Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

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General Certificate of Secondary Education
June 2004

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY
HIGHER TIER

3421/H

Monday 14 June 2004 9.00 am to 11.15 am

H

In addition to this paper you will require:
- a ruler;
- the Data Sheet (enclosed).

You may use a calculator.

Time allowed: 2 hours 15 minutes

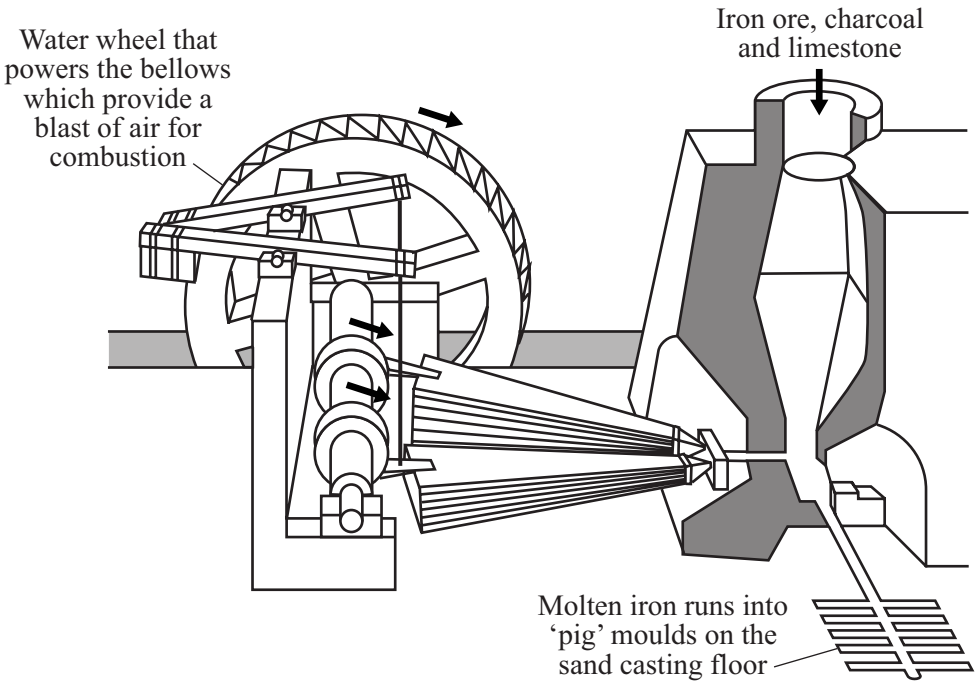
Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 135.
- Mark allocations are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Number	Mark	Number	Mark
1		10	
2		11	
3		12	
4		13	
5		14	
6		15	
7		16	
8		17	
9		18	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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

1 The diagram shows an early type of blast furnace used in Wales about 300 years ago.



(a) (i) This early type of furnace uses charcoal. Name the raw material that has replaced charcoal in modern furnaces.

.....

(1 mark)

(ii) State **one** other way in which this early type of furnace differs from a modern furnace.

.....

.....

(1 mark)

(b) The charcoal provides carbon. This reacts with oxygen to form carbon monoxide. The iron oxide in the iron ore is *reduced* by the carbon monoxide.

(i) State what the word *reduced* means.

.....

(1 mark)

(ii) Name the **two** substances formed when iron oxide reacts with carbon monoxide.

..... and .....

(1 mark)

(c) Why is limestone added to the blast furnace?

.....

.....

(1 mark)

(d) Explain why sodium cannot be extracted from its ore by this method.

The Data Sheet may help you to answer this question.

.....

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(2 marks)

(e) Stainless steel is an alloy which contains iron and other metals.

This kettle is made from stainless steel.

(i) Name a metal which is added to iron to make stainless steel.

.....

(1 mark)

(ii) Why is stainless steel a good material for making kettles?

