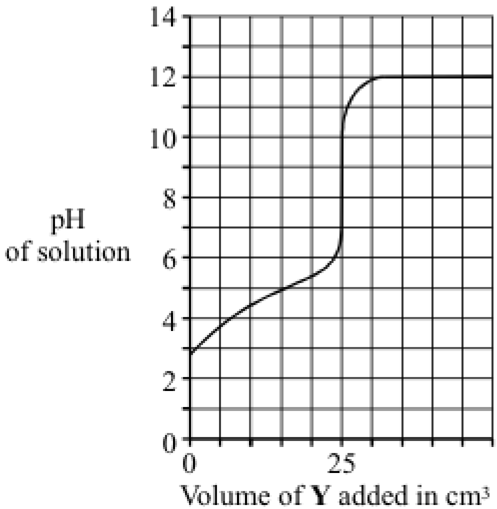
1 A solution of **Y** was slowly added to a solution of **X**. The graph shows how the pH of the resulting solution changed.



(a) (i) What was the pH of solution **X** before any of solution **Y** was added?

____

(1)

(ii) State whether solution **Y** was acidic, alkaline or neutral.

____

(1)

(iii) What volume of solution **Y** was needed to react with all of the substance in solution **X**?

____ cm^3

(1)

(b) The chemical equation shows the reaction between an acid and an alkali to form a salt and water.

(i) Draw a circle round the formula of the alkali.

$$H_2SO_4 \quad + \quad 2KOH \quad \rightarrow \quad K_2SO_4 \quad + \quad 2H_2O$$

(1)

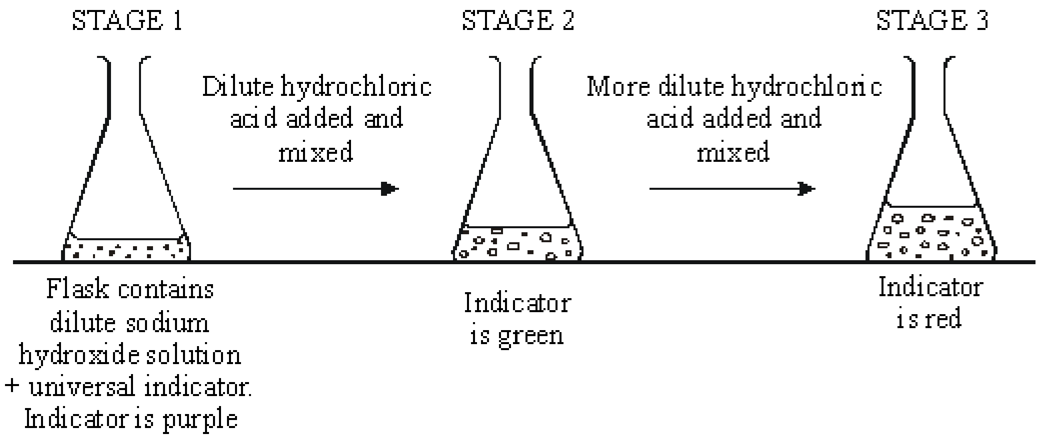
(ii) What is the formula of the salt?

____

(1)

(Total 5 marks)

2 The diagrams show what happens when an acid is added to an alkali.



(a) What is present in the solution at stages 2 and 3 apart from universal indicator and water?

(i) At stage 2 ____

(ii) At stage 3____

(3)

(b) Write an ionic equation to show how water is formed in this reaction and state the sources of the ions.

____

____

____

____

(3)

(Total 6 marks)

3 Here is a word equation for a chemical reaction.

copper oxide + sulphuric acid $\longrightarrow$ **copper sulphate + water**

Write down everything that the word equation tells you about the reaction.

____

____

____

(Total 4 marks)

4 Sodium carbonate reacts with acids.

(i) Complete the word equation.

sodium carbonate + hydrochloric acid → sodium chloride + ___________ + water

(1)

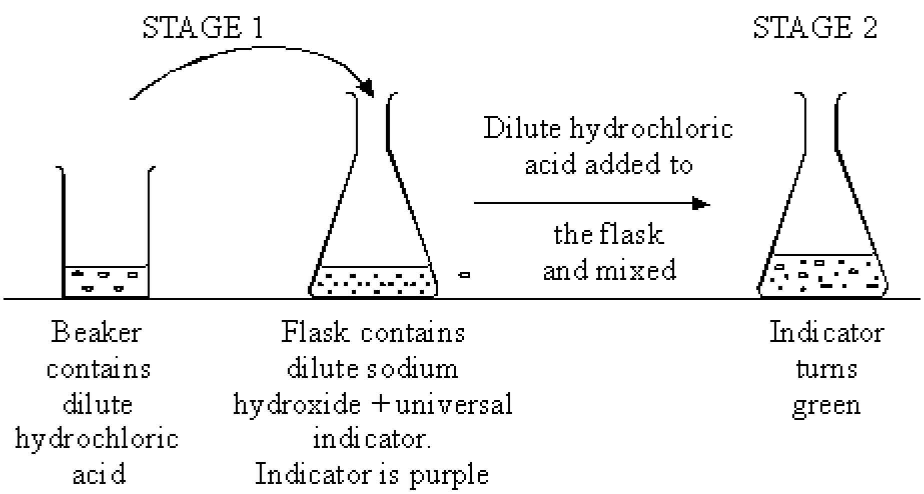
(ii) Name the salt produced if sodium carbonate reacts with dilute nitric acid.

____

(1)

(Total 2 marks)

5 The diagrams show what happens when an acid is added to an alkali.



(a) What is present in the flask at stage 2, besides universal indicator and water?

____

(1)

(b) Write an ionic equation to show how water is formed in this reaction and state the sources of the ions.

____

____

____

____

(3)

(Total 4 marks)

6 Use the Formulae of Some Common Ions table on the Data Sheet to help you to answer this question.

Acids react with alkalis to form salts and water.

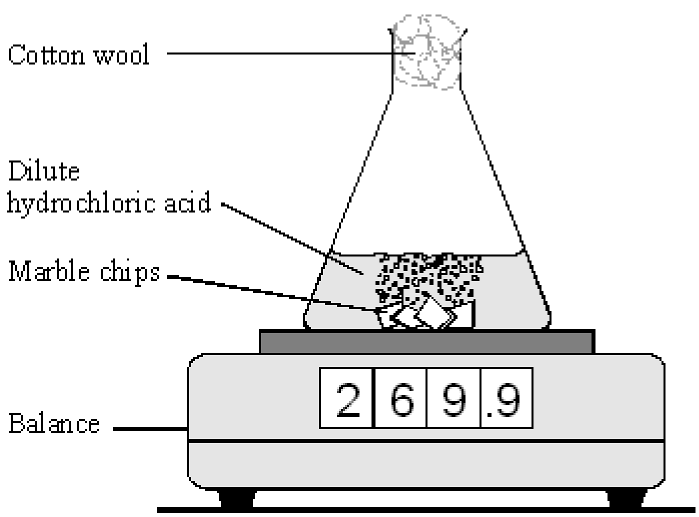
Complete the table below by writing in the name and formula of the salt formed in each reaction.

The first one has been done for you.

Acid	Alkali	Salt	Formula of salt
Hydrochloric acid	Sodium hydroxide	Sodium chloride	NaCl
Nitric acid	Sodium hydroxide		
Sulphuric acid	Potassium hydroxide		

(Total 4 marks)

7 The apparatus shown in the diagram was used to investigate the rate of reaction of excess marble chips with dilute hydrochloric acid, HCl. Marble is calcium carbonate, formula $CaCO_3$. The salt formed is calcium chloride, $CaCl_2$.



(a) Write a balanced equation for the reaction.

____

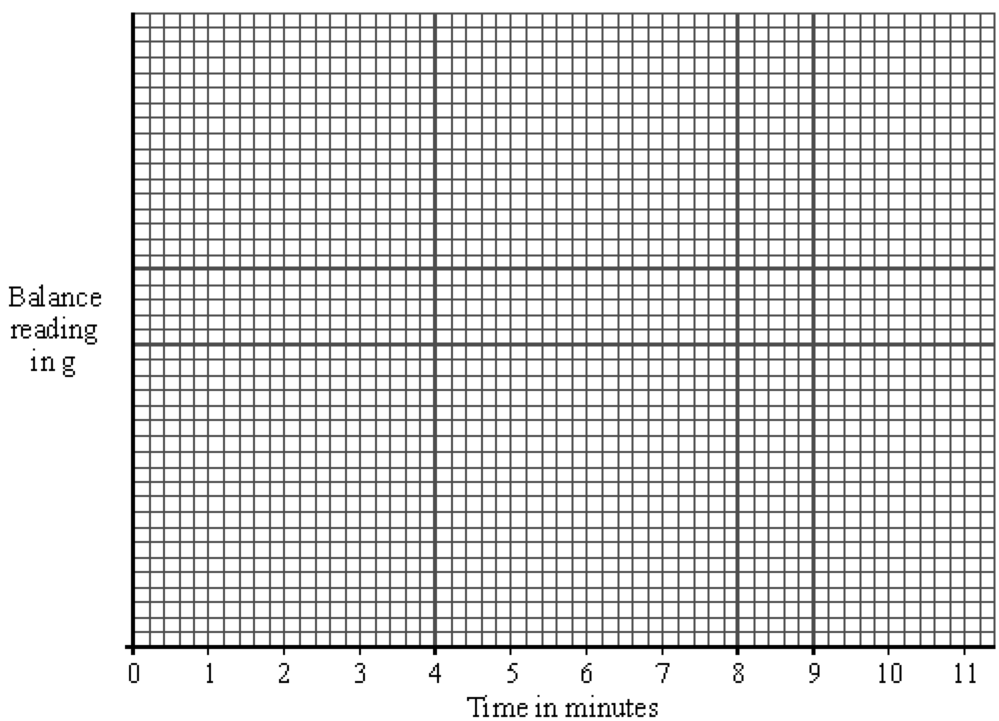
____

(2)

The following results were obtained from the experiment.

Time in minutes	**Reading on balance in g**
0.5	269.6
1.0	269.3
2.0	269.0
3.0	268.8
5.0	268.7
9.0	268.6

(b) (i) Plot the results and draw a graph on the axes below.



(3)

(ii) Continue the graph you have drawn to show the expected reading after11 minutes.

(1)

(iii) On the axes above, sketch a graph of the result which would be obtained if in a similar experiment the same mass of powdered marble was used instead of marble chips.

(2)

(Total 8 marks)

8 (i) Which acid from the list should the student add to sodium hydroxide solution to make sodium sulphate?

ethanoic acid **hydrochloric acid** **nitric acid** **sulphuric acid**

____

(1)

(ii) When the acid was added to the alkali the beaker became warm.
Name the type of reaction that releases heat.

____

(1)

(iii) Use the Data Sheet to help you to write the formula of sodium sulphate.

Formula: ____

(1)
(Total 3 marks)

9 The table shows some information about acids and alkalis.

Name of acid or alkali	Type	Ions produced in solution		pH	Effect on Universal Indicator
Hydrochloric acid	Strong acid	H^+	Cl^-	1	Goes red
Sodium hydroxide	Strong alkali	Na^+	OH^-	13	Goes purple

Use the information in the table to help you answer parts **(a)** and **(b)**.

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

(i) Hydrochloric acid is acidic.

This is because it contains [Cl^- / H^+ / OH^-] ions

(1)

(ii) Sodium hydroxide solution is alkaline.

This is because it contains

H^+
Na^+
OH^-

ions

(1)

(iii) The pH of acids is

higher than
lower than
the same as

the pH of alkalis.

(1)

(b) Ethanoic acid is a weak acid.

Universal Indicator can be used to show that hydrochloric acid is a stronger acid than ethanoic acid of the same concentration.

Explain how.

____

____

____

____

(2)

(c) Draw a ring around the correct answer to complete this sentence.

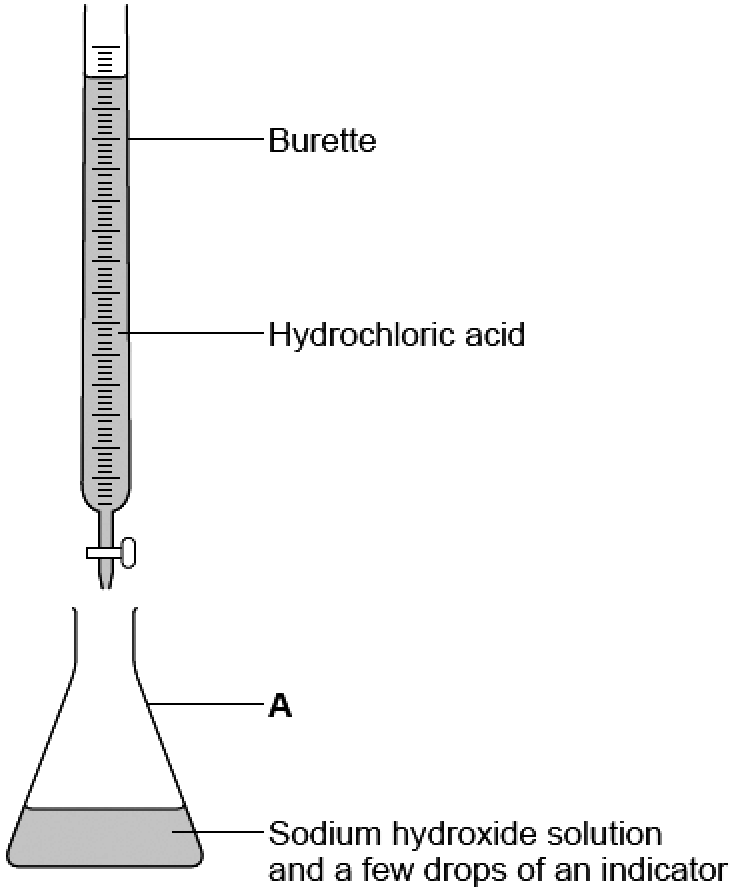
Strong acids and strong alkalis are

completely
not
partially

ionised in water.

(1)

(d) The diagram shows the apparatus used to find the volume of hydrochloric acid that reacts with 25.0 cm^3 of sodium hydroxide solution.



(i) Which **one** of the following is the correct name for **A**?

Draw a ring around your answer.

beaker **conical flask** **pipette**

(1)

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

distillation	**filtration**	**titration**

The method used to find the volume of acid that reacts with a known volume

of alkali is ___________________________________ .

(1)

(iii) Suggest **one** way to make the results more reliable.

