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# GCSE (9–1) Chemistry B (Twenty First Century Science)

**H**

## J258/03 Breadth in chemistry (Higher Tier)

Sample Question Paper

# Date – Morning/Afternoon

Time allowed: 1 hour 45 minutes

**You must have:**
- a ruler (cm/mm)
- the Data Sheet

**You may use:**
- a scientific or graphical calculator



| | |
|---|---|
| **First name** | |
| **Last name** | |
| **Centre number** | **Candidate number** |

**INSTRUCTIONS**
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

**INFORMATION**
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

Answer **all** the questions.

**1** Scientists think that the composition of the early atmosphere changed slowly over many billions of years.

Scientists estimated the composition of the earliest atmosphere on Earth.

**Earth's earliest atmosphere**

| Gas | Percentage composition % |
|---|---|
| carbon dioxide | 1.9 |
| water vapour | 95.8 |
| other gases | 2.3 |

Estimated surface temperature = 700 – 1100 °C

Scientists also estimated the composition of the atmosphere shortly before the first plant life existed.

**Atmosphere just before the first plant life**

| Gas | Percentage composition % |
|---|---|
| carbon dioxide | 89.8 |
| water vapour | 2.1 |
| other gases | |

**(a)** Explain the change in the amount of water vapour shown in the tables.

……

……

…… **[2]**

**(b)** Plants caused further changes to the composition of gases in the atmosphere.

Predict the effect that plants had on the percentage of carbon dioxide in the atmosphere.

Explain your reasoning.

……

……

…… **[2]**

**2** Metal extraction produces a lot of waste. The zinc ions from this waste could leak into watercourses and contaminate soil. This plant, Alpine Penny-cress, grows on waste heaps that contain toxic zinc ions.

The cress plants take up the zinc ions and store them in their leaves.

**(a)** Explain how the planting of Alpine Penny-cress could be used to recycle zinc.

……

……

…….. **[1]**

**(b)** Explain how growing these plants could reduce risk.

……

……

…….. **[2]**

**(c)** Alpine cress takes up zinc ions from contaminated soil very well.

Oilseed rape cannot take up zinc. The table shows data on Alpine Penny-cress and oilseed rape.

| Plant | Height (cm) | Dry mass per plant (g) | Plants per $m^2$ | Time to fully grown (days) |
|---|---|---|---|---|
| Alpine Penny-cress | 25 | 1 | 20 | 100 |
| Oilseed rape | 125 | 2 | 50 | 85 |

Scientists have put genes from Alpine Penny-cress into the oilseed rape plant.

Explain what effect this modified plant could have on the uptake of zinc ions in contaminated soil.

……

……

…… **[2]**

**(d)** The Alpine Penny-cress contains toxic zinc ions.

Abi decides to do some experimental research to find out whether the Alpine Penny-cress can be used as grazing for sheep.

What research would she need to do to find out if the Alpine Penny-cress is safe for sheep to eat?

……

……

…… **[2]**

**(e)** Abi does some tests to find out which metal ions are in some other samples of mining waste, samples **A, B** and **C**.

She adds dilute sodium hydroxide, NaOH, to a solution of the metal ions.
These are her results.

| Mining waste sample | After adding a few drops of NaOH | After adding excess NaOH |
|---|---|---|
| **A** | white precipitate | precipitate dissolves |
| **B** | blue precipitate | no further change. |
| **C** | no precipitate | |

What conclusions can Abi make about the metal ions in the mining waste?