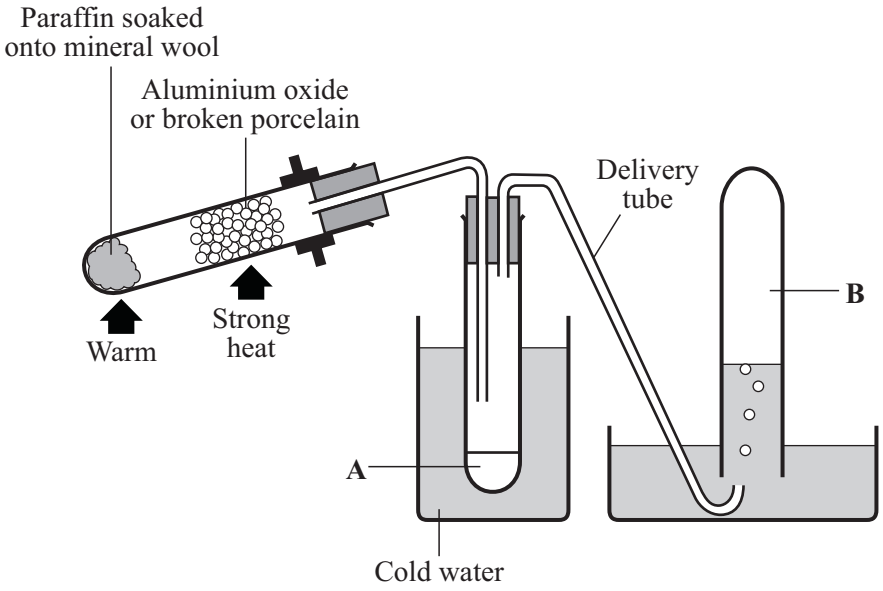
.....

.....

(1 mark)

9

2 The diagram shows an apparatus that can be used to carry out cracking reactions in a laboratory.



(a) Why is aluminium oxide or broken porcelain used?

.....

(1 mark)

(b) Paraffin contains decane. The cracking of decane can be represented by the equation below. A decane molecule is split into two smaller molecules.

Complete the equation by adding the formula of the other product.

$C_{10}H_{22}$ (l) → ..... (l) + C_2H_4 (g)
decane

(1 mark)

(c) Would you expect C_2H_4 molecules to collect at position **A** or **B** shown on the diagram?

Position.....

Explain your answer.

.....

.....

(1 mark)

(d) Cracking reactions involve *thermal decomposition*.

What is meant by *thermal decomposition*?

.....

.....

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.....

(2 marks)

(e) Explain, as fully as you can, why cracking is used in the oil industry.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

.....

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(3 marks)

(f) The cracking reaction produces a mixture of products. The mixture contains hydrocarbons with different boiling points.

Suggest a method of separating this mixture.

.....

.....

(1 mark)

9

3 The periodic table on the Data Sheet may help you to answer this question.

(a) Newlands and Mendeleev both designed periodic tables in which the elements were put in the order of their relative atomic masses.

When the elements are put in this order a few of them are placed incorrectly when compared with a modern periodic table.

(i) Give **one** example of a pair of elements that would be placed incorrectly if they were in the order of their relative atomic masses.

..... and .....

(1 mark)

(ii) Explain why placing these two elements in the order of their relative atomic masses would **not** be correct.

.....

.....

(1 mark)

(b) In the modern periodic table the elements are put in order of their atomic (proton) numbers.

Explain how the positions of the elements in the periodic table are linked to the electronic structure of their atoms.

.....

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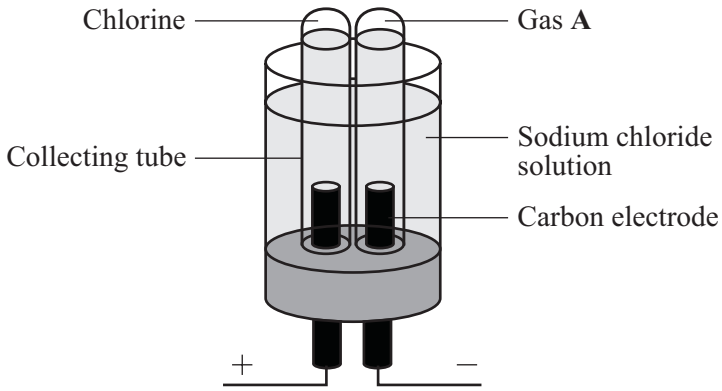
(2 marks)

4

4 The electrolysis of sodium chloride solution is an important industrial process. The apparatus shown below can be used to show this electrolysis in the laboratory.



(a) Name gas **A**. .....

(1 mark)

(b) Chlorine is produced at the positive electrode. Describe and give the result of a chemical test to prove that the gas is chlorine.

.....

.....

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(2 marks)

(c) Chloride ions move to the positive electrode. Explain why.

.....

.....

(1 mark)

(d) A small quantity of chlorine is added to drinking water. Explain why.

.....

.....

(1 mark)

(e) The solution around the negative electrode becomes alkaline. Name the ion which makes the solution alkaline.

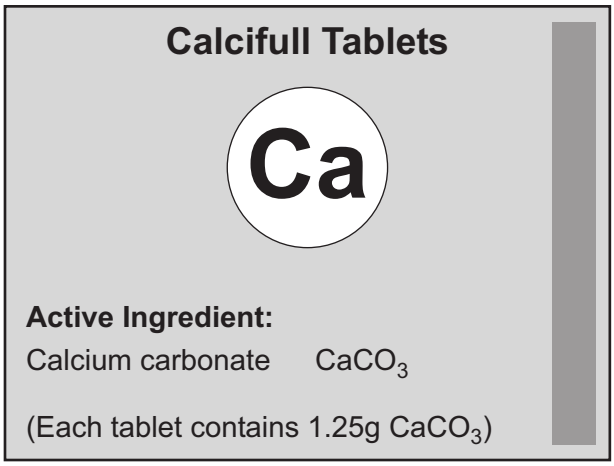
.....