____

(1)

(Total 9 marks)

10 Explain, in terms of ions and molecules, what happens when any acid reacts with any alkali.

____

____

____

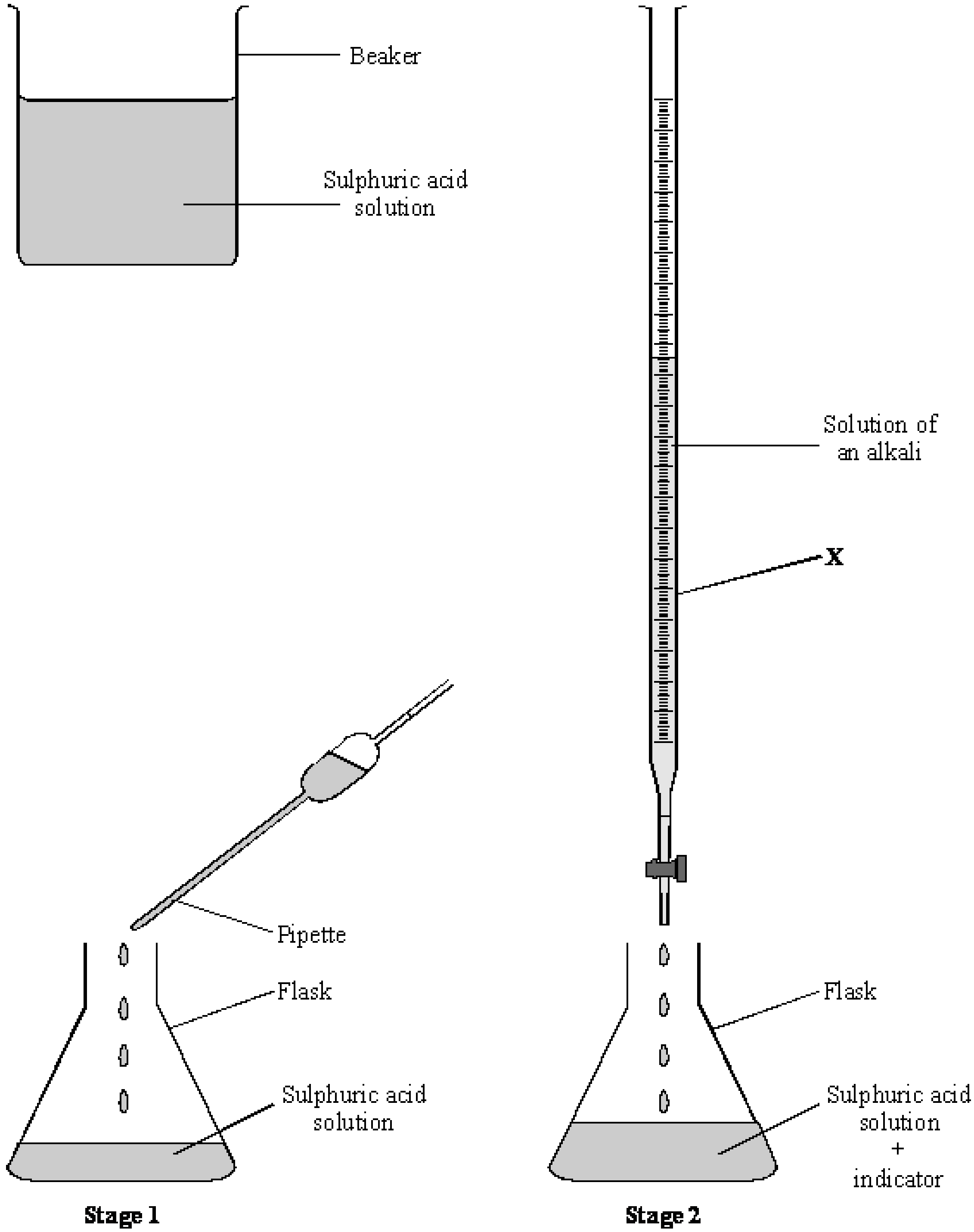
____

____

____

(Total 3 marks)

11 A titration was used to find the concentration of the sulphuric acid solution in the beaker.



Stage 1 25.0 cm^3 of the sulphuric acid solution was added to a flask using a pipette.

Stage 2 A solution of an alkali was added to the acid until the solution was neutral.
The volume of the alkali was noted.

(a) What would be the pH of the sulphuric acid solution?

____

(1)

(b) Why was a pipette used instead of a measuring cylinder in **Stage 1**?

____

(1)

(c) Name the apparatus labelled **X** which is used to add the alkali in **Stage 2**.

____

(1)

(d) Name an alkali that could be used in **Stage 2**.

____

(1)

(e) (i) Name an indicator that you could use to find out when the solution was neutral.

____

(1)

(ii) How would you know that the solution was neutral?

____

(1)

(Total 6 marks)

12 Neutralisation reactions can be used to make salts.

(a) Write an ionic equation for a neutralisation reaction, including state symbols.

____

(2)

(b) Ammonium nitrate is a salt used as a fertiliser.

(i) Ammonium nitrate is made by mixing two solutions. Name these solutions.

______________________________ and ______________________________

(1)

(ii) Hazard information about ammonium nitrate states:

- it is not itself a fire hazard (does not burn);
- it must not be allowed to come into contact with combustible materials such as fuels because it can cause these to catch fire.

Suggest why ammonium nitrate helps other substances to burn.

____

____

(1)

(Total 4 marks)

13 Nitric acid can be neutralised by alkalis to make salts.

(i) The salt called potassium nitrate can be made from nitric acid.

Complete the word equation for this neutralisation reaction.
Choose the correct substances from the box.

hydrogen	**oxygen**	**potassium chloride**
potassium hydroxide		**water**

nitric acid + ________________ →potassium nitrate + ________________

(2)

(ii) Ammonium nitrate is another salt made from nitric acid.

Which **one** of the following is the main use of ammonium nitrate? Draw a ring around your answer.

dye **fertiliser** **plastic** **fuel**

(1)

(iii) Complete this sentence by choosing the correct ion from the box.

H^+	NH_4^+	NO_3^-	O^{2-}	OH^-

The ion that makes solutions acidic is ______________________________ .

(1)

(Total 4 marks)

14 (a) Citric acid produces hydrogen ions in aqueous solution.

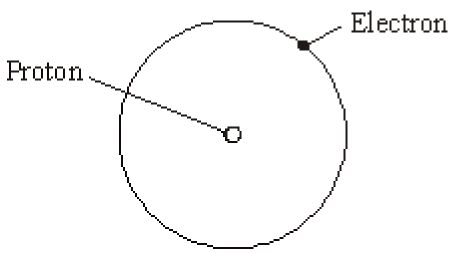
These ions can be represented as $H^+(aq)$.

Complete this sentence.

The (aq) means that the acid has been dissolved in ______________________ .

(1)

(b) The diagram represents a hydrogen atom, H.



Use the diagram to explain why a hydrogen ion, H^+, is a proton.

____

____

(1)

(c) Citric acid is a *weak* acid.

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

The word *weak* means that the acid	has a low boiling point. is dilute. is partially ionised in water.

(1)

(d) A student measured the pH of four acids, **A**, **B**, **C** and **D**.

The acids were the same concentration. The same quantity of magnesium ribbon was added to each of the acids. The volume of gas produced after 5 minutes was recorded.

The results are shown in the table.

Acid	**pH**	**Volume of gas in cm^3**
A	2	18
B	5	6
C	1	24
D	4	12

(i) State **one** way in which the student made sure that the experiment was fair.

____

(1)

(ii) Use the results to arrange the acids, **A**, **B**, **C** and **D** in order of **decreasing** acid strength.

Most acidic ____ Least acidic.

(1)

(e) When acids react with alkalis, the hydrogen ions from the acid react with the hydroxide ions from the alkali.

(i) Which **one** of the following represents the formula of a hydroxide ion?

Draw a ring around your answer.

H^- O^- OH^-

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

A solution with more hydrogen ions than hydroxide ions is
- acidic.
- alkaline.
- neutral.

(1)

(Total 7 marks)

15 The table shows some information about acids and alkalis.

Name of acid or alkali	Type	Ions produced in solution		pH	Effect on Universal Indicator
Hydrochloric acid	Strong acid	H^+	Cl^-	1	Goes red
Sodium hydroxide	Strong alkali	Na^+	OH^-	13	Goes purple

Use the information in the table to help you answer parts (a) and (b).

(a) Draw a ring around the correct answer to complete the sentences.

(i) Hydrochloric acid is acidic.

This is because it contains [Cl^- / H^+ / OH^-] ions.

(1)

(ii) Sodium hydroxide solution is alkaline.

This is because it contains [H^+ / Na^+ / OH^-] ions.

(1)

(b) Hydrochloric acid is a stronger acid than ethanoic acid.

When Universal Indicator is added to solutions of these acids at the same concentration the results are different.

Describe how the results would show that ethanoic acid is a weaker acid than hydrochloric acid.

___

___

___

___

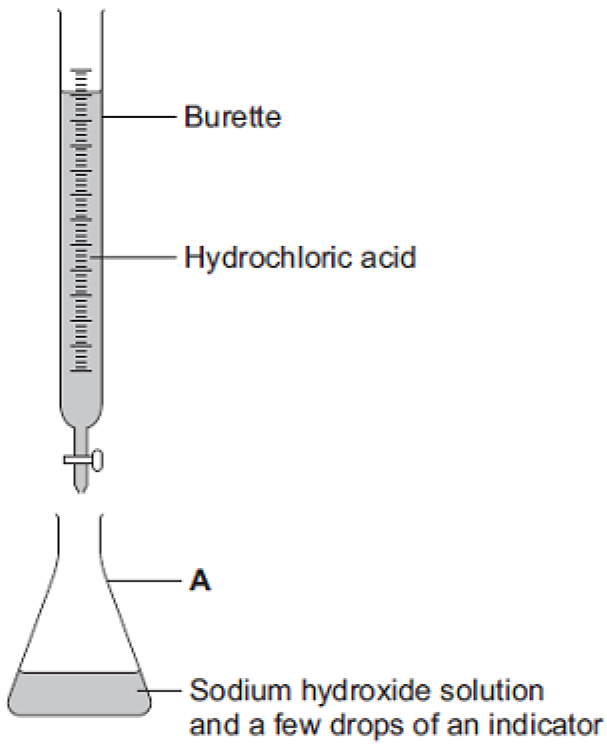
(2)

(c) Draw a ring around the correct answer to complete this sentence.

	completely	
Strong acids and strong alkalis are	not	ionised in water.
	partially	

(1)

(d) The diagram shows the apparatus used to find the volume of hydrochloric acid that reacts with 25.0 cm^3 of sodium hydroxide solution.



(i) Which **one** of the following is the correct name for **A**?

Draw a ring around your answer.

beaker **conical flask** **pipette**

(1)

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

distillation **filtration** **titration**

(1)

The method used to find the volume of acid that reacts with a known volume of alkali is called____

(1)

(iii) Suggest **one** way to make the results more reliable.

___

___

(1)

(Total 8 marks)

16 Hydrogen fluoride is used to make hydrofluoric acid.

(a) A company makes hydrogen fluoride by reacting solid calcium fluoride with sulfuric acid.
The reaction takes place in a rotating kiln.

calcium fluoride + sulfuric acid → calcium sulfate + hydrogen fluoride

The company want this reaction to take place quickly.

(i) Rotating the kiln makes the reaction take place faster.

Suggest why.

___

___

(1)

(ii) Draw a ring around the correct word in each box.

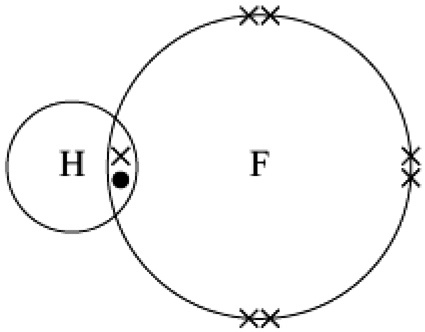
To make the reaction take place **faster**:

the temperature should be	higher / lower	so that the particles have	less / more	energy
the solid calcium fluoride should be	powder / lumps	to give a	small / big	surface area
the sulfuric acid solution should be	dilute / concentrated	to give	less / more	collisions

between the particles each second.

(3)

(b) The diagram represents a molecule of hydrogen fluoride.



The hydrogen and fluorine atoms are joined by a covalent bond.

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

electrons	**neutrons**	**protons**

In a covalent bond the atoms share ____ .

(1)

(c) Hydrogen fluoride is dissolved in water to make an acidic solution of hydrofluoric acid.

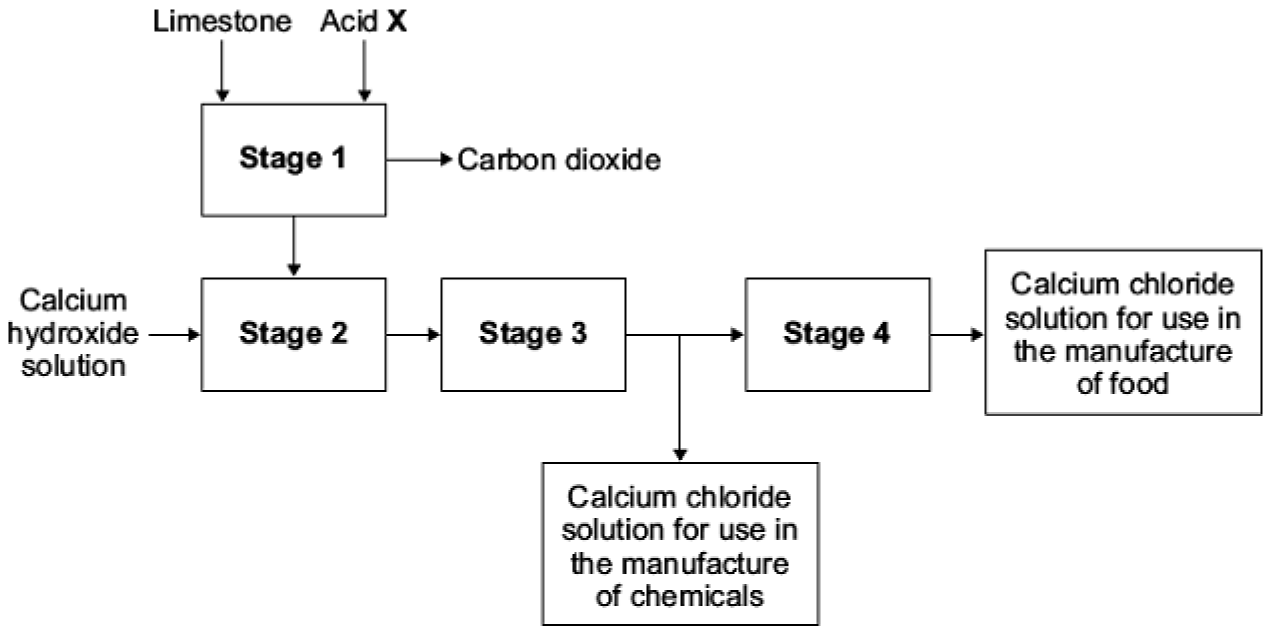
Draw a ring around the symbol of the ion that makes the solution acidic.

H^+ **OH^-** **F^-**

(1)

(Total 6 marks)

17 (a) Calcium chloride is made from limestone. The limestone used contains mainly calcium carbonate and a small amount of magnesium carbonate.