……

……

……

…… **[3]**

**3** **(a)** Chlorine is used in the treatment of drinking water.

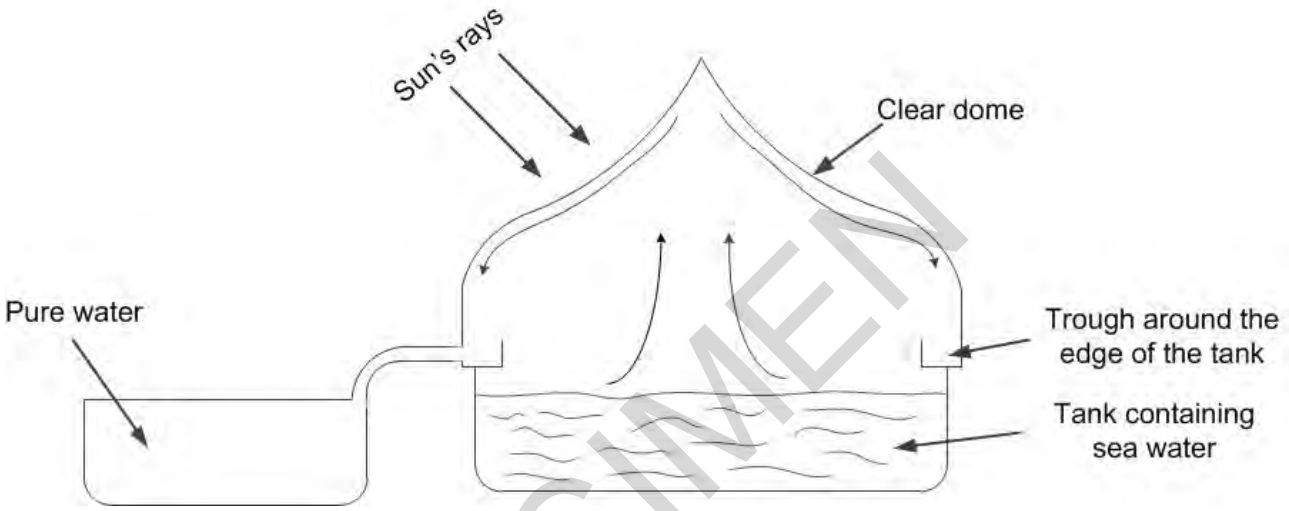
Describe how you would test a sample of gas to show that it is chlorine.

……..

……..

…… **[2]**

**(b)** A solar still can be used to make sea water safe to drink.




The diagram shows a cross-section of a solar still. Describe how a solar still produces drinking water from sea water.

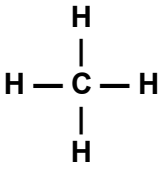
……..

……..

…… **[2]**

**4** The surface of the planet Neptune is covered with clouds of dense material. The clouds contain substances in solid, liquid and gas states.

One of the compounds in the clouds is methane.



The table shows the melting point and boiling point of methane.

| | |
|---|---|
| melting point (°C) | -182.5 |
| boiling point (°C) | -161.5 |

**(a)** The temperature in the clouds is -218 °C.

Predict the state of methane in Neptune's clouds.

…… **[1]**

**(b)** What is the bonding and structure of methane at room temperature?

……..

……..

…… **[2]**

**(c)** What is the name for the family of organic compounds (homologous series) that includes methane?

…… **[1]**

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**PLEASE TURN OVER FOR THE NEXT QUESTION**

**5** Methane and hydrogen can both be used in fuel cells for cars.

The table shows some information about the reactions that happen in a hydrogen/oxygen fuel cell and in a methane/oxygen fuel cell.

| **Fuel** | **Source of fuel** | **Equation for reaction in fuel cell** | **Energy change for reaction in fuel cell (kJ/mol)** |
|---|---|---|---|
| hydrogen | High temperature reaction between natural gas and steam. | $H_2(g) + ½ O_2(g) \rightarrow H_2O(g)$ | -286 |
| methane | Directly extracted as natural gas. | $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ | -890 |

**(a)** Evaluate the use of hydrogen and methane in fuel cells for cars.

Use the information in the table in your answer.

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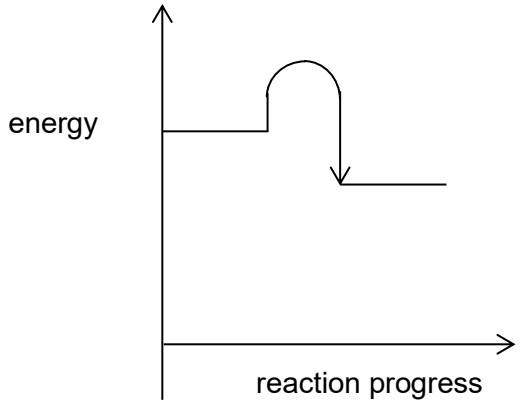
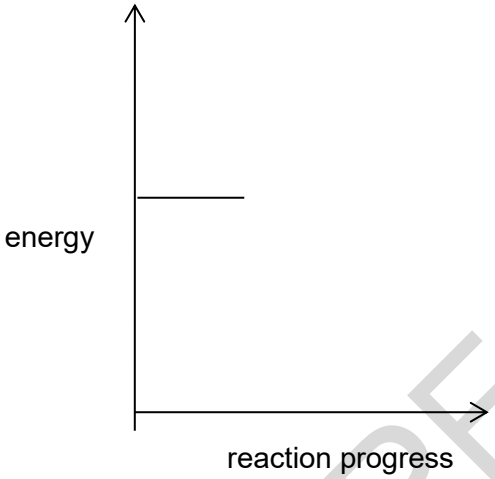
…… **[3]**