.....

(1 mark)

6

5 Calcium carbonate tablets are used to treat people with calcium deficiency.



(a) Calculate the relative formula mass (M_r) of calcium carbonate.

Relative atomic masses: C = 12; O = 16; Ca = 40.

.....

.....

Relative formula mass = ...

(2 marks)

(b) Calculate the percentage of calcium in calcium carbonate, $CaCO_3$.

.....

.....

Percentage of calcium = ... %

(2 marks)

(c) Calculate the mass of calcium in each tablet.

.....

.....

Mass of calcium = ... g

(2 marks)

(d) An unwanted side effect of this medicine is that it can cause the patient to have 'wind' (too much gas in the intestine).

The equation below represents the reaction between calcium carbonate and hydrochloric acid (the acid present in the stomach).

$$CaCO_3\ (s) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O\ (1) + CO_2\ (g)$$

Suggest why the patient may suffer from 'wind'.

.....

.....

(1 mark)

7

TURN OVER FOR THE NEXT QUESTION

6 Many foods contain chemical additives.

(a) A tin of creamed rice contains sodium carbonate as an acidity regulator.

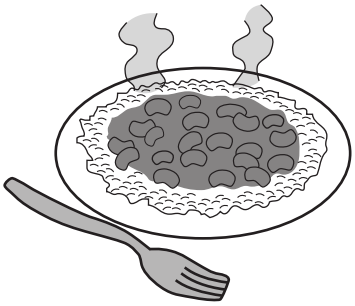
Use the table of ions on the Data Sheet to help you to work out the formula of sodium carbonate.

.....

.....

(1 mark)

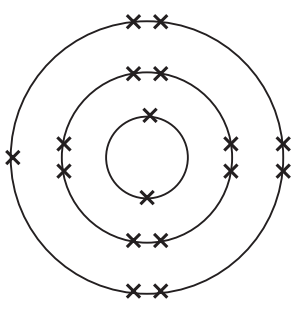
(b) A tin of red kidney beans contains calcium chloride as a firming agent.

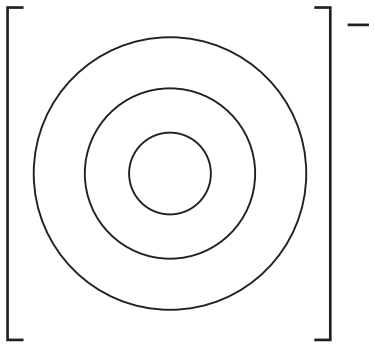


Calcium chloride is an ionic compound which contains calcium ions (Ca^{2+}) and chloride ions (Cl^{-}).

(i) The diagram on the left represents the electronic structure of a chlorine atom.

Complete a similar diagram on the right to represent a chloride ion.





(2 marks)

(ii) Explain how a calcium **atom** changes into a calcium **ion** which has a 2+ charge.

.....

.....

.....

.....

(2 marks)

(c) Cola drinks contain phosphoric acid, H_3PO_4. The two equations show how phosphoric acid can be made from phosphorus.

Balance these two equations.

(i) P_4 + ... O_2 → P_4O_{10} *(1 mark)*

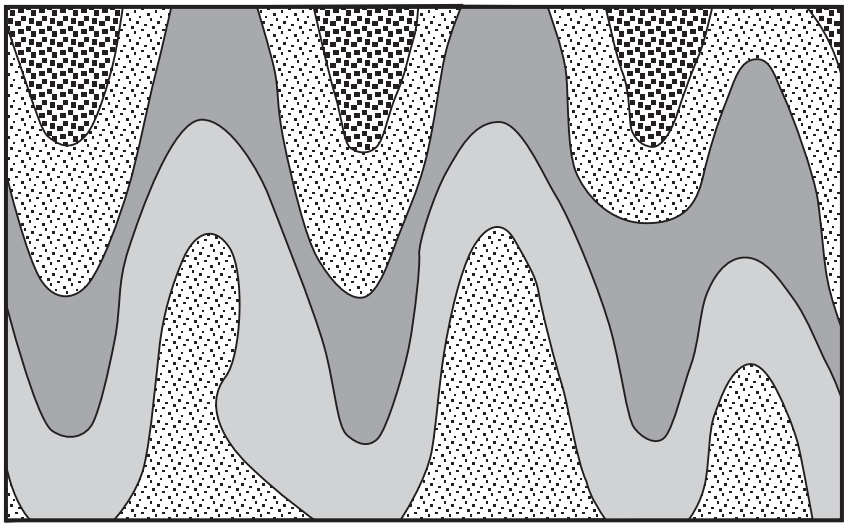
(ii) P_4O_{10} + ... H_2O → $4H_3PO_4$

(1 mark)

7

TURN OVER FOR THE NEXT QUESTION

7 The diagram shows a cross section through some metamorphic rocks.



These rocks were once horizontal layers of sedimentary rocks.