(i) In **stage 1** calcium carbonate reacts with acid **X** to form calcium chloride.

Name acid **X**.

____

(1)

(ii) **Stage 1** produces a concentrated solution of calcium chloride.
The solution also contains magnesium chloride.

Calcium hydroxide solution is added to remove the magnesium chloride:

$$MgCl_2(aq) \quad + \quad Ca(OH)_2(aq) \quad \rightarrow \quad Mg(OH)_2(s) \quad + \quad CaCl_2(aq)$$

This is an example of a *precipitation* reaction.

What is the meaning of the term *precipitation* reaction?

____

____

(1)

(iii) The magnesium hydroxide can be separated from the calcium chloride solution.

State how.

____

____

(1)

(iv) Suggest why **stage 4** is needed.

____

____

(1)

(v) Name a method that can be used to change calcium chloride solution into solid calcium chloride.

____

(1)

(b) Calcium chloride can also be made by reacting calcium with chlorine.

Calcium chloride is an ionic compound. It contains calcium ions (Ca^{2+}).

(i) Complete the equation for the formation of calcium ions.

$$Ca \rightarrow Ca^{2+} + \_\_\_\_\_\_$$

(1)

(ii) Why can the formation of calcium ions from calcium atoms be described as oxidation?

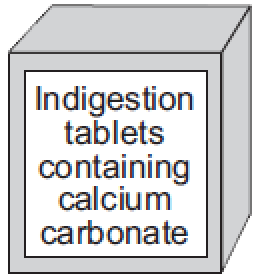
____

____

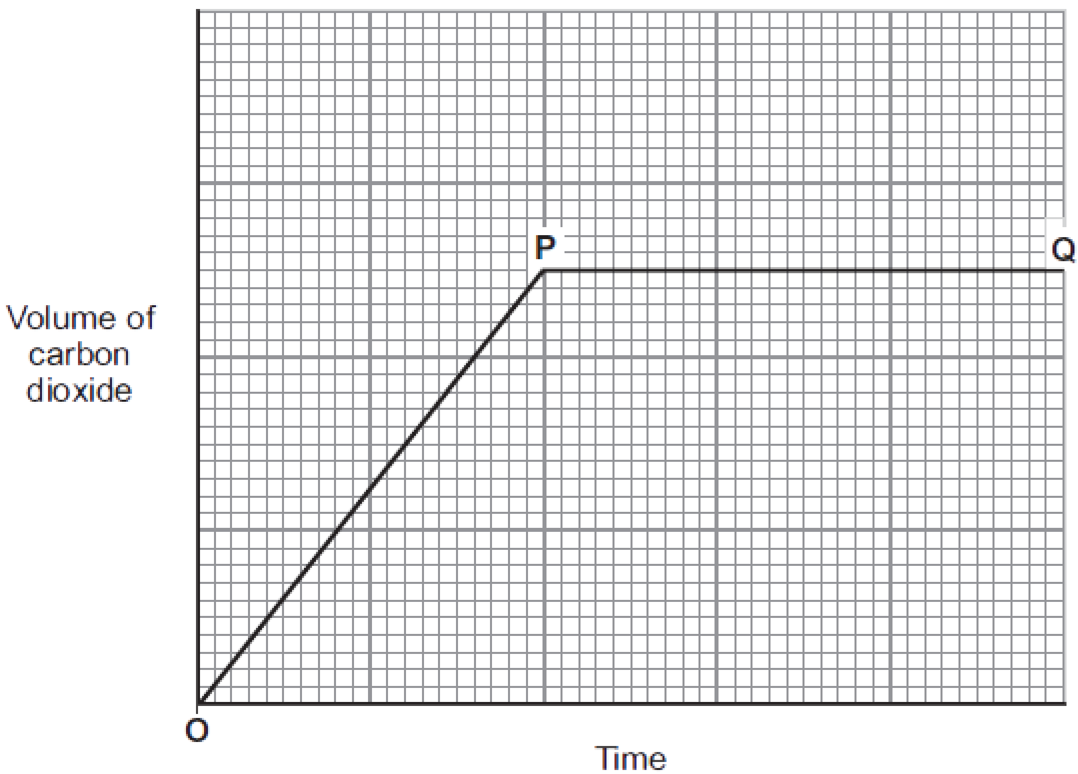
(1)

(Total 7 marks)

18 Human stomachs contain hydrochloric acid.
Stomach ache can be caused by too much acid in the stomach.
Indigestion tablets can be used to reduce the amount of acid in the stomach.



(a) The graph shows how the volume of carbon dioxide produced changes with time, after some calcium carbonate is added to hydrochloric acid.



(i) Complete the sentence to explain what happens between **O** and **P**.

Between **O** and **P** the calcium carbonate and hydrochloric acid __________

(1)

(ii) Complete the sentence to explain what happens at **P**.

At **P** the calcium carbonate and hydrochloric acid ____________________

because ____

(2)

(iii) Describe the test for carbon dioxide gas.

Test ____

Result of the test ____

(2)

(b) Calcium carbonate is found in limestone.
Limestone is removed from the ground by quarrying.

Photograph supplied by Stockbyte/Thinkstock

Tick (✓) **one** advantage and tick (✓) **one** disadvantage of quarrying limestone.

Statement	Advantage Tick (✓)	Disadvantage Tick (✓)
Quarrying limestone destroys the shells and skeletons of marine organisms that formed the limestone.		
Quarrying limestone releases dust, and lorries release carbon dioxide from burning diesel fuel.		
Quarrying limestone provides building materials, employment and new road links.		
Quarrying limestone removes ores from the ground.		

(2)

(Total 7 marks)

19 Limestone is used as a building material. Acid rain erodes limestone.

(a) Limestone contains calcium carbonate.
The symbol equation for the reaction of calcium carbonate with hydrochloric acid is shown.

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

Describe a test to show that carbon dioxide is produced in this reaction.

Give the result of the test.

___

___

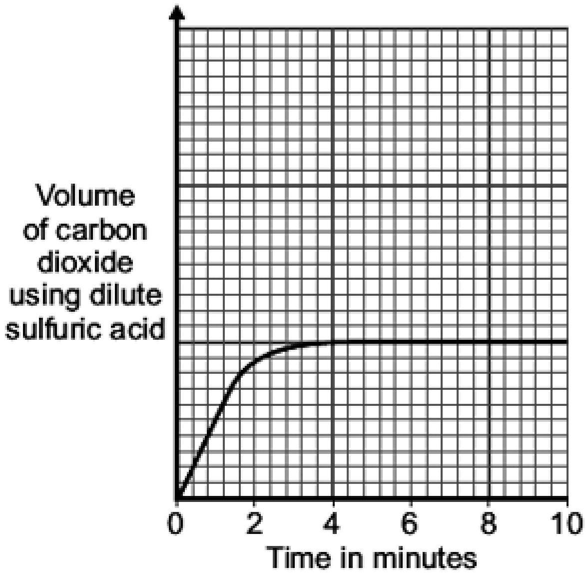
___

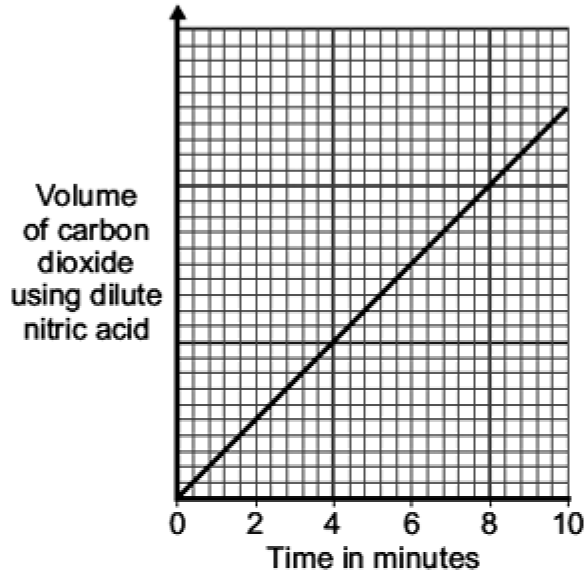
___

(2)

(b) Gases from vehicle exhausts produce sulfuric acid and nitric acid.

A student investigated the reaction of these two acids with calcium carbonate (limestone).
The type of acid was changed but all other variables were kept the same.
The student measured the volume of carbon dioxide produced each minute for a total of 10 minutes. He did this first for the reaction between dilute sulfuric acid and a cube of calcium carbonate (limestone).
The student repeated the experiment using dilute nitric acid in place of the dilute sulfuric acid.
The results are shown below.





(i) State **two** variables that must be kept the same for this investigation.

____

____

____

____

(2)

(i) Reacting calcium carbonate with sulfuric acid gave different results to nitric acid.

The symbol equations for the reaction of calcium carbonate with sulfuric acid and with nitric acid are shown below.

$$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)$$

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

Describe how the results for sulfuric acid are different **and** use the symbol equations to explain this difference.

____

____

____

____

____

____

____

____

(3)
(Total 7 marks)

20 This question is about chemical analysis.

(a) A student has solutions of three compounds, **X, Y** and **Z**.

The student uses tests to identify the ions in the three compounds.

The student records the results of the tests in the table.

	Test			
Compound	**Flame test**	**Add sodium hydroxide solution**	**Add hydrochloric acid and barium chloride solution**	**Add nitric acid and silver nitrate solution**
X	no colour	green precipitate	white precipitate	no reaction
Y	yellow flame	no reaction	no reaction	yellow precipitate
Z	no colour	brown precipitate	no reaction	cream precipitate

Identify the **two** ions present in each compound, **X, Y** and **Z**.

X ____

Y ____

Z ____

(3)

(b) A chemist needs to find the concentration of a solution of barium hydroxide.
Barium hydroxide solution is an alkali.

The chemist could find the concentration of the barium hydroxide solution using two different methods.

Method 1

- An excess of sodium sulfate solution is added to 25 cm^3 of the barium hydroxide solution. A precipitate of barium sulfate is formed.
- The precipitate of barium sulfate is filtered, dried and weighed.
- The concentration of the barium hydroxide solution is calculated from the mass of barium sulfate produced.

Method 2

- 25 cm^3 of the barium hydroxide solution is titrated with hydrochloric acid of known concentration.
- The concentration of the barium hydroxide solution is calculated from the result of the titration.

Compare the advantages and disadvantages of the two methods.

____

____

____

____

____

____

____

____

____

____

(5)

(Total 8 marks)

21 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)

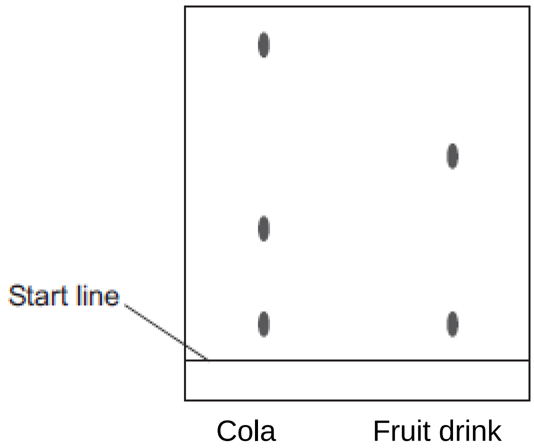
(ii) Which ion causes the pH to be 2.9?

____

(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.

____

____

____

____

____

____

(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)

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.

____

____

____

____

____

____

____

____

(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 Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, SO_2

(a) Why is it important that sulfur dioxide is **not** released into the atmosphere?

Tick (✓) **one** box.

Sulfur dioxide causes acid rain. ☐

Sulfur dioxide causes global dimming. ☐

Sulfur dioxide causes global warming. ☐

(1)

(b) Sulfur dioxide dissolves in water.

What colour is universal indicator in a solution of sulfur dioxide?
Give a reason for your answer.

____

____

____

____

(2)

(c) Sulfur dioxide is a gas at room temperature.

The bonding in sulfur dioxide is covalent.

Explain, in terms of its structure and bonding, why sulfur dioxide has a low boiling point.

____

____

____

____

____

____

(3)

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

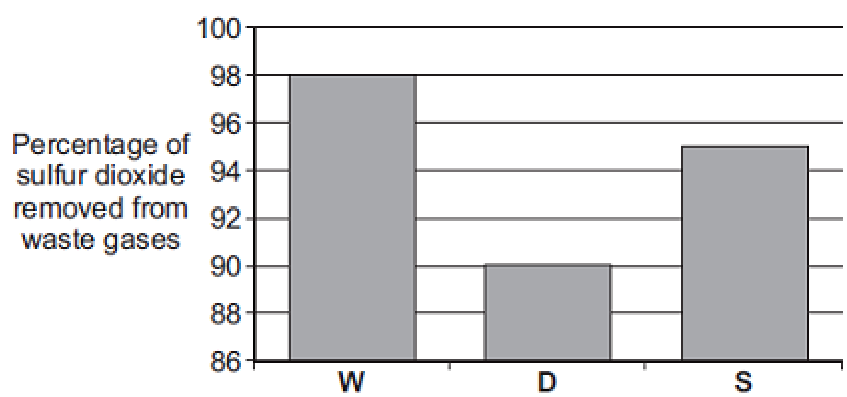
Sulfur dioxide is produced when fossil fuels are burned.

It is important that sulfur dioxide is not released into the atmosphere.

Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

- wet gas desulfurisation (**W**)
- dry gas desulfurisation (**D**)
- seawater gas desulfurisation (**S**).

Information about the three methods is given in the bar chart and in **Table 1** and **Table 2**.



Method of removing sulfur dioxide

Table 1

Method	Material used	How material is obtained
W	Calcium carbonate, $CaCO_3$	Quarrying
D	Calcium oxide, CaO	Thermal decomposition of calcium carbonate: $CaCO_3 \longrightarrow CaO + CO_2$
S	Seawater	From the sea

Table 2

Method	What is done with waste material
W	Solid waste is sold for use in buildings. Carbon dioxide is released into the atmosphere.
D	Solid waste is sent to landfill.
S	Liquid waste is returned to the sea.

Evaluate the three methods of removing sulfur dioxide from waste gases.

Compare the three methods and give a justified conclusion.

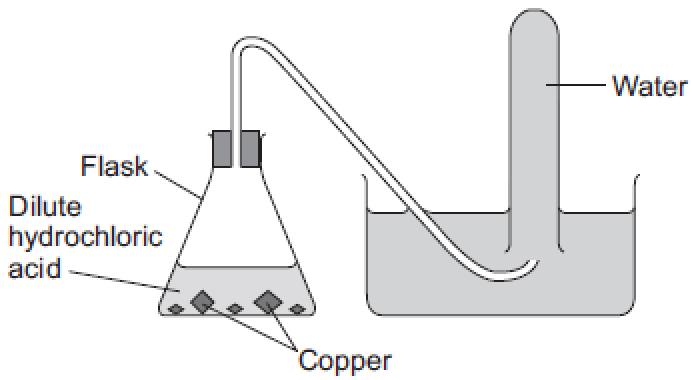
(6)

(Total 12 marks)

24 A student was trying to produce hydrogen gas.

Figure 1 shows the apparatus she used.