**(b)** The graph shows the energy change when **hydrogen** reacts with oxygen.




**(i)** Complete the diagram below to show the energy change when **methane** reacts with oxygen.



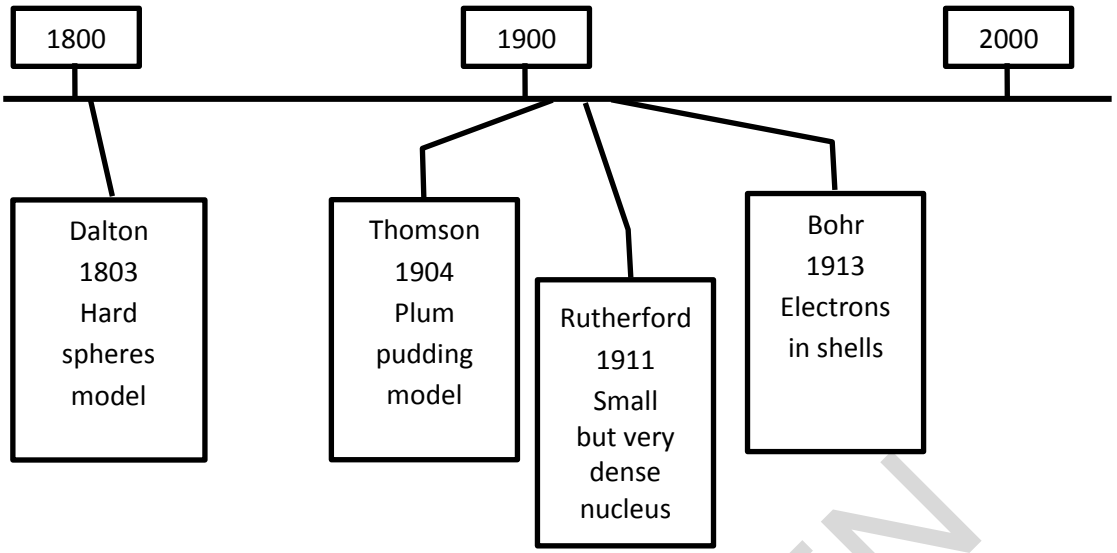

**[1]**

**(ii)** Use data from the table on the opposite page to explain the energy change you have drawn in **(b)(i)**.

……

…… **[1]**

**6** The models scientists use to describe atoms have changed over the last 200 years. This timeline shows some of the main ideas.




**(a)** Write the name of the scientist whose model of the atom could be represented by each of these pictures of everyday items. Use each name once.



…… …… …… …….. **[2]**

**(b)** Which scientist was the first scientist to include electrons in his model?
Put a ring around the correct answer.

**Dalton** **Thomson** **Rutherford** **Bohr**

**[1]**

**7** Group 1 and Group 7 of the Periodic Table both contain reactive elements.

**(a)** Sodium, Na, reacts with water, $H_2O$.

Write a balanced symbol equation for this reaction.

…….. **[2]**

**(b)** Complete the table below to show the molecular formula, state and colour of the three Group 7 elements.

| | **Chlorine** | **Bromine** | **Iodine** |
|---|---|---|---|
| **Molecular formula** | | | |
| **State (at room temperature)** | | | |
| **Colour** | | | |

**[3]**

**(c)** Sodium (Group 1) and chlorine (Group 7) react together as shown by this equation.

$$2Na + Cl_2 \rightarrow 2NaCl$$

Strontium is in Group 2.

Predict the name and formula of the compound that forms when strontium reacts with chlorine.

**Name**……

**Formula**……

**[2]**

**8** Some people have warts on their skin.

Warts can be removed by treating them with a corrosive solution of acids.

**(a)** Ellen uses chromatography to find out what acids are in a medicine used to treat warts.

She needs to use a locating agent on her chromatogram.

Explain why a locating agent is needed.

……

……

…….. **[2]**

**(b)** Ellen finds out that the medicine contains a mixture of acids.

One of the acids in the medicine is ethanoic acid.

The equation shows ethanoic acid behaving as an acid.

$$\underset{\text{ethanoic acid}}{CH_3COOH(aq)} \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

**(i)** How does the equation show that ethanoic acid is an acid?

…… **[1]**

**(ii)** Draw the **fully displayed formula** for ethanoic acid.

**[2]**

**(c)** Methanoic acid is another acid in the medicine.

| **HCOOH** | **$CH_3COOH$** |
|---|---|
| **methanoic acid** | **ethanoic acid** |

Ellen says that she thinks that methanoic acid and ethanoic acid have the same empirical formula.