Describe how the sedimentary rock was changed into metamorphic rock.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

.....

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(3 marks)

3

8 The following passage is about the preparation of lead iodide, an insoluble salt.

> An excess of potassium iodide in solution was shaken with some lead nitrate solution in a test tube.
>
> The lead iodide precipitate was separated from the mixture and then washed several times with water.
>
> The lead iodide was dried and then placed in a bottle.

(a) Suggest a reason why excess potassium iodide was used.

.....

.....

(1 mark)

(b) What word used in the passage shows that lead iodide is insoluble?

.....

(1 mark)

(c) Suggest how lead iodide can be separated from the mixture.

.....

.....

(1 mark)

(d) Why was the lead iodide washed with water?

.....

.....

(1 mark)

(e) Suggest a method which could be used to dry this lead iodide.

.....

.....

(1 mark)

(f) Lead compounds are toxic.

Suggest a suitable safety precaution that should be taken when using toxic substances in laboratories.

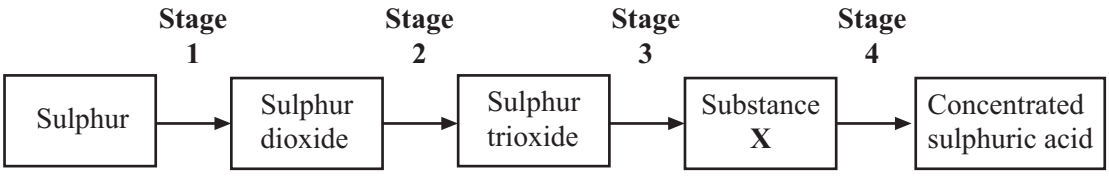
.....

(1 mark)

6

9 Sulphuric acid can be made by the Contact Process.

(a) There are four main stages in the Contact Process.



Give the name of:

(i) the catalyst used in **Stage 2**;

.....

(1 mark)

(ii) the substance which dissolves sulphur trioxide in **Stage 3**;

.....

(1 mark)

(iii) substance **X**, formed in **Stage 3**.

.....

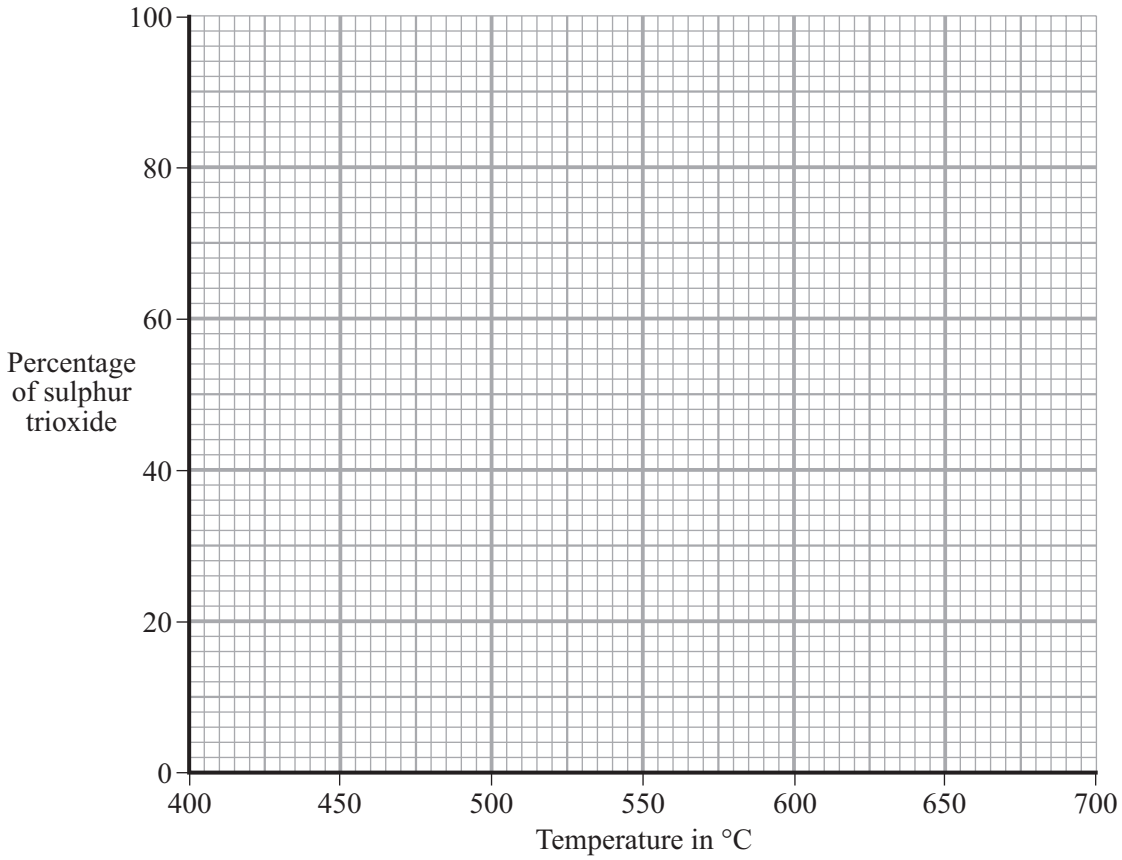
(1 mark)