Figure 1



(a) No gas was produced.

The student's teacher said that this was because the substances in the flask did **not** react.

(i) Suggest why the substances in the flask did **not** react.

____

____

____

(1)

(ii) Which two substances could the student have put in the flask to produce hydrogen safely?

Tick (✓) **one** box.

Gold and dilute hydrochloric acid ☐

Potassium and dilute hydrochloric acid ☐

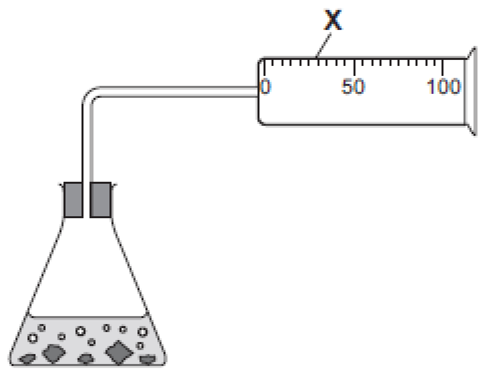
Zinc and dilute hydrochloric acid ☐

(1)

(b) Another student did produce hydrogen from two substances.

Figure 2 shows the apparatus the student used to collect and measure the volume of the hydrogen gas.

Figure 2



Give the name of the apparatus labelled **X**.

____

(1)

(c) The student did the experiment four times. Her results are shown in the table below.

Experiment	**Volume of hydrogen collected in one minute in cm^3**
1	49
2	50
3	35
4	48

(i) One of the results is anomalous.

Which result is anomalous? Write your answer in the box. ☐

Give a reason for your choice.

____

(2)

(ii) Calculate the mean volume of hydrogen collected in one minute.

Mean volume = ____________________ cm^3

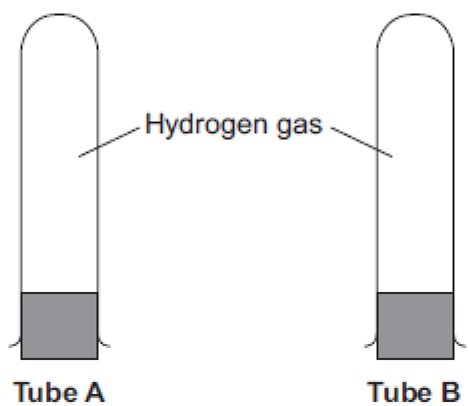
(2)

(iii) Give a reason why the experiment should be repeated several times.

(1)

(d) A teacher collected two tubes full of hydrogen gas, as shown in **Figure 3**.

Figure 3



She tested tube **A** with a lighted splint as soon as she took the bung out.

She tested tube **B** with a lighted splint a few seconds after taking the bung out.

(i) Suggest why tube **B** gave a much louder pop than tube **A**.

(1)

(ii) Complete and balance the chemical equation for the reaction that takes place when the hydrogen reacts in this test.

$$H_2 \quad + \quad O_2 \longrightarrow$$

(2)
(Total 11 marks)

25 This question is about compounds.

(a) The table gives information about the solubility of some compounds.

Soluble compounds
All potassium and sodium salts
All nitrates
Chlorides, bromides and iodides, except those of silver and lead

Use information from the table to answer these questions.

(i) Name a soluble compound that contains silver ions.

____

(1)

(ii) Name a soluble compound that contains carbonate ions.

____

(1)

(b) Metal oxides react with acids to make salts.

What type of compound is a metal oxide?

____

(1)

(c) Lead nitrate solution is produced by reacting lead oxide with nitric acid.

(i) State how solid lead nitrate can be obtained from lead nitrate solution.

____

____

(1)

(ii) Balance the equation for the reaction.

$PbO \quad + \quad HNO_3 \quad \longrightarrow \quad Pb(NO_3)_2 \quad + \quad H_2O$

(1)

(iii) Give the total number of atoms in the formula $Pb(NO_3)_2$

____

(1)

(d) An oxide of lead that does **not** have the formula PbO contains 6.21 g of lead and 0.72 g of oxygen.

Calculate the empirical formula of this lead oxide.

Relative atomic masses (A_r): O = 16; Pb = 207

You must show your working to gain full marks.

____

____

____

____

____

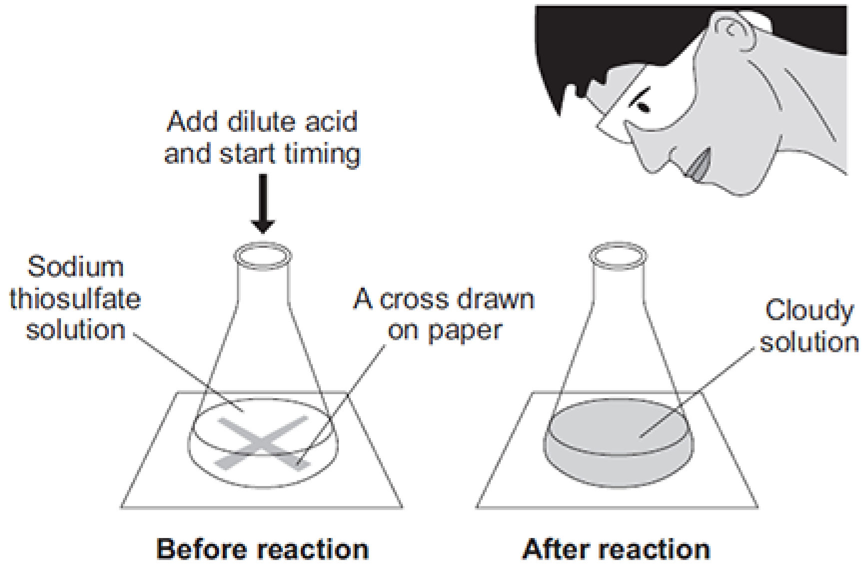
____

Empirical formula = ______________________

(4)

(Total 10 marks)

26 A student investigated the effect of temperature on the rate of a reaction.
The picture below shows an experiment.



The student:

- put sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:

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

sodium thiosulfate	hydrochloric acid	sodium chloride	water	sulfur dioxide	sulfur

(a) Explain why the solution goes cloudy.

____

____

____

____

(2)

(b) Give **two** variables the student must control to make the investigation a fair test.

1. ____

2. ____

(2)

(c) State the effect that increasing the temperature of the sodium thiosulfate solution has on the rate of the reaction.
Explain this effect in terms of particles and collisions.

____

____

____

____

____

____

____

____

____

(4)

(d) Suggest how the student should change the method to investigate the rate of reaction at 5°C.

____

____

(1)
(Total 9 marks)

27 This question is about ammonia and fertilisers.

(a) Ammonia is produced by a reversible reaction.

The equation for the reaction is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Complete the sentence.

The forward reaction is exothermic, so the reverse reaction

is ________________________

(1)

(b) Calculate the percentage by mass of nitrogen in ammonia (NH_3).
Relative atomic masses (A_r): H = 1; N = 14
You **must** show how you work out your answer.

___

___

___

___

___

___

Percentage by mass of nitrogen = ____________________ %

(3)

(c) A neutral solution can be produced when ammonia reacts with an acid.

(i) Give the pH of a neutral solution.

pH ____________________

(1)

(ii) Which of these ionic equations shows a neutralisation reaction?

Tick (✓) **one** box.

$H^+ + OH^- \longrightarrow H_2O$ ☐

$NH_4^+ + OH^- \longrightarrow NH_4OH$ ☐

$H^+ + Cl^- \longrightarrow HCl$ ☐

$H^+ + H_2O \longrightarrow H_3O^+$ ☐

(1)

(iii) Name the salt produced when ammonia reacts with hydrochloric acid.

____

(1)

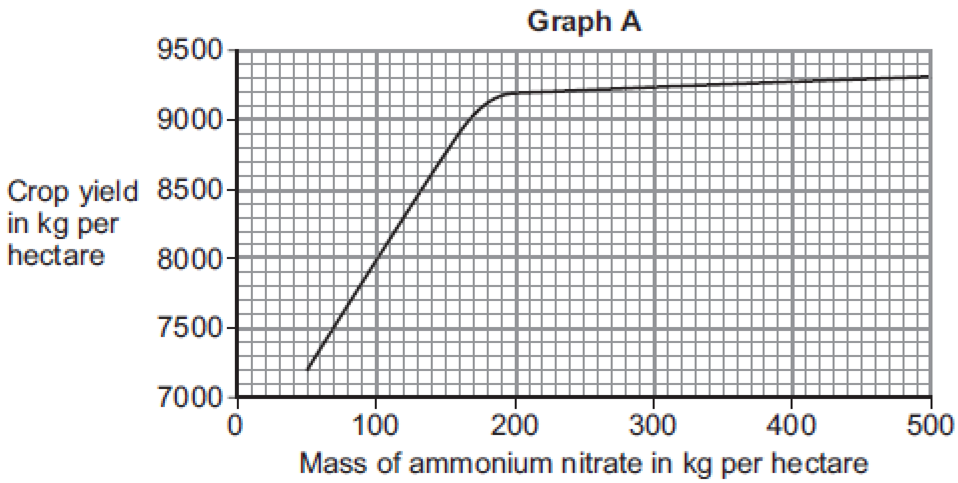
(d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

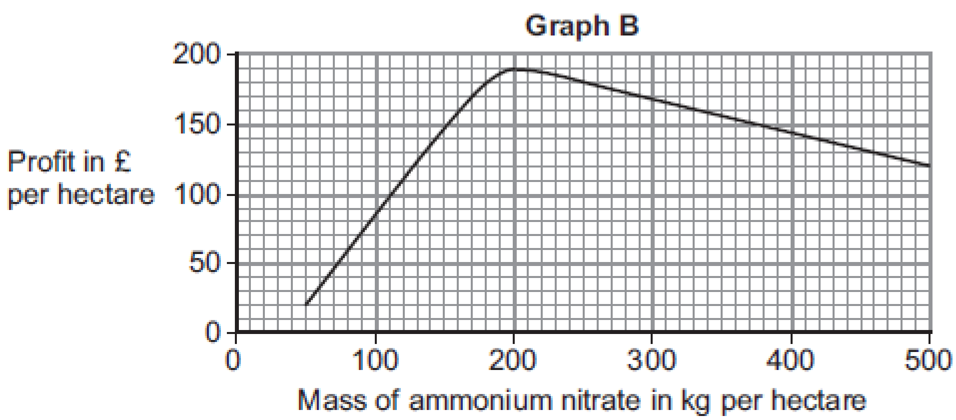
Farmers use ammonium nitrate as a fertiliser for crops.

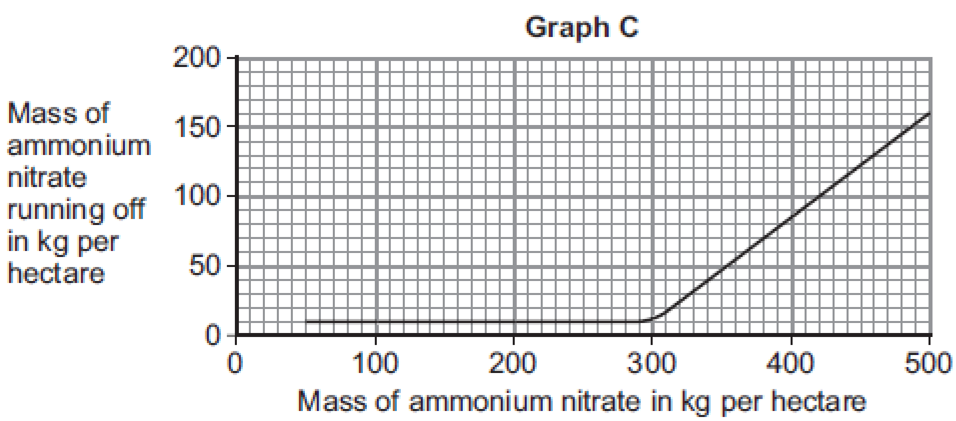
Rainwater dissolves ammonium nitrate in the soil.

Some of the dissolved ammonium nitrate runs off into rivers and lakes.

The graphs **A**, **B** and **C** below show information about the use of ammonium nitrate as a fertiliser. A hectare is a measurement of an area of land.







Suggest how much ammonium nitrate farmers should use per hectare.

Give reasons for your answer.

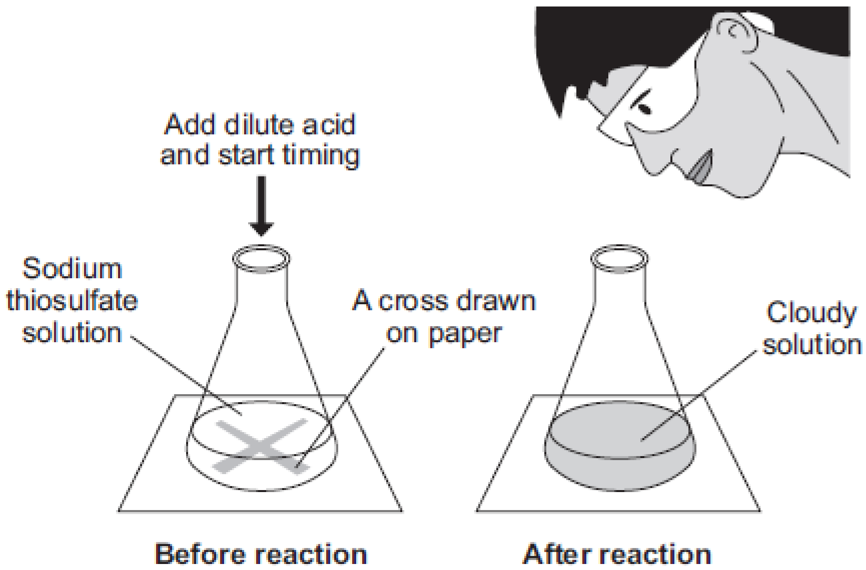
Use information from graphs **A**, **B** and **C**.

(6)
(Total 13 marks)

28 A student investigated the effect of temperature on the rate of a reaction.

Figure 1 shows an experiment.

Figure 1



The student:

- put 50 cm^3 sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added 5 cm^3 dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:

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

sodium thiosulfate	hydrochloric acid	sodium chloride	water	sulfur dioxide	sulfur

(a) Which product is a gas?