Do you agree with Ellen?

Explain your answer by comparing the empirical formula of each acid.

……

……

……

…… **[3]**

**(d)** The acids in the medicine are weak acids.

Weak acids are safer to use on skin than strong acids because they are less corrosive.

**(i)** Which statements about weak and strong acids are **true** and which are **false**?
Put a tick (✓) in one box in each row.

| | **True (✓)** | **False (✓)** |
|---|---|---|
| Both types of acids form water in neutralisation reactions. | | |
| Weak acids have a slower rate of reaction with magnesium. | | |
| Strong acids have a lower degree of ionisation than weak acids. | | |

**[3]**

**(ii)** Ellen uses the hydrogen ion concentration to estimate the pH values of acids.

Estimate the pH of 0.001 mol/$dm^3$ hydrochloric acid.

pH = ……

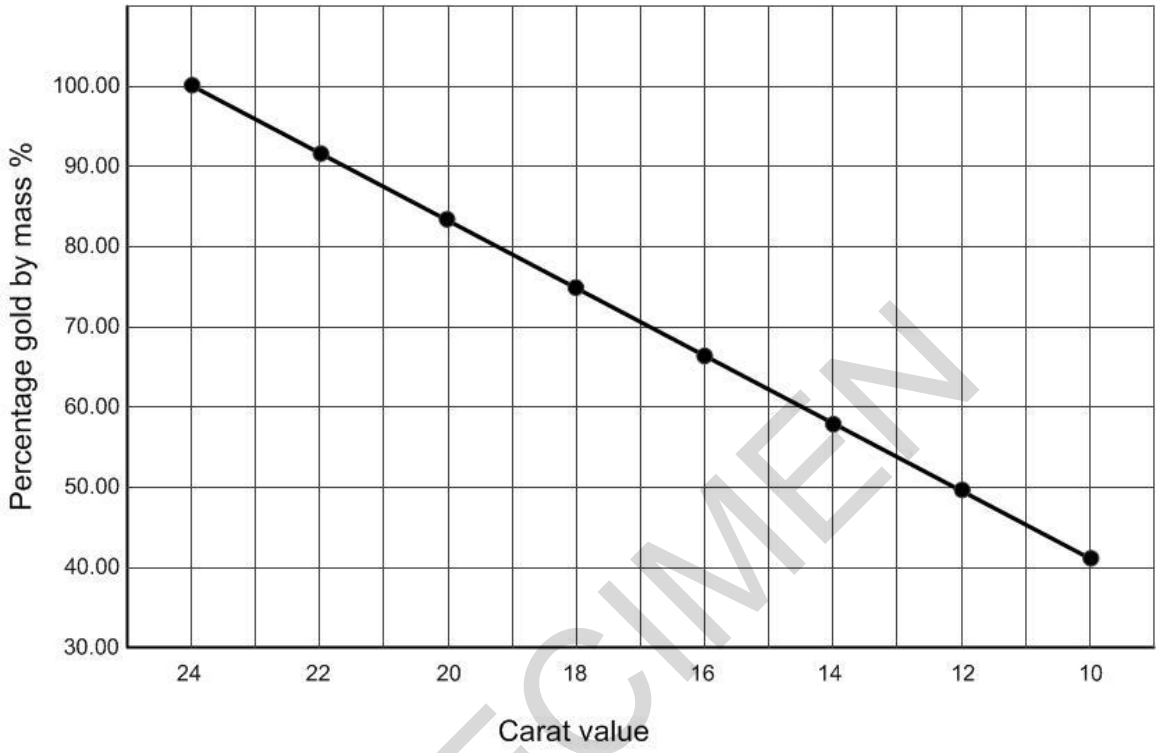
**[2]**

**9** The purity of gold is measured in carats.

24 carat gold is almost pure gold.

Gold with lower carat values is an alloy which contains other metals such as silver and copper.

The graph shows how the percentage of gold by mass is related to its carat value.






**(a)** What mass of other metals are in 20 g of 11 carat gold?

Show your working

……g **[2]**

**(b)** A chemist tests a 50 g sample of gold.

He finds that it contains 0.19 **moles** of gold.

What is the carat value of the sample?

Use the periodic table and the graph above to help you.

Carat value = …… **[3]**

**(c)** Gold, silver and copper are transition metals.

Transition metals are different from metals in Group 1.

Compare chemical properties of transition metals with the chemical properties of Group 1 metals?

……

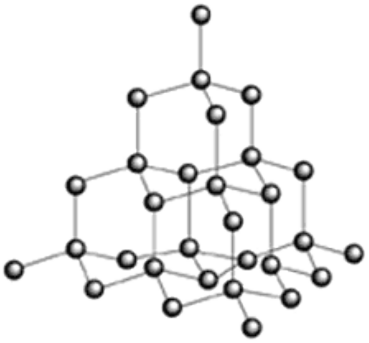
……

……

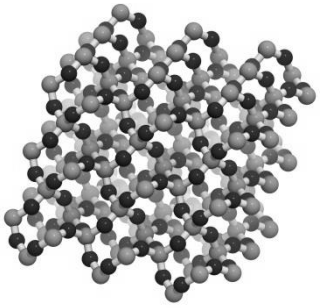
…….. **[2]**

**10** Diamond and silicon dioxide have similar properties.

**Diamond**



**Silicon dioxide**



**(a)** Describe **two** similarities and **one** difference between the structures of diamond and silicon dioxide.

**Similarity 1**……..

……

**Similarity 2**……..

……

**Difference** ……..

…… **[3]**

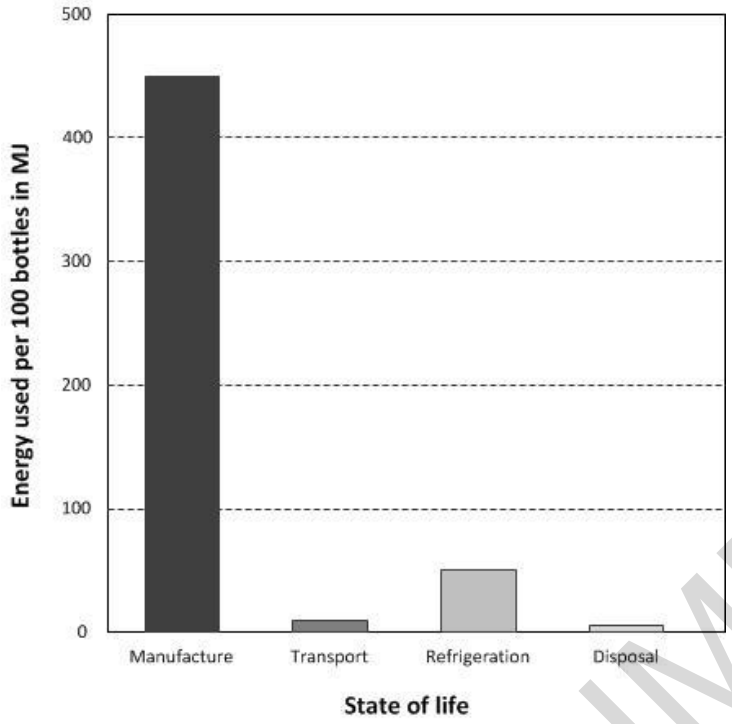
**(b)** The structure of graphite can be used to explain its properties.
Draw straight lines to connect each **property** to the correct **explanation**.

| **Property** | **Explanation** |
|---|---|
| Conducts electricity. | Structure contains layers |
| High melting point. | Charged particles in structure can move. |
| Flaky and soft. | Strong giant structure. |

**[2]**

**11** Disposable drink bottles are made from a polymer called PET.

This chart shows the energy used in millions of joules (MJ) for 100 PET bottles during their lifetime.




Jay talks about recycling waste bottles.

**Jay**
'I save my empty bottles and take them to a recycling point. This saves on the energy used in disposal of the bottles. '

Does saving energy during disposal make a large impact on the life cycle assessment for 100 bottles?

Use data from the chart to explain your answer.

…….

…….

…… **[2]**

**12** Rose is a laboratory technician.

She makes up a dilute solution of lime water (calcium hydroxide).

**(a)** One laboratory use of lime water is to test for a gas.

What is the name of the gas and what is the positive result of the test?

**Gas**……

**Result**……

**[2]**

**(b)** Rose makes 200 $cm^3$ of 1.50 $g/dm^3$ solution of calcium hydroxide.

**(i)** The formula for calcium hydroxide is $Ca(OH)_2$.
Calculate the concentration of the solution in $mol/dm^3$.

Give your answer to three significant figures.

concentration of solution…….$mol/dm^3$ **[3]**

**(ii)** Lime water is used to remove sulfur dioxide from waste gases produced by industry.

The equation for this reaction is

$$\mathbf{Ca(OH)_2(aq) + SO_2(g) \rightarrow CaSO_3(s) + H_2O(l)}$$

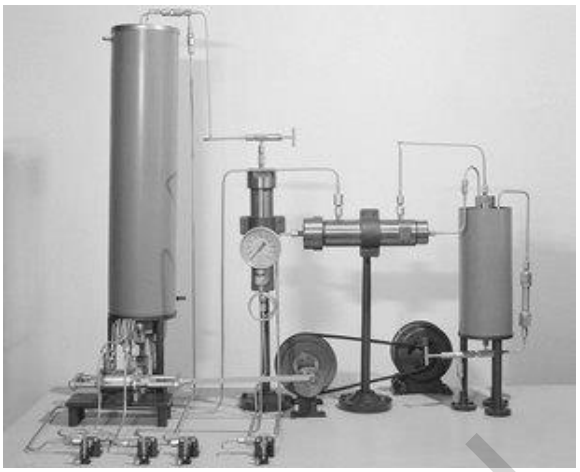
Calculate the volume of sulfur dioxide that Rose's lime water could remove.

(Assume that one mole of gas has a volume of 24 $dm^3$ at room temperature and pressure)

Volume of sulfur dioxide…… $dm^3$ **[3]**

**13** 100 years ago, Fritz Haber was the first scientist to successfully react nitrogen gas from the air to make a compound.

He used laboratory apparatus similar to this.



**(a)** Haber reacted small amounts of nitrogen and hydrogen in a closed system to make ammonia. The reaction is exothermic.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

He investigated how changing the conditions affected the yield.

What effect does increasing the pressure, temperature and using a catalyst have on the yield?

……...

……...

……...

……..... **[3]**

**(b)** Haber's reaction vessels were too small scale to make large amounts of ammonia.

Karl Bosch scaled up Haber's laboratory reaction to an industrial scale process.

Compare Karl Bosch's industrial scale process with Haber's laboratory reaction.

……...

……...

……...

……..... **[3]**

**(c)** Ammonia is used to make fertilisers for agriculture.
Ammonia provides nitrogen compounds to make crops grow faster.

Give the names of the **two** other important elements that fertilisers provide.

……and…….. **[2]**

**14** Sodium and sodium compounds are involved in many different types of reactions.

The equations for four reactions, **A, B, C** and **D** are shown below.

**A** $2NaBr(aq) + Cl_2(g) \rightarrow 2NaCl(aq) + Br_2(aq)$

**B** $Na^+(l) + e^- \rightarrow Na(s)$

**C** $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

**D** $2HCl(aq) + Na_2S_2O_3(aq) \rightarrow 2NaCl(aq) + SO_2(g) + S(s) + H_2O(l)$

**(a)** **(i)** Which reaction, **A, B, C** and **D**, can be followed by looking at an orange colour change in the solution?

Answer…… **[1]**

**(ii)** Which reaction, **A, B, C** and **D**, can be followed by looking at a precipitate forming in a solution?

Answer…… **[1]**

**(iii)** Which reaction, **A, B, C** and **D**, shows sodium being reduced?

Answer…… **[1]**

**(b)** Reaction **C** is faster if the solid sodium hydrogencarbonate is used as a powder rather than as a large lump.

Explain why.

……..

……..... **[2]**

**15** Sam works in a lab that tests samples of vinegar to check their quality.

Vinegar is mainly a mixture of ethanoic acid and water. Vinegar needs to have a minimum of 5% acidity to be used to preserve food.

He uses a titration to find out how much 1 mol/dm$^3$ sodium hydroxide he needs to add to exactly react with 25.0 cm$^3$ of vinegar.

**(a)** Calculate how much ethanoic acid needs to be in 25 cm$^3$ of vinegar.

Use the equation:

$$\textbf{\% acidity} = \frac{\textbf{mass of ethanoic acid (g)}}{\textbf{mass of vinegar(g)}} \times 100$$

1 cm$^3$ of vinegar = 1.01 g

amount of ethanoic acid……..g **[2]**

**(b)** The equation below shows ethanoic acid behaving as an acid.

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

Calculate the minimum volume of sodium hydroxide Sam uses in his titration.

Relative formula mass of $CH_3COOH$ = 60.0

volume of sodium hydroxide…….cm$^3$ **[3]**

**END OF QUESTION PAPER**