(b) The percentage of sulphur trioxide formed in **Stage 2** depends upon the temperature.

The table gives information about the percentage of sulphur trioxide formed at different temperatures.

Percentage of sulphur trioxide	98	96	90	80	66	50	32
Temperature in ºC	400	450	500	550	600	650	700

(i) Plot the data on the grid opposite. Draw a smooth curve to show how temperature affects the percentage of sulphur trioxide formed.



(2 marks)

(ii) Use your graph to find the temperature which gives 70% of sulphur trioxide.

.....ºC
(1 mark)

(c) A balanced symbol equation which represents the overall process is

$$S + H_2O + 1\tfrac{1}{2}O_2 \rightarrow H_2SO_4$$

This equation means that the formula mass of sulphuric acid can be made starting from the formula mass of sulphur.

The formula mass of sulphur is 32 g.

(i) Show that the formula mass of sulphuric acid is 98 g.

Relative atomic masses: H = 1; O = 16; S = 32.

.....

.....
(2 marks)

QUESTION 9 CONTINUES ON THE NEXT PAGE

(ii) In practice, the actual amount of sulphuric acid made from 32 g of sulphur is less than 98 g. **Stage 2** of the Contact Process is reversible.

Suggest why this lowers the amount of sulphuric acid made.

.....

.....

(1 mark)

(d) The balanced symbol equation which represents the reaction between sulphuric acid and sodium hydroxide solution is

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

Use the ideas of Arrhenius and Bronsted-Lowry to explain why sodium hydroxide is a base when it reacts with sulphuric acid.

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(3 marks)

12

10 Caesium is an element in Group 1 of the periodic table.

(a) Which of the electronic structures represented by **A** to **D** is correct for a caesium atom?

The periodic table on the Data Sheet may help you to answer this question.

	Electronic structure
A	2, 8, 18, 18, 8, 1
B	2, 8, 18, 18, 9
C	2, 8, 18, 27
D	2, 8, 18, 18, 6, 3

The electronic structure for a caesium atom is represented by letter .....

(1 mark)

(b) When a small piece of lithium is added to cold water it fizzes around on the surface of the water. A small piece of caesium explodes when added to water.

Explain in terms of electronic structure why a caesium atom is more reactive than a lithium atom.

.....

.....

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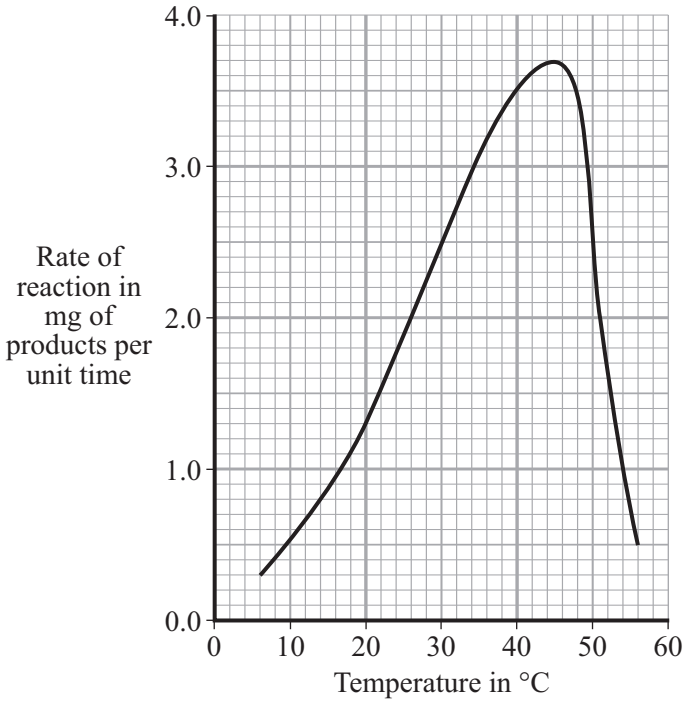
(2 marks)

3

TURN OVER FOR THE NEXT QUESTION

11 (a) The graph shows how the rate of an enzyme-catalysed reaction changes with temperature.



(i) Explain why, in terms of particles, the rate of most reactions increases as the temperature is increased.

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(3 marks)

(ii) Suggest a disadvantage of using an enzyme to speed up this reaction.

.....

.....

(1 mark)

(b) Read the passage below about one use of enzymes in industry.

Preparation of acrylamide

Acrylamide is an important chemical used in the manufacture of polymers. It is produced by the addition of water to acrylonitrile.

acrylonitrile + water → acrylamide

The reaction can be catalysed using Cu^+ ions but the yield of acrylamide is low and a mixture of products is obtained at the relatively high temperature needed (between 80 °C and 140 °C).

These problems can be overcome by using an immobilised enzyme. The stability of the enzyme is increased by making it immobilised.

This enzyme-catalysed reaction takes place at 10 °C and produces a high yield of acrylamide and virtually no other products.

About 4000 tonnes of acrylamide are produced each year using this method.

(i) Give **three** advantages of using an enzyme catalyst for this reaction.

1 .....

.....

2 .....

.....

3 .....

.....

(3 marks)

(ii) Why is it important that the enzyme is stabilised?

.....

(1 mark)

(iii) Describe how the enzyme could be immobilised.

.....

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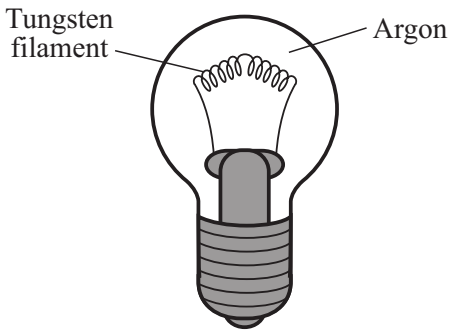
(2 marks)

10

Turn over ▶

12 The diagram shows an electric light bulb.



When electricity is passed through the tungsten filament it gets very hot and gives out light.

(a) What reaction would take place if the hot tungsten was surrounded by air?

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(1 mark)

(b) State why argon is used in the light bulb. Explain your answer in terms of the electronic structure of an argon atom.

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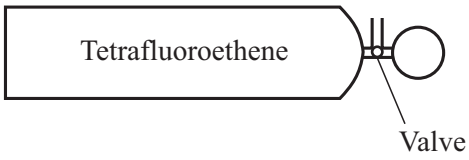
(3 marks)

4

13 In 1939 Roy Plunkett opened the valve on a new cylinder of tetrafluoroethene gas. No gas came out!



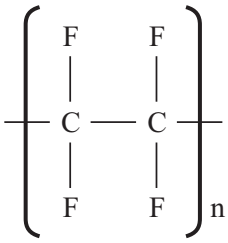
He cut the cylinder open and found that the gas had changed into a white solid. This solid was an addition polymer.

(a) Give the name of the addition polymer that formed inside the cylinder.

.....

(1 mark)

(b) The structure of this polymer can be represented by the diagram below.



Draw the structure of the monomer, tetrafluoroethene, from which it is formed.

(2 marks)

(c) Describe how this addition polymer forms from monomers.

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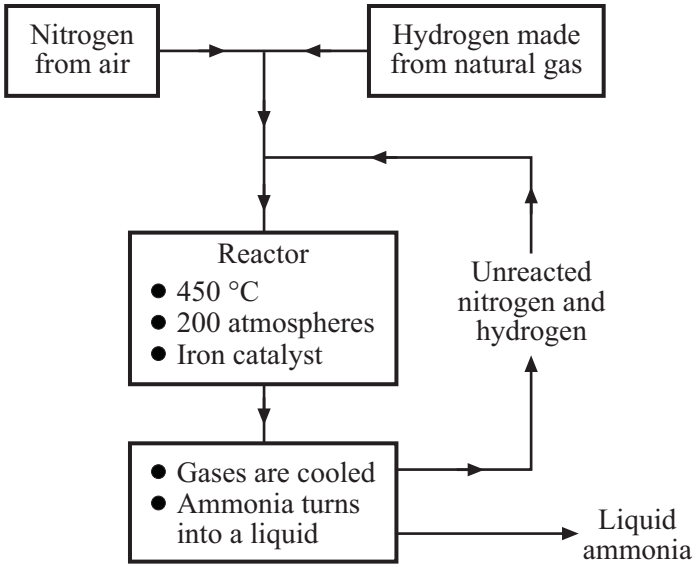
(3 marks)

6

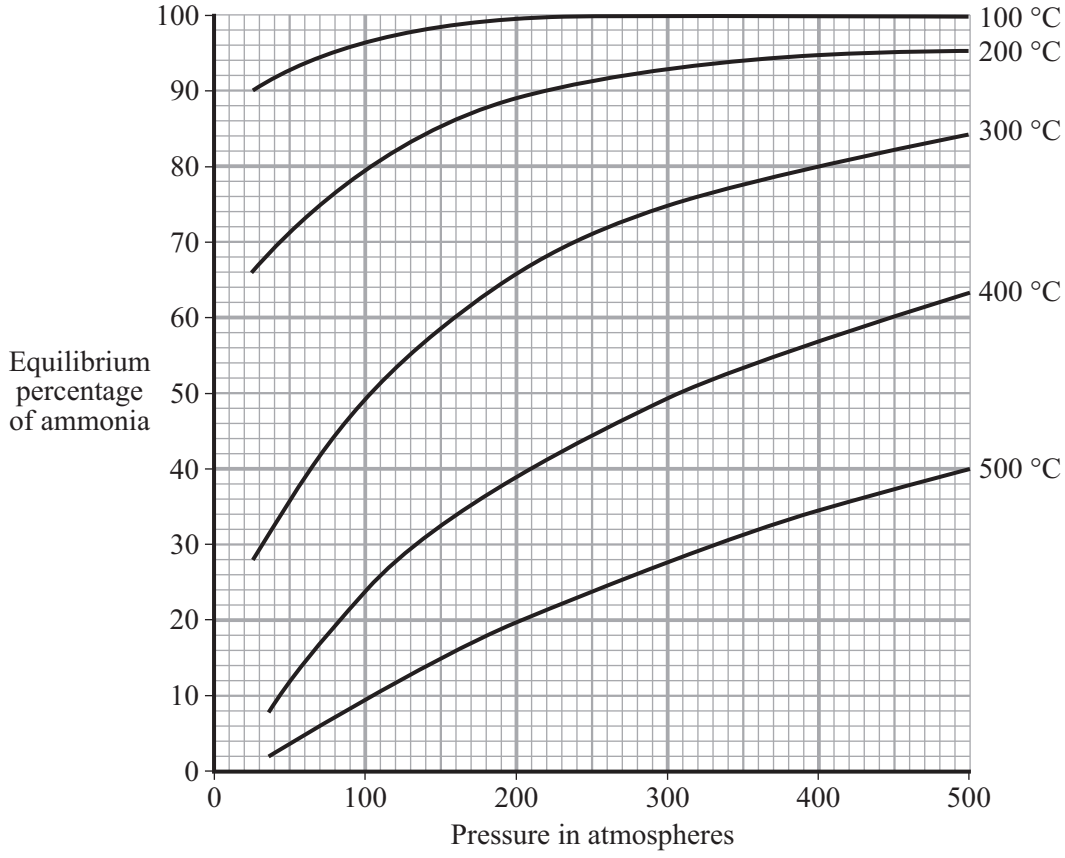
14 Ammonia is made from nitrogen and hydrogen in the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \text{ (+ heat)}$$

Flow Chart for the Haber Process



Effect of temperature and pressure on the amount of ammonia at equilibrium



(a) Use information from the page opposite and your knowledge of the Haber process and reversible reactions to help you to answer this question.

State which conditions of temperature and pressure would give the highest percentage of ammonia at equilibrium. Explain why.

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(4 marks)

(b) The Haber process uses a temperature of 450 ºC and a pressure of 200 atmospheres.

Explain why these conditions are chosen.

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(3 marks)

7

15 Silicon is an important element used in the electronics industry.

(a) Silicon can be made by heating a mixture of sand (silicon dioxide) with magnesium powder.

The equation for this reaction is shown below.

$$SiO_2\ (s) + 2Mg\ (s) \rightarrow 2MgO\ (s) + Si\ (s)$$

Calculate the mass of silicon dioxide needed to make 1 g of silicon.

Relative atomic masses: O = 16; Si = 28

.....

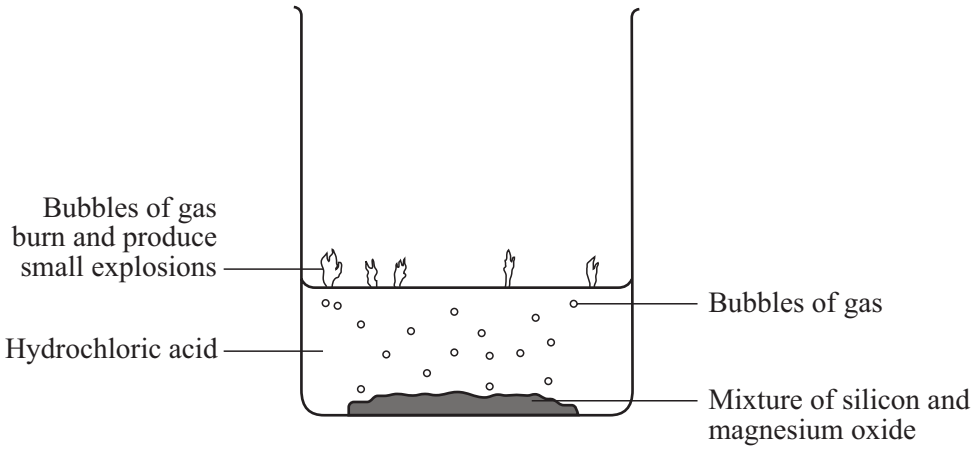
.....

.....

Mass = ...g

(3 marks)

(b) The resulting mixture of magnesium oxide and silicon is added to a beaker containing hydrochloric acid. The silicon is then filtered from the solution.



(i) The magnesium oxide reacts with the hydrochloric acid and forms magnesium chloride ($MgCl_2$) solution and water.

magnesium oxide + hydrochloric acid → magnesium chloride solution + water

Write a balanced symbol equation for this reaction, including state symbols.

.....

(2 marks)

(ii) The gases produced are a mixture of several silicon hydrides.

One of the gases produced in the reaction is the silicon hydride with the formula SiH_4. The structure of this molecule is similar to methane, CH_4.

Draw a diagram to show the bonding in a molecule of SiH_4. Represent the electrons as dots and crosses and only show the outer shell (energy level) electrons.

(1 mark)

(iii) A sample of a different silicon hydride was found to contain 1.4 g of silicon and 0.15 g of hydrogen.

Calculate the formula of this silicon hydride. You must show all your working to gain full marks.

Relative atomic masses: H = 1; Si = 28

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(4 marks)

QUESTION 15 CONTINUES ON THE NEXT PAGE

(iv) The silicon hydrides react immediately they come into contact with oxygen in the air. They burst into flames with a small explosion and give out energy.

Which letter, **A** to **H**, best describes this reaction?

Energy involved in breaking and forming bonds	Activation energy	Rate of reaction	Letter
The energy released from forming new bonds is greater than the energy needed to break existing bonds	high	fast	**A**
		slow	**B**
	low	fast	**C**
		slow	**D**
The energy needed to break existing bonds is greater than the energy released from forming new bonds	high	fast	**E**
		slow	**F**
	low	fast	**G**
		slow	**H**

Letter.....
(1 mark)

(c) The structure of silicon is similar to the structure of diamond.

Describe the structure of silicon and explain why it has a high melting point. You may draw a diagram if this helps.

.....

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(4 marks)

15

16 **Starting** with molten iron from a blast furnace, describe and explain how steel is made.

Your description should also include reference to:

- redox reactions;
- acid-base reactions.

.....

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(5 marks)

5

TURN OVER FOR THE NEXT QUESTION

17 This label has been taken from a bottle of household ammonia solution.

Household ammonia is a dilute solution of ammonia in water. It is commonly used to remove grease from ovens and windows.

(a) The amount of ammonia in household ammonia can be found by titration.

25.0 cm^3 of household ammonia is placed in a conical flask. Describe how the volume of dilute nitric acid required to neutralise this amount of household ammonia can be found accurately by titration. Name any other apparatus and materials used.

To gain full marks you should write down your ideas in good English. Put them into a sensible order and use correct scientific words.

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(4 marks)

(b) In an experiment, it was found that 25.0 cm^3 of household ammonia was neutralised by 20.0 cm^3 of dilute nitric acid with a concentration of 0.25 moles per cubic decimetre.

The balanced symbol equation which represents this reaction is

$$NH_3\ (aq) + HNO_3\ (aq) \rightarrow NH_4NO_3\ (aq)$$

Calculate the concentration of the ammonia in this household ammonia in moles per cubic decimetre.

.....

.....

.....

.....

Concentration = ... moles per cubic decimetre
(2 marks)

(c) The salt, ammonium nitrate, is formed in this reaction.

Describe, and give the result of, a chemical test which shows that ammonium nitrate contains ammonium ions.

.....

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.....

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(2 marks)

8

TURN OVER FOR THE NEXT QUESTION

18 (a) The first two members of the *homologous series* of alcohols are methanol and