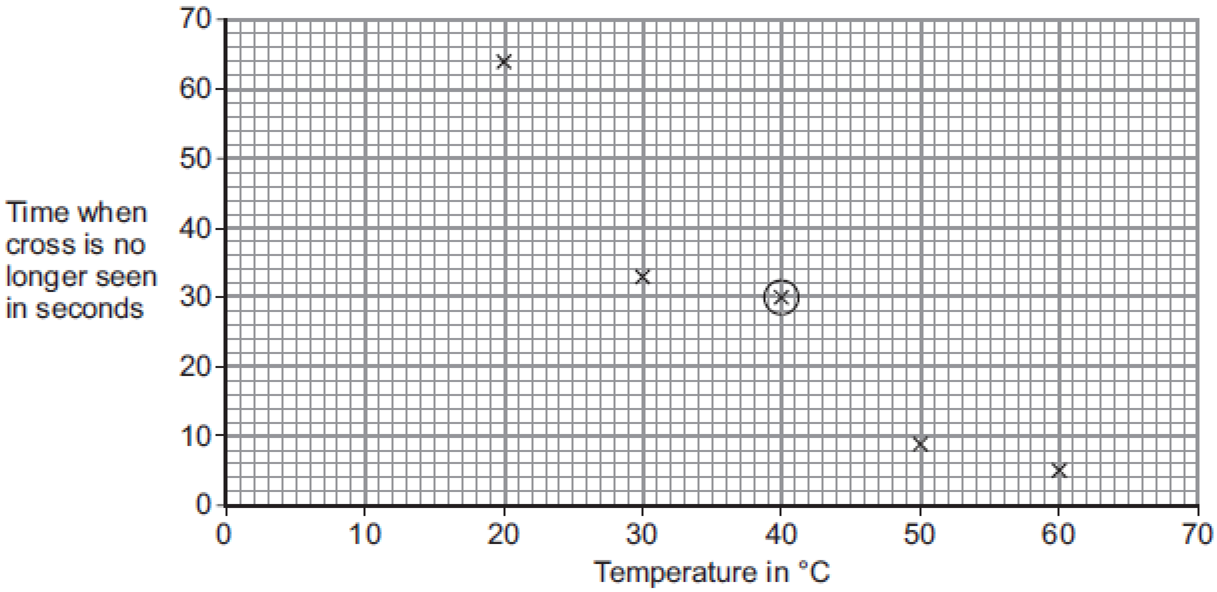
____

(1)

(b) **Figure 2** shows the results of this experiment at five different temperatures.

The circled result point is anomalous.

Figure 2



(i) Draw a line of best fit on **Figure 2** to show how the reaction time varied with reaction temperature.

(1)

(ii) Give a possible reason for the anomalous result at 40 °C.

____

____

(1)

(iii) The reaction at 20 °C produced 0.32 g of sulfur in 64 seconds.

Calculate the rate of the reaction at 20 °C using the equation:

$$\text{Rate of reaction} = \frac{\text{mass of sulfur}}{\text{time}}$$

____

____

____

____

Rate of reaction = ____________________ grams per second

(2)

(iv) Give **two** reasons why the rate of the reaction increases as the temperature increases.

Tick (✓) **two** boxes.

The particles move faster.	☐
The particles collide less often.	☐
All the particles have the same energy.	☐
The particles collide with more energy.	☐
The number of particles increases.	☐

(2)

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

activation	**collision**	**exothermic**

The minimum amount of energy particles must have to react is called

the ___________________________ energy.

(1)

(Total 8 marks)

29 A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

(a) Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

____

____

____

____

____

____

____

____

(4)

(b) A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$$

Relative atomic masses, A_r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

____

____

____

____

Mass of copper carbonate = ____________________ g

(4)

(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

___

___

Actual mass of copper chloride produced = ____________ g

(2)

(d) Look at the equations for the two reactions:

Reaction 1 $CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l) + CO_2(g)$

Reaction 2 $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

Reactive formula masses: $CuO = 79.5$; $HCl = 36.5$; $CuCl_2 = 134.5$; $H_2O = 18$

The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

Calculate the percentage atom economy for Reaction 2.

___

___

___

___

___

___

Percentage atom economy = ________________________ %

(3)

(e) The atom economy for Reaction 1 is 68.45 %.
Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference.

___

___

(1)

(Total 14 marks)

30 Sodium carbonate reacts with dilute hydrochloric acid:

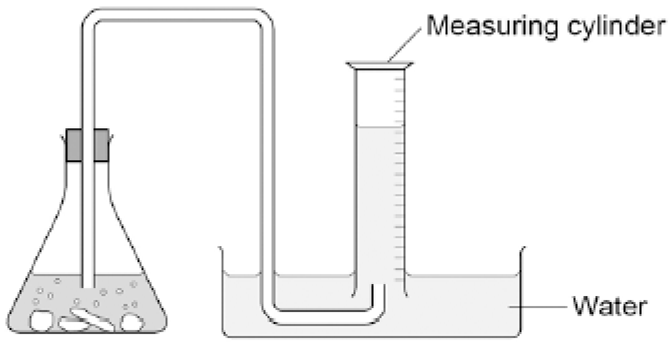
$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

(a) The student set up the apparatus as shown in the figure below.



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

___

___

___

___

(2)

(b) The student corrected the error.

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

Mass of sodium carbonate in g	**Volume of carbon dioxide gas in cm^3**
0.07	16.0
0.12	27.5
0.23	52.0
0.29	12.5
0.34	77.0
0.54	95.0
0.59	95.0
0.65	95.0

The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

___

___

(1)

(c) Why does the volume of carbon dioxide collected stop increasing at 95.0 cm^3?

___

___

(1)

(d) What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm^3 of carbon dioxide?

___

___

(1)

(e) The carbon dioxide was collected at room temperature and pressure.
The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3.

How many moles of carbon dioxide is 95.0 cm^3?

Give your answer in three significant figures.

____

____

____

____

____ mol

(2)

(f) Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

____

____

____

____

(2)

(g) One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

____

____

____

____

____

____

(2)

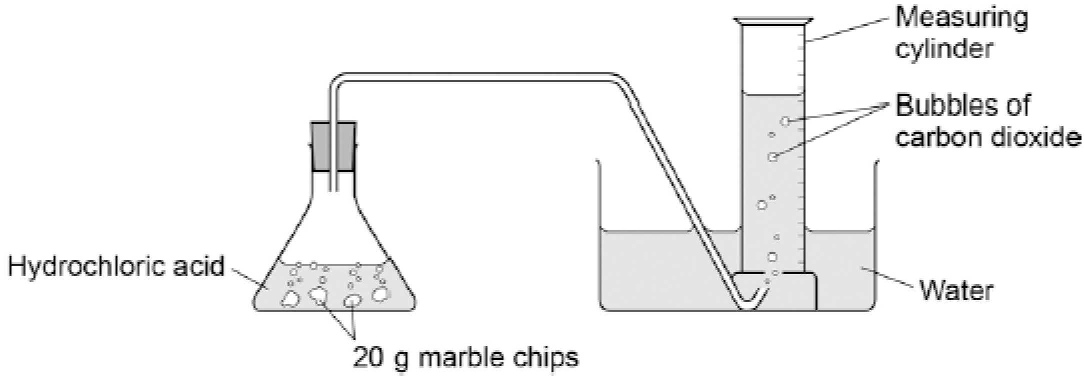
(Total 11 marks)

31 Marble chips are mainly calcium carbonate ($CaCO_3$).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

$\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_ \rightarrow CaCl_2 + \_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_$

(2)

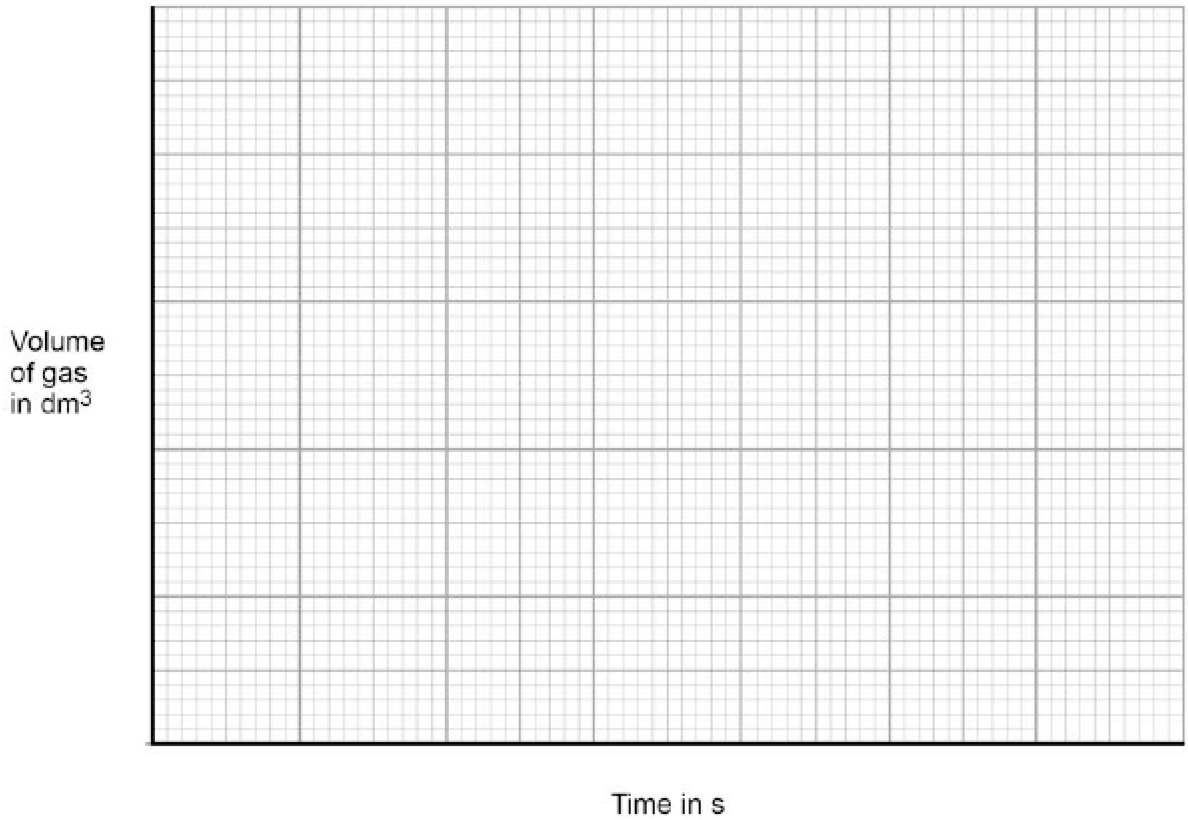
(b) The table below shows the student's results.

Time in s	**Volume of gas in dm^3**
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

___

___

___

___

___

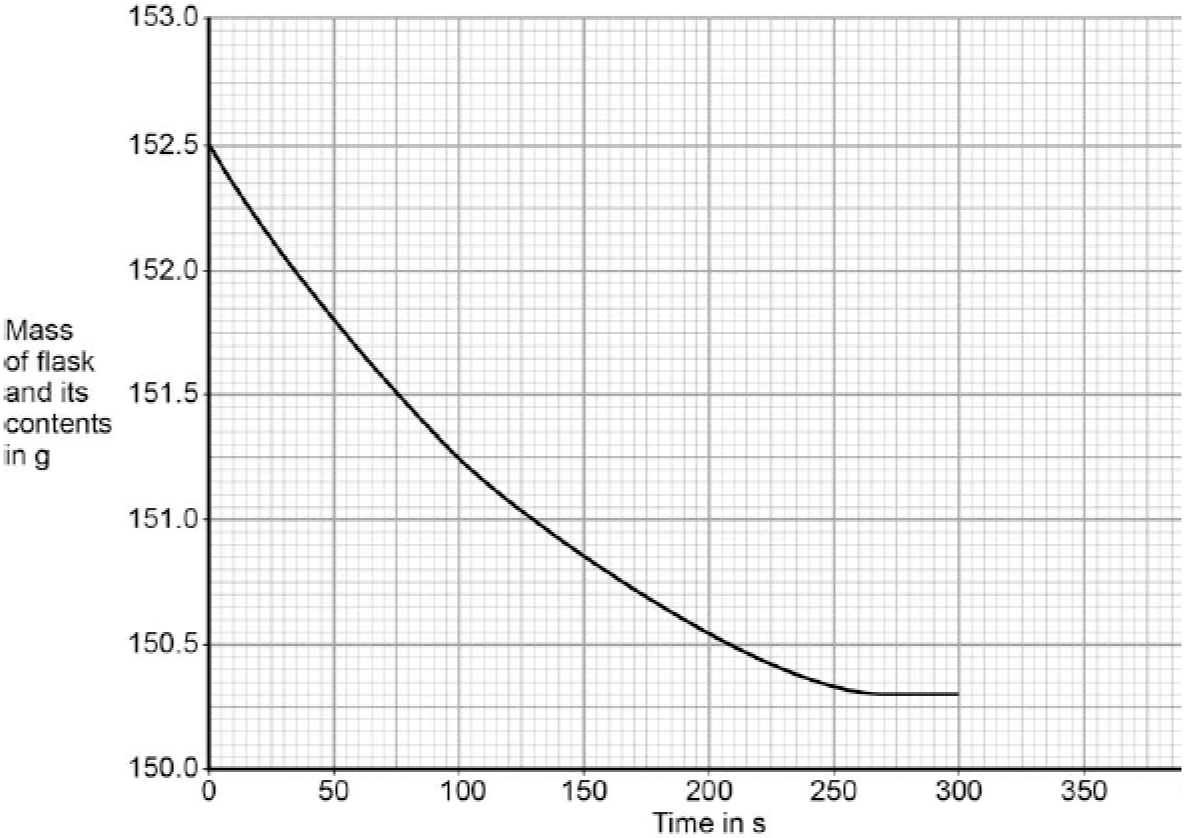
___

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

____

____

____

____

____

____

____

____

Mean rate of reaction = ______________________ g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

____

____

____

____

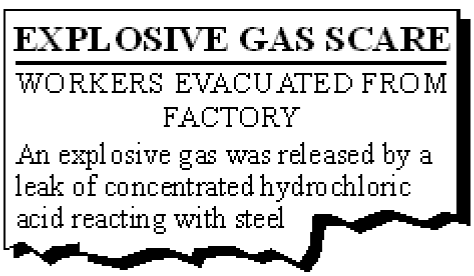
____

Rate of reaction at 150 s = ______________________ g / s

(4)

(Total 20 marks)

32 This article appeared in a newspaper.



EXPLOSIVE GAS SCARE

WORKERS EVACUATED FROM FACTORY

An explosive gas was released by a leak of concentrated hydrochloric acid reacting with steel

(a) The balanced chemical equation shows the reaction between steel and hydrochloric acid.

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

(i) Which metal in steel reacted with the hydrochloric acid?

____

(1)

(ii) The gas released was described as explosive. Explain why.

____

____

____

____

____

(3)

(b) In the factory hydrogen chloride is manufactured by reacting hydrogen with chlorine. Hydrochloric acid is formed when hydrogen chloride forms a solution in water.

(i) Water was sprayed on the steel and hydrochloric acid. This slowed the rate of reaction. Explain why.

____

____

____

____

(2)

(ii) It would have been better to neutralise the acid with an alkali rather than to just add water. Hydrochloric acid can be neutralised by reaction with sodium hydroxide. Complete the ionic equation for the neutralisation reaction.

$(aq) + (aq) \rightarrow H_2O(l)$

(2)

(iii) In the factory the acid leak was neutralised with slaked lime, $Ca(OH)_2$, and not sodium hydroxide, NaOH. Suggest why.

____

____

____

____

____

(2)

(Total 10 marks)

Mark schemes

1 (a) (i) allow a number between 2.5 and 3 (inclusive)

accept just under 3 ***or*** *about 3*

1

(ii) alkaline **or** alkali

1

(iii) 25

ignore any reference to units

1

(b) (i) a circle round KOH or 2 KOH

1

(ii) K_2SO_4

do not credit potassium sulphate

1

[5]

2 (a) (i) sodium ions and chloride ions

(allow sodium chloride/salt) [not "chlorine"] for 1 mark

1

(ii) sodium ions and chloride ions

(allow sodium chloride/salt) for 1 mark

H + ions (*allow* hydrochloric acid)

for 1 mark

2

(b) $H^+ + OH^- \rightarrow H_2O$ [N.B Na^+ and Cl^- may also be present]

H^+ ions from acid

OH^- ions from alkali

each for 1 mark

[N.B First mark lost if changes on ions not shown]

3

[6]

3

- correct use of react/reaction/reactants <u>NOT</u> mixed added to join/combine/displace NOT equals
- correct use of produce/products/gives/forms/makes/creates
- reactants correctly identified
- products correctly identified

(copper oxide reacts with sulphuric acid to produce copper sulphate and water, will be awarded all 4 marks)

for 1 mark each

Reactants must be correctly identified for 'react' mark to be given. Similarly for products

[4]

4

(i) carbon dioxide *(allow* CO_2*)*

for 1 mark

1

(ii) sodium nitrate (accept correct formula)

for 1 mark

1

[2]

5

(a) sodium ions and chloride ions (not chlorine)
allow sodium chloride/salt/common salt

for 1 mark

1

(b) $H^+ + OH^- \rightarrow H_2O$
H^+ from (hydrochloric) acid
OH^- from alkali/sodium hydroxide
lose 1 mark if no charge shown disregard other ions

each for 1 mark

3

[4]

-

6

sodium nitrate

1

N_aNO_3

do not credit lower case N ***or*** *O****,*** *upper case A*

1

potassium sulphate

1

K_2SO_4

*accept potassium hydrogen sulphate **or** $KHSO_4$*
do not credit lower case K, S or O
ignore charges on ions

1

[4]

7 (a) $CaCO_3$ + **2**HC1 → $CaC1_2$ + $\mathbf{CO_2 + H_2O}$

*one mark for CO_2 and H_2O **or** H_2CO_3*

one mark for balancing the equation

2

(b) (i) linear suitable scale for y axis

± *one small square*

1

accurate plots

deduct one mark for each error plot

1

smooth curve through the points **or** a line of best fit

this mark requires a neat smooth curve

1

(ii) curve becomes almost horizontal at **or** above 268.5

do not credit a straight line reaching 268.5 at 11 mins

accept a plot at 268.6

1

(iii) steeper initial part to curve

1

becoming nearly horizontal between 268.6 and 268.4 g

1

[8]

8 (i) sulphuric acid / H_2SO_4

accept sulfuric *1 for one mark*

1

(ii) exothermic

for one mark

1

(iii) Na_2SO_4 / $(Na)_2SO_4$ / $Na_2(SO_4)$ / $(Na^+)_2SO_4^{2-}$

for one mark
lower case O(Na_2SO_4) not accepted / tops of subscripted letters should be in line or lower than lower case letters of symbols

1

[3]

9 (a) (i) H^+

1

(ii) OH^-

1

(iii) lower than

1

(b) with HCl:

UI goes red / pink

allow a comparison eg redder than ethanoic acid

1

has a pH 0 ,1 ,2 **or** 3

allow a comparison eg has pH less than ethanoic acid.

*do **not** accept an incorrect pH.*

or

with ethanoic acid:

UI goes orange / yellow (1)

allow a comparison with HCl

has a pH 4 / or above (but less than 7) (1)

allow a comparison with HCl

1

(c) completely

1

(d) (i) conical flask

1

(ii) titration

1

(iii) repeat

allow compare with another students results

or

take average

1

[9]

10 hydrogen ions (from acid) or protons / H^+ 1

react with hydroxide ions (from alkali) / OH^- 1

to produce water

*$H^+ + OH^- \longrightarrow H_2O$ gains all **3** marks*
ignore state symbols
*molecules of hydrogen <u>ions</u> and molecules of hydroxide <u>ions</u> produce water = **2** marks*
*if they fail to get any of the above marks they can get **1** mark for neutralisation / product neutral*

1

[3]

11 (a) 0 – 6 1

(b) more accurate 1

(c) burette 1

(d) sodium hydroxide / potassium hydroxide / ammonia / any other soluble Group I or II hydroxide 1

(e) (i) named indicator / litmus / U.I. / methyl orange / methyl red / phenolphthalein 1

(iii) colour at end point 1

[6]

12 (a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ **or**

$H_3O^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

mark for correct equation
mark for state symbols
any other symbols = 0 marks
accept correct spectator ions e.g.
$Na^+(aq) + OH^-(aq) + H^+(aq) + Cl^-(aq) \rightarrow Na^+(aq) + Cl^-(aq) + H_2O(l)$

2

(b) (i) nitric acid **and** ammonia (solution)
HNO_3 NH_3 / NH_4OH

mark for both
accept ammonium hydroxide / NH_4OH instead of ammonia

*do **not** accept ammonia hydroxide*
*do **not** accept hydrogen nitrate solution*

accept correct formulae

1

(ii) provides oxygen or oxidising (agent) **or** oxidant

*do **not** accept it contains oxygen alone **or** rich in oxygen*

1

[4]

13 (i) potassium hydroxide

accept correct formulae

1

water

1

(ii) fertiliser

1

(iii) H^+

*accept hydrogen but **not** H*

1

[4]

14 (a) water / H_2O / hydrogen oxide

1

(b) eg H (atom) loses an electron to form H^+
or only a proton left

1

(c) is partially ionised in water

1

(d) (i) eg same concentration / quantity of Mg

accept: volume of acid / ribbon for both / same time

accept: volume of gas measured under the same conditions

1

(ii) C A D B

1

(e) (i) OH^-

1

(ii) acidic

1

[7]

15 (a) (i) H^+

1

(ii) OH^-

1

(b) with ethanoic acid:

'it' refers to ethanoic acid

UI goes Orange/yellow

1

but HCl goes red/pink

1

or

ethanoic acid has pH 4 or above but less than 7 (1)

but HCl has a pH3 / or lower (1)

(c) completely

1

(d) (i) conical flask

1

(ii) titration

1

(iii) repeat

or

take average

allow compare with another student's results

1

[8]

16 (a) (i) mix (owtte)

accept to allow more collisions / helps particles to collide (owtte)

idea of more efficient heat transfer

*do **not** allow heat is a catalyst*

1

(ii) higher **and** more

1

powder **and** big

1

concentrated **and** more

1

(b) electrons

1

(c) H^+

1

[6]

17 (a) (i) hydrochloric (acid) / HCl

allow phonetic spelling

ignore incorrect formula

ignore state symbols

1

(ii) idea of a solid / insoluble substance being formed (from solutions)

accept solid / insoluble product

ignore cloudy

*do **not** accept evaporation*

1

(iii) filtration / filter

accept decanting / centrifugation

ignore evaporate if after filtering

1

(iv) idea of making safe (to eat)

*allow remove harmful substances / organisms **or** sterilisation*

or
idea of purification
or
idea of neutralisation

1

(v) crystallisation

accept evaporation / heating / boiling

allow cooling

*do **not** allow freezing / solidifying*

1

(b) (i) $2e^-$

accept e^- + e^-

ignore working out

1

(ii) electron(s) are lost (from calcium atoms)

ignore numbers if given

*do **not** accept any reference to oxygen*

1

[7]

18 (a) (i) react

allow neutralise

allow bubbles / fizzes

accept produces gas / CO_2F

ignore rises

1

(ii) stop <u>reacting</u> / <u>producing</u>

stops on its own is insufficient allow stop working / bubbling / fizzing

1

the (hydrochloric) acid / (calcium) carbonate is used up

accept because the (calcium) carbonate has neutralised the (hydrochloric) acid

OR

have been used up (1)

the <u>graph line</u> becomes horizontal / levels out (1)

OR

stays the same / no change (1)

ignore reference to graph line

no further reaction (1)

1

(iii) bubble the gas through limewater / calcium hydroxide solution

allow (add) limewater

test must be correct to gain result mark

1

(the solution) goes cloudy

allow milky

1

(b) advantage > Quarrying limestone provides building materials, employment and new road links

1

disadvantage > Quarrying limestone releases dust, and lorries release carbon dioxide from burning diesel fuel

1

[7]

19 (a) limewater **or** calcium hydroxide solution

1

(reacts with carbon dioxide and) turns cloudy / milky

linked to first point

if no other mark awarded 'puts out lighted splint' gains ***1*** *mark*

1

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

- same volume / amount of the acids
- concentration of the acids
- temperature
- same surface area / size / mass / amount of calcium carbonate
- same measuring equipment

2

(ii) any **three** from:

- (after about 4 minutes) the sulfuric acid stops reacting **or** nitric acid continues to react

  accept more CO_2 with nitric acid at any time after 4 minutes
- (initially) the reaction with sulfuric acid is faster
- (the reaction stops) because calcium sulfate is a solid

  allow sulfuric acid produces a solid
- (the reaction continues) because calcium nitrate is soluble / in solution / aqueous

  allow nitric acid produces an (aqueous) solution
- because the calcium sulfate prevents the sulfuric acid reacting with the calcium carbonate
- (the rate is faster) because sulfuric acid contains two hydrogens

3

[7]

20 (a) **X:**

Fe^{2+} / iron(II), SO_4^{2-} / sulfate

allow iron(II) sulfate

or *$FeSO_4$*

1

Y:

Na^+ / sodium, I^- / iodide

allow sodium iodide
or *NaI*

1

Z:

Fe^{3+} / iron(III), Br^- / bromide

allow iron(III) bromide
or *$FeBr_3$*

correct identification of any two ions = one mark

correct identification of any four ions = two marks

1

(b) any **five** from:

allow converse arguments

method 1

- weighing is accurate
- not all barium sulfate may be precipitated
- precipitate may be lost
- precipitate may not be dry
- takes longer
- requires energy

allow not all the barium hydroxide has reacted

method 2

- accurate
- works for low concentrations

allow reliable / precise

5

[8]

21 (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]

22 (a) neutralisation

ignore reference to exothermic or endothermic

1

(b) 2 HCl + CaO ➔ $CaCl_2$ + 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) *white* 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) Sulfur dioxide causes acid rain.

1

(b) red / orange / yellow

*do **not** accept any other colours*

1

because sulfur dioxide (when in solution) is an acid

1

(c) (there are) <u>weak</u> forces (of attraction)

*do **not** accept any reference to covalent bonds breaking*

1

between the molecules

*do **not** accept any other particles*

1

(these) take little energy to overcome

award third mark only if first mark given

1

(d) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
A relevant comment is made about the data.

Level 2 (3 – 4 marks)
Relevant comparisons have been made, and an attempt made at a conclusion.

Level 3 (5 – 6 marks)
Relevant, detailed comparisons made and a justified conclusion given.

examples of the points made in the response

effectiveness

- W removes the most sulfur dioxide
- D removes the least sulfur dioxide

material used

- Both W and D use calcium carbonate
- Calcium carbonate is obtained by quarrying which will create scars on landscape / destroy habitats
- D requires thermal decomposition, this requires energy
- D produces carbon dioxide which may cause global warming / climate change
- S uses sea water, this is readily available / cheap

waste materials

- W product can be sold / is useful
- W makes carbon dioxide which may cause global warming / climate change
- D waste fill landfill sites
- S returned to sea / may pollute sea / easy to dispose of

6

[12]

24 (a) (i) copper is less reactive than hydrogen **or** copper is unreactive

1

(ii) Zinc and dilute hydrochloric acid

1

(b) (gas) syringe

1

(c) (i) 35

allow 3

1

because not close to others

accept it is <u>much</u> lower than the others

ignore references to trends or patterns

dependent on the first mark

1

(ii) (49 + 50 + 48) / 3

= 49

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

1

*allow ecf from anomaly identified in (i) for **2** marks:*

- *Exp 1 anomalous gives 43.3*
- *Exp. 2 anomalous gives 44*
- *Exp. 4 anomalous gives 44.7*

*answer of 45.5 or 46 (anomaly not excluded) gains **1** mark*

*correct working **excluding anomaly** but with wrong answer gains **1** mark*

1

(iii) so that a mean can be calculated

*accept improves accuracy of the mean **or** so anomalies can be identified / discarded **or** to reduce effect of random errors*

ignore makes it a fair test

ignore reliability, validity, repeatability, reproducibility

1

(d) (i) idea of mixing with oxygen / air, letting air / oxygen in

accept converse

1

(ii) H_2O

do not accept incorrect additional products

1

balancing 2 … (1) … 2

allow fractions or multiples

dependent on first mark

1

[11]

25 (a) (i) silver nitrate

allow $AgNO_3$

1

(ii) potassium carbonate **or**

allow K_2CO_3

sodium carbonate

allow Na_2CO_3

1

(b) base

allow ionic

ignore insoluble or soluble

ignore alkali

1

(c) (i) evaporate
or
crystallise

allow heat or boil or leave (to evaporate)

allow cool

ignore filtration unless given as an alternative

*do **not** accept freeze or solidify*

1

(ii) 2 (HNO_3)

accept multiples

1

(iii) 9

accept nine

1

(d) 6.21 / 207 0.72 / 16

***1** mark for dividing mass by A_r*

1

= 0.03 = 0.045

***1** mark for correct proportions (allow multiples)*

1

2 3

***1** mark for correct whole number ratio (allow multiples). Can be awarded from formula.*

1

Pb_2O_3

allow O_3Pb_2

***ecf** allowed throughout if sensible attempt at step 1*

*correct formula with no working gains **1** mark*

1

[10]

26 (a) because sulfur / S (forms)

1

(which) is solid / insoluble / a precipitate / a suspension

1

(b) any **two** from:

- volume of sodium thiosulfate
  ignore amount of sodium thiosulfate
- volume of (hydrochloric) acid
  ignore amount of (hydrochloric) acid
- concentration of sodium thiosulfate
- concentration of (hydrochloric) acid

*if no other mark, allow **1** mark for same cross **or** same flask **or** unspecified volume **or** unspecified concentration*

ignore same person

*do **not** accept references to temperature*

2

(c) rate increases

1

because particles move faster

accept particles have more energy

1

so frequency of collisions increases

*accept particles are more likely to collide **or** more chance of collisions*

ignore more collisions

1

more particles / collisions have energy greater than (or equal to) the activation energy

1

(d) cool

*accept refrigerate **or** method to decrease temperature*

or

decrease the temperature (of the solutions)

1

[9]

27 (a) endothermic

1

(b) 82 (%)

*correct answer with working gains **3** marks*

*if 17 or 34 not shown in working **max 2** marks*

accept 82.4

accept 82.35 to full calculator display (82.35294...) correctly rounded to at least 2 sf

if no answer or incorrect answer, then

*(M_r =) 17 gains **1** mark **or***

*14/17 gains **2** marks*

OR

*($2M_r$ =) 34 gains **1** mark **or***

*28/34 gains **2** marks*

OR

*14/their M_r shown gains **1** mark **or***

*correct calculation of 14/their M_r gains **2** marks*

3

(c) (i) 7 / seven

1

(ii) $H^+ + OH^- \rightarrow H_2O$

1

(iii) ammonium chloride

allow NH_4Cl

1

ignore an incorrect formula

(d) 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 apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
Suggestion with reasons from all three graphs, and linking of ideas which may explain a compromise.

Level 2 (3 – 4 marks):
Suggestion with reasons referring to more than one graph.

Level 1 (1 – 2 marks):
Suggestion with a reference to a graph.

0 marks:
No relevant content.

Examples of chemistry points made in response:
A reasonable suggested amount of fertiliser would be in the region of 200 kg (per ha).
Accept any suggestion from about 180 kg (per ha) to 500 kg (per ha).

Yield:
- Using fertiliser improves yield.
- Yield improved most up to about 200 kg (per ha) of fertiliser.
- Yield only increased slightly above about 200 kg (per ha).

Profit:
- About 200 kg of fertiliser gives the most profit.
- Above about 200 kg (per ha) of fertiliser profit declines.

Run off:
- Run off is at low levels until about 300 kg (per ha) of fertiliser.
- Above about 300 kg (per ha) of fertiliser, run off increases.

Examples of linking of ideas:
- Overall 200 kg gives high crop yield and most profit.
- In conclusion 200 kg gives high crop yield and low run off.
- 200 kg gives most profit and low run off.

Examples of compromise:
- Profits go down after about 200 kg (per ha) of fertiliser because cost of fertiliser is not covered by increased yield.
- 200 kg gives the highest profit although it is not the highest yield.
- 500 kg gives the best yield but has the most runoff.

6

[13]

28 (a) sulfur dioxide

accept SO_2

1

(b) (i) curved line of best fit between the 4 non-anomalous points

1

(ii) temperature was lower (than 40 °C)

accept student missed the moment when the cross disappeared

accept smaller volume of acid or acid more dilute

1

(iii) 0.005 **or** 1/200

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

*if answer incorrect, allow **1** mark for 0.32 / 64*

2

(iv) The particles move faster.

1

The particles collide with more energy.

1

(v) activation

1

[8]

29 (a) add excess copper carbonate (to dilute hydrochloric acid)

accept alternatives to excess, such as 'until no more reacts'

1

filter (to remove excess copper carbonate)

reject heat until dry

1

heat filtrate to evaporate some water **or** heat to point of crystallisation

accept leave to evaporate or leave in evaporating basin

1

leave to cool (so crystals form)

until crystals form

1

*must be in correct order to gain **4** marks*

(b) M_r $CuCl_2$ = 134.5

*correct answer scores **4** marks*

1

moles copper chloride = (mass / M_r = 11 / 134.5) = 0.0817843866

1

M_r $CuCO_3$= 123.5

1

Mass $CuCO_3$ (=moles × M_2= 0.08178 × 123.5) = 10.1(00)

1

*accept 10.1 with no working shown for **4** marks*

(c) $\frac{79.1}{100} \times 11.0$

or

11.0 × 0.791

1

8.70 (g)

1

*accept 8.70(g) with no working shown for **2** marks*

(d) Total mass of reactants = 152.5

1

$\frac{134.5}{152.5}$

allow ecf from step 1

1

88.20 (%)

1

*allow 88.20 with no working shown for **3** marks*

(e) atom economy using carbonate lower because an additional product is made **or** carbon dioxide is made as well

allow ecf

1

[14]

30 (a) (delivery) tube sticks into the acid

1

the acid would go into the water **or** the acid would leave the flask or go up the delivery tube

ignore no gas collected

1

(b) any **one** from:

- bung not put in firmly / properly
- gas lost before bung put in
- leak from tube

1

(c) all of the acid has reacted

1

(d) take more readings in range 0.34 g to 0.54 g

1

take more readings is insufficient

ignore repeat

(e) $\frac{95}{24000}$

1

0.00396

or

3.96×10^{-3}

1

*accept 0.00396 or 3.96×10^{-3} with no working shown for **2** marks*

(f) use a pipette / burette to measure the acid

1

because it is more accurate volume than a measuring cylinder
or
greater precision than a measuring cylinder
or
use a gas syringe to collect the gas

so it will not dissolve in water

or
use a flask with a divider

accept description of tube suspended inside flask

so no gas escapes when bung removed

1

(g) they should be collected because carbon dioxide is left in flask at end

1

and it has the same volume as the air collected / displaced

1

[11]

31 (a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

2

*allow **1** mark for correct formulae*

(b) sensible scales, using at least half the grid for the points

1

all points correct

± ½ small square

*allow **1** mark if 8 or 9 of the points are correct*

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up

allow marble / reactant used up

1

so concentration decreases

allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second

*do **not** accept fewer collisions unqualified*

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of
270 s

allow values in range 265 − 270

1

$\frac{2.2}{270} = 0.00814814$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

*allow **1** mark for correct calculation of value to 3 sig figs*

*accept 0.00815 or 8.15×10^{-3} with no working shown for **4** marks*

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 − 0.0075

1

7×10^{-3}

1

*accept 7×10^{-3} with no working shown for **4** marks*

[20]

32 (a) (i) iron **must** be <u>named</u>

*do **not** accept Fe*

1

(ii) hydrogen

1

and oxygen mixtures

1

burn <u>rapidly</u>

1

(b) (i) lowers concentration

accept dilutes the acid

*do **not** accept cooling*

1

less collisions (between particles)

1

(ii) H^+ (aq)

accept H_3O^+ only if 2 in front of H_2O

1

OH^- (aq)

*if spectator ions correctly included on both sides, maximum = **1** mark*

1

(iii) $Ca(OH_2)$ weak alkali

accept NaOH strong alkali

1

$Ca(OH)_2$ causes no problems

accept NaOH causes named problem
*(eg caustic **or** exothermic **or** burns **or** corrosive)*

1

[10]

Examiner reports

1 Part (a) of this question generally attracted good answers. However in part (b) many candidates appeared not to understand the meaning of the term ‘formula’, and therefore had difficulty in providing the correct answers. Some candidates thought that ‘salt’ could only mean sodium chloride.

2 (a) This part was generally well answered.

(b) Word equations and non-ionic symbol equations were far more commonly provided than the ionic equation specifically asked for in the question.

3 **Paper F2**

The reactants were often simply “mixed” rather than “reacted”. Water was sometimes considered as one of the reactants, or added at the completion of the reaction.

Paper I4

A good answer stated that copper oxide reacted with sulphuric acid to produce copper sulphate and water. The use of words like mix, join and equals were not creditworthy. Some candidates spoilt their answers by stating the copper reacted with the sulphur to give copper sulphate and that water was added.

5 A large proportion of candidates did not identify salt/sodium chloride in (c). In (b) very few equations with ions were given.

6 **Foundation Tier**

Most candidates correctly identified sodium nitrate, with fewer correctly identifying potassium sulphate (potassium sulphide was a common mistake). For the formulae. a good proportion were able to quote $NaNO_3$ correctly but very few were able to come up with the correct formula for potassium sulphate, KSO_4 or KS being the most common incorrect answers.

Higher Tier

Most candidates correctly identified both salts. A majority were able to quote $NaNO_3$ correctly but very surprisingly, few were able to come up with the correct formula for potassium sulphate, KSO_4 or KS being the most common incorrect answers.

7 In part (a), the more able candidates coped well with writing a balanced equation but this proved outside the capability of middle to low scoring candidates. It was disappointing to see how few candidates know that carbon dioxide and water are the products of acid on a carbonate. Usually those that got the products correct could also balance the equation.

Graphical skills were well tested by this question. Many candidates failed to ensure an appropriate scale although very few experienced difficulty in accurate plotting. The ability to draw an appropriate 'line of best fit' was mixed across all the range of candidates. Many lines looked as though they had been drawn with a 6B pencil with a blunt end. Many candidates used a pen for drawing graphs and consequently, they got into difficulties if they went wrong. Extrapolation was generally poor but the first mark for part (b)(iii) was often gained as most candidates knew that powdered marble chips gave a faster rate of reaction, even though they often failed to continue the curve correctly. It is interesting to note that not one candidate used the weight shown in the diagram of the balance to plot a zero-time point.

The drawing of graphs is an important part of science, both in examinations and in investigations. Particular importance is attached to drawing an appropriate 'curve of best fit'.

8 This was well answered by most, part (b) proving the most testing. In (b)(ii) exothermic was not well known. Few got part (b)(iii) correct. Some let themselves down by not obeying the rules of writing formulae. Sadly this often seemed to be through sheer carelessness. Answers of $Na^{+}SO_4^{2-}$ were often seen. Centres should seek to ensure candidates are well trained in this skill and in particular are clear on the importance of upper and lower case usage.

9

(a) There were no major problems with this part.

(b) Almost half of the students gained no marks. Many candidates gave the answer in terms of carrying out a titration and adding methyl orange while others gave vague answers such as there will be a colour change.

(c) A large majority of the candidates were unable to recognise the fact that strong acids and strong alkalis are completely ionized in water.

(d) The majority of the candidates were able to gain marks for all the parts.

(iii) Some candidates wrote add a few drops at a time while others suggested making the equipment more accurate.

10 Some excellent descriptions were seen of hydrogen ions reacting with hydroxide ions to make water molecules. However, a sizeable number of candidates ignored the instruction, in terms of ions, and simply talked about the acid reacting with the alkali to make a salt and water.

11 Part (a) was well answered. In part (b), some candidates interpreted the diagram to mean that a pipette is used primarily to add liquids slowly rather than to deliver a precise volume. The spelling of 'burette' caused many problems! Few correct answers were given in part (d) and some were wild guesses (various acids were popular). A common answer to part (e) was 'universal indicator' with a correct end-point colour and this was accepted despite the fact that it is a poor indicator for a titration of this type.

12 **Higher Tier**

With the exception of part (b)(ii), this question discriminated well between the candidates.

(a) The ionic equation was not well known, and state symbols were often omitted or incorrect when included. Many irrelevant equations unrelated to ions were given.

(b) (i) This part was surprisingly poorly answered. Nitrates from nitric acid is generally not known. Incorrect responses frequently seen included ammonium and nitrate, nitrogen and hydrogen, various oxides of nitrogen, and nitric acid.

(ii) Most candidates realised that the substance provides oxygen to support combustion. Some candidates did not go far enough and simply noted that it contained oxygen (so does water) or said it provides oxygen and hydrogen. Oxygen does not fuel a fire.

13 **Foundation Tier**

(i) Many candidates identified the alkali correctly as potassium hydroxide but water was not well known as the second product. Many chose hydrogen or oxygen.

(ii) Although a good number of candidates selected the correct response there were also many who gave 'dye' as their answer.

(iii) A surprisingly large number of candidates chose the ammonium ion as the answer to this part.

14 In Part (a) quite a few candidates got this mark but others wrote 'liquid', 'aqueous' or 'solution'.

Part (b) was very poorly attempted. A large number of candidates repeated the question by saying 'it is positively charged'. Some wrote 'it has only 1 electron' instead of saying 'it **loses** one electron'.

The majority of the candidates in Part (c)(i) scored this mark although a few wrote 'he repeated the test'.

In Part (d)(ii) quite a few candidates reversed the order and wrote 'BDAC'.

15 (a) (i) Many students scored this mark although some thought that it was the 'chloride' ion.

(ii) Here again, a large number of students scored credit but quite a few thought it was the 'sodium' ion.

(b) Most answers showed a lack of knowledge and understanding with a large number of students scoring no marks. There were vague responses such as 'it would be a different colour' or 'different pH'. Many got the numbers wrong while some students wrote in terms of 'ionization'.

(c) This was very poorly answered. A large majority of students gave their answer as 'partially' instead of 'completely'.

(d) (i) A small number of students gave the answer as ‘beaker’ instead of ‘conical flask’ and lost the mark.

(ii) The majority of the students were able to identify ‘titration’ as the correct answer.

(iii) This part was well answered and most students gave their answer as ‘repeat the test’.

16 (a) (i) A lot of confused answers were seen, which referred to increased heat or energy or the idea that the kiln was a catalyst. Creditworthy answers discussed the mixing or the idea of heat being spread throughout the reaction mixture and not being concentrated in one place.

(ii) Generally well answered with the majority of candidates gaining one or two marks and a significant number gaining all three.

(b) Most candidates correctly identified the particles as electrons although a significant number chose neutrons.

(c) Both distracters attracted significant numbers of candidates.

17 (a) (i) The majority of students correctly named the acid. The most common incorrect response was chlorine/chloride.

(ii) Although some students were able to describe precipitation reactions by stating that “the solution goes cloudy”, only a minority were able to correctly give the meaning of a precipitation reaction in terms of a solid being formed.

(iii) Only a minority of students correctly stated that the mixture should be separated by filtration. Common incorrect responses were electrolysis and evaporation/heating.

(iv) The majority of students gained this mark, with the idea of making the calcium chloride safe for use in food being the most common. The idea of purification was also well represented and gained credit. Common non-scoring answers were “to make it suitable for food”, “to separate it into different uses” and “to reduce waste”.

(v) Only a minority of students gained this mark with evaporation being the most common correct answer. Common incorrect answers were freezing and solidifying.

(b) (i) Approximately a third of students were able to correctly complete the half equation.

(ii) Approximately a half of students were able to show correct understanding of the term oxidation in this context. Common incorrect answers were “loss of ions”, “gain of electrons” and references to oxygen.

18 (a) (i) Several students managed to gain the mark for stating that it was reacting, some even stated that carbon dioxide was produced. The most common incorrect response was 'increase' or 'rise' because this related to the trend in the graph.

(ii) Most students who managed to gain a mark here did so for stating 'stayed the same', 'the reaction had stopped' or 'neutralised'. Very few students could explain why they thought it was staying the same. The tablets have done their job or the stomach ache was gone were popular incorrect explanations.

(iii) Many students did not attempt this question. The few students who knew the correct test scored both marks here. There were very few students who only gained one mark for use of limewater as the test. There was a range of other gas tests given of which the most common was the 'pop test'.

(b) Most students achieved full marks for correctly identifying an advantage and a disadvantage of quarrying limestone. Several students did not follow the instructions to tick one advantage and to tick one disadvantage; many ticked several in each column and did not gain any credit.

19 (a) This question was a good discriminator. The wording of the first part of this question, 'in this reaction', seemed to confuse many pupils. Less than half of the students gave the correct test for carbon dioxide and its result. A significant proportion of the students added the limewater to the reaction mixture rather than the gas.

(b) (i) The variables were familiar ground from ISAs and scored well, although a lot of answers surprisingly referred to the time intervals or the volume of carbon dioxide produced.

(ii) In the last part, relatively few pupils referred to the graph in their answers, which would have earned up to two relatively low level descriptive marks. However, the mark most frequently obtained was that for 'sulfuric acid produces a solid'. The equivalent mark for nitric acid was often lost by pupils who clearly did not know the meaning of (aq) referring to a liquid or acid instead of to a solution.

20 (a) A wide spread of responses was seen, as might be expected. In general, the cation tests were better known than the anion tests. Sulfate was the least well known of all. Some students spoiled their halide ion answers by naming them iodine and bromine. Fewer than a quarter knew all six ion results.

(b) The responses to this question were generally poor. A large number of students considered how difficult it would be for them to do the experiments rather than compare the two methods being done by a competent chemist. Therefore they frequently stated that the titration would take a long time and the results would be inaccurate due to the difficulty of recognising the end point in a titration. Students also considered the calculation (instead of the actual method) and gave the response that a titration calculation would be difficult to do and was prone to mistakes, whereas the calculation for the precipitation reaction would be very easy to do. Even students who recognised that some of the precipitate would be lost then sometimes went on to state that this method is more accurate than the titration. In general, the greater speed and accuracy of the titration were the two marks most frequently awarded, with loss of precipitate also mentioned by some students. The other marking points were seldom seen and in general the award of four marks was uncommon and of five marks extremely rare. As with question 4(b), students need to be careful that their responses in respect of each method do not contradict each other.

21 (a) (i) The majority of students correctly named the ingredient as phosphoric acid recognising that a pH of 2.9 indicated acidity.

(ii) The correct response was hydrogen ion. Only a few students read the question and were able to give an ion. Most chose an incorrect answer from the list of ingredients for Cola. The most popular answers were phosphoric acid, carbonated water and sugar.

(b) (i) Most students scored a mark for using a pencil. To gain the second mark the idea was needed that the pencil was insoluble and that ink was soluble with the appropriate consequences for the chromatogram. Answers scoring no further credit included the line being straight, being able to erase the line if an error occurred and vague answers that ink interfered with the results of the separation.

(ii) This question discriminated well with the full range of marks awarded. Many students were poor at expressing their ideas. The most common answer quoted the cola as having the most colours with the fruit juice having fewer colours. Good answers showed students had analysed the chromatogram and referred to the number of colours in each drink and deduced that one of the colours was the same. Misconceptions were often in terms of the speed of dots rising up the paper. There were several incorrect conclusions about the similarity and differences of the dots.

(c) This was poorly answered. Reference to substances travelling at different speeds was rare. Common incorrect answers involved boiling point or pH. Several answers confused gas chromatography with mass spectrometry thinking that the speed through the column was related to the mass of the molecule.

(d) (i) About half of students chose the correct answer, ‘Is there caffeine in a certain brand of drink?’

(ii) Common correct responses were concerned with opinion or choice or ethical / moral reasons followed by words to the effect that caffeine has different effects on different people. Answers involving the inability to do an experiment were less frequent. Lots of confused responses discussed the labels on the drinks at length.

22

(a) While many students got this right, almost all reaction types were seen as answers at some point. Neutralisation proved to be a difficult word to spell for some students; however, as long as the word was recognisable they were not penalised.

(b) The most common error here was to get the formula of calcium chloride or calcium oxide wrong, along with additional incorrect products.

(c) While the majority of answers were correct, common errors involved one forming a precipitate and one not (despite both making the same salt) or claiming that calcium oxide would make a gas.

(d) The most common error was one of omission, where students did not mention the need for excess calcium carbonate and hence also missed the need to filter the solution. There were some excellent descriptions of heating to the point of crystallisation. Many answers suggested the calcium carbonate needed to be heated with the hydrochloric acid for a reaction to occur: while this was not penalised, it does seem that many students had not carried out the simple task of preparing crystals of a soluble salt from an acid reacting with an insoluble carbonate.

(e) (i) While the majority if students were aware that a white precipitate would form, many did not address what would happen with excess sodium hydroxide and so were unable to gain the second mark.

(ii) While some students were aware that magnesium ions would give the same results as calcium ions, a large number of students thought aluminium ions would also give the same results. Testing for cations using sodium hydroxide solution should involve the addition of a few drops of sodium hydroxide followed by an excess: many students seemed not to have met the addition of excess.

(iii) Some overly long answers were seen, describing in detail how to do a flame test. All that was needed was a statement that you should do a flame test, or very simple description of a flame test along with the colour of the flame. The most common error in the flame colour stated was to mix up calcium with lithium and give the colour as crimson.

24 (a) (i) The low reactivity of copper was well known, although some students suggested that heating of a greater concentration of acid would result in hydrogen being made. Some students gave two answers: examiners will not select which of two answers should be marked, and so if one of the answers given is wrong then the mark cannot be awarded.

(ii) Despite the clear instruction to tick **one** box, a significant number of students ticked two boxes. Students should be reminded to read all of the information and instructions in questions. An appreciable number selected potassium and dilute hydrochloric acid. While this combination would undoubtedly produce hydrogen, it would not be safe, which was a specified requirement in the question.

(b) A surprising number of students were not able to identify the item of apparatus as some type of syringe. Students should be familiar with gas syringes; even if they have not used them, they should have seen them in use in experiments such as the passing of air over heated copper to determine the percentage of air that is oxygen.

(c) (i) Almost all students selected the correct result and almost all of these could explain that this result was far from the others.

(ii) It was pleasing to see that the vast majority of students excluded the anomalous result in their calculations. However, there were careless mathematical errors resulting in a mean larger than any of the results that had been used to calculate it. Students should check calculations through carefully.

(iii) There were many good answers based on calculating a mean or identifying and excluding anomalies. However, some students used terms such as reliability, validity, repeatability, reproducibility and fair test with abandon, clearly not understanding what the terms mean. It should be noted that repeating an experiment does not produce fewer anomalous results (if there are no repeats, there can be no anomalous results); nor does it make the results reproducible (there could be very different results each time) or reliable.

(d) (i) It was disappointing that many students did not seem to understand that in the test for hydrogen the reaction is between hydrogen and oxygen; often the hydrogen was stated to be reacting with the flame or the splint. A significant number of answers tried to explain why the pop was louder with tube A – the opposite of the statement in the question. There were, however, some excellent and well-explained answers.

(ii) Despite the lack of understanding shown in (i), this question was very well answered. The most common errors were to have hydrogen peroxide or hydroxyl radicals as products.

25 (a) (i) About half of all students gained this mark, and a wide variety of incorrect responses was seen, many of which are not compounds, eg all nitrates, or chlorides.

(ii) Less than half of all students gained this mark, and a variety of incorrect responses was seen, including all potassium and sodium salts, and calcium carbonate.

(b) A minority of students recognised a metal oxide to be a base. Ionic was an allowed response given by some students. Soluble and insoluble were frequently seen.

(c) (i) Surprisingly, only a minority of students gained credit. This could again be related to lack of practical experience. Filtration was a popular misconception, as were electrolysis and precipitation. Some students implied in their responses that the solution, rather than the water, would evaporate.

(ii) About half of all students were awarded this mark. Working could be seen in many cases, and this usually led to the correct answer.
Some students realised that the HNO_3 needed to be doubled but did not know how to write this correctly and gave $2(HNO_3)$ or $(HNO_3)_2$.
Students should be reminded that formulae should not be changed when balancing an equation.

(d) Only a minority of students were awarded 4 marks, but just over half of all students gained 2 marks. Some students had great difficulty and wrote down, seemingly at random, some of the numbers given in the question. This resulted in no marks.
A common error was to divide the mass by the incorrect A_r, or divide the A_r by the mass. Although these responses did not gain the first marking point, credit for further correct working based on this incorrect start was given.

Many students lost one mark due to inappropriate rounding. The ratio of 1:1.5 was rounded to 1:2 giving a formula of PbO_2 Occasionally 0.045 was inappropriately rounded to 0.05, leading to Pb_3O_5, which also resulted in the loss of one mark.

A small number of students used the ‘percentage method’ and worked out the percentage of lead as 89.6 or 90 and oxygen as 10.6 or 10 and then went on to work out the correct formula for the 4 marks.

Some students did not gain full marks because they calculated the correct whole number ratio but did not go on to give a formula. Students should be reminded to be careful about decimal points. Writing 0.03 and 0.45 for the second marking point resulted in not gaining both that mark and further marks.

Students should check their working if they suspect that an answer is not sensible.

Occasionally a student gave two sets of working out with two answers. One set was correct and one incorrect but no mark could be awarded. Students should be advised to cross out one answer.

26 (a) A minority of students gained both marks. It appeared that a large number of students were unfamiliar with the reaction between sodium thiosulfate and hydrochloric acid, and were unable to link the state symbol (s) with the formation of a solid precipitate, causing the cloudiness.

Responses which did not gain credit included suggestions that sulfur dioxide or sodium chloride were produced. Some students simply said that the cloudiness was due to a reaction taking place, which was true, but insufficient to gain credit.

A small, but significant minority of students ignored the information given about the reaction and suggested that carbon dioxide was responsible for the cloudiness, presumably confusing the reaction given with testing for carbon dioxide with limewater.

(b) Many students used the word “amount”, which did not gain credit. Students should be encouraged to use correct terminology, ie to refer to the volume and concentration of the reactants rather than the “amount”. A number of students gave three variables, despite being clearly asked in the question for two. These were treated as a list, so any incorrect responses negated credit earned from other responses.

(c) The use of collision theory to explain reaction rates has improved, with most students gaining at least two marks. Weaker responses often gained the first two marking points. Approximately half of the responses gained the first three marking points, including an explanation of the increased frequency of collisions. Only a small number of students realised that more of the particles or collisions had energy equal to or exceeding the activation energy and gained the fourth marking point.

(d) Only a minority of students realised that carrying out the reaction at 5 °C meant that the temperature of the mixture needed to be reduced from room temperature. Many students suggested heating the mixture to 5 °C.

27

Foundation

(a) This was correctly answered by most students. Credit was scored for endothermic. Vague references to reversible, thermic and heat were common.

(b) Correct answers followed the correct route to produce the answer within the range 82-82.4. Incorrect rounding of answers was common. Partial credit was given for errors carried forward. A number of students worked out the correct Mr of 17 and then proceeded to calculate their answer without using it.

(c) (i) Most students knew the pH of a neutral solution was 7.

(ii) Guesses were evident and only a minority recognised the correct equation for a neutralisation reaction.

(iii) Only a very small number of students were able to correctly name ammonium chloride as the salt produced.

(d) Most students were able to suggest how much ammonium nitrate farmers should use with reasons from the graphs to achieve level 2. Only a minority attempted to link the graphs and therefore did not attain level 3. The quality of written communication was often poor and students did not gain marks for incorrect use of units, or by getting information wrong, e.g. ‘a yield of 9200kg gives a mass of 200g’.

Graph A – Many students stated that 200kg of ammonium nitrate gave the highest yield, not recognising that the graph continued to rise.

Graph B – Many students correctly recognised that 200kg of ammonium nitrate gave the maximum profit, and that the profit decreased when more was added. Some students were confused and discussed the cost of the fertiliser.

Graph C – A large number thought that the horizontal start of the graph indicated zero run off.

A significant number of students did not attempt the question while others wrote only irrelevant material without referring to the graphs.

Higher

(a) The small number of students who did not gain credit for this question gave “exothermic” as their response, or stated the reverse equation.

(b) Virtually all students were able to make a meaningful attempt at this calculation, with many gaining full marks by giving clear working as well as a correct answer. Some students worked with 28/34, which gained full credit if correctly calculated. There were some rounding errors (eg 82.3), costing students the third marking point, and some students did not know how to proceed once they had calculated the Mr of ammonia to be 17. A few students calculated 17/14 or misinterpreted the subscript in the formula and calculated the Mr of N3H3.

(c) (i) Most students were awarded this mark.

(ii) A majority of students gained this mark.

(iii) Only a minority of students gained this mark. Commonly seen errors included ammonia chloride, nitrogen chloride, and sodium chloride. Some students may have given sodium chloride as they did not realise that the term “salt” has a wider meaning. A minority of students were not familiar with the general format of the name of a salt (ie two words), and gave water, nitrogen, or sulfur.

(d) Most students approached this question with confidence and were able to make a sensible suggested mass of ammonium nitrate to use, giving reasons from two or more graphs.

More detailed responses included some linking of information from the graphs, including a clear expression of the idea that there was a conflict between the most yield and the highest profit.

A large majority of students suggested using 200kg per hectare of fertiliser, citing graph B showing that this gave the largest profit. Many students carefully observed that 200kg per hectare of fertiliser gave a high yield, but not the maximum, and most realised that the run off from 200kg per hectare of fertiliser was very low.

Some students gave creditworthy responses, but misquoted from graphs, omitted units, or gave incorrect units. Others interpreted graph B as indicating that farmers would make a loss if they used more than 200 kg of fertiliser per ha.

Some students had difficulty interpreting the graphs, so were unable to give a sensible suggestion for the amount of fertiliser to use, or to use the graphs for their explanations. The poorest responses were descriptions of the graphs in terms of reaction rates, eg that in graph A it was fast at first, then slowed down.

28

(a) The majority of the students identified the gas as sulfur dioxide.

(b) (i) There was a common misconception that a line of best fit must be a straight line. Therefore, the majority of students completed the graph by drawing a straight line with a negative gradient rather than a smooth curve. Some curves were drawn which included the anomalous point but most curves were creditworthy.

(ii) Common incorrect answers included human error such as ‘did not measure it properly’ or vague references to temperature e.g. ‘It was not at the correct temperature’ instead of recognising that the temperature was lower than 40°C. Good answers were that a longer time than expected could be caused by starting the stop clock early or by the student missing when the cross disappeared.

(iii) This was generally well answered. Most students scored credit for 0.32/64 but then often failed to calculate the correct answer 0.005. Incorrect answers such as 0.5 and 0.05 were prevalent as was 0.32/0.64 and writing down calculator displays which were not understood such as 5.03 or 5^{-3}.

(iv) Most scored full credit.

(v) Many students scored a mark for recognising activation energy.

32

Nearly every candidate identified iron as the metal and hydrogen as the gas released. However, most candidates could not give a satisfactory explanation as to why hydrogen burns explosively. In (b) many suggested that spraying the steel with water simply cooled it down and did not refer to the lowering of the concentration of the hydrochloric acid. Far too many candidates could not correctly complete the ionic equation for the neutralisation reaction. Many candidates did not understand the idea of weak/strong alkalis. This should have been appreciated when considering pH and the application of the principle of neutralisation in everyday life.