amount of energy given out

**1**

which is used to heat a smaller total volume **or** mixture has lower thermal capacity

**or**

number of moles reacting is the same

but the total volume / thermal capacity is less

*if no other marks awarded award **1** mark for idea of reacting faster*

**1**

**[14]**

**25** (a) base line drawn in ink

*explanation must match problem*

**1**

which will run (and confuse the spots)

**or**

spots under water will dissolve into water / wash off

**1**

(b) (i) copper(II) and iron (III)

**1**

(ii) orange / brown

*accept rusty*

**1**

(iii) $Fe(OH)_3$

*accept formula of complex $[Fe(H_2O)_3(OH)_3]$ or any other formula for hydrated iron oxide,such as $Fe_2O_3.9H_2O$*

**1**

(c) (i) distance moved by spot **X**: 2.1,

*both needed for mark*

distance moved by solvent from baseline: 5.0

*allow ± 0.1 cm*

*accept answers in mm (21 and 50 ± 1 mm) and units stated as mm*

**1**

cm

*correct unit used at least once*

**1**

(ii) 2.1 / 5.0

*allow ecf from table*

= 0.42

*ignore units given in answer for $R_f$*

**1**

(d) (i) substances **B** and **D**

*both required*

**1**

(ii) do chromatography on mixture using ethanol **or** propanone as the solvent

*accept conducting chromatography using any other solvent, but such answers cannot score second mark*

**1**

result gives different $R_f$ values

ie if ethanol solvent, **B** gives 0.62, **D** gives 0.45; if propanone, **B** gives 0.84, **D** gives 0.31

**or**

do chromatography on pure samples of **B**, **D** and mixture in ethanol or propanone (1)

*allow water under same conditions as solvent*

position of unknown spot will match that of either pure **B** or pure **D** in chromatogram (1)

**1**

**[11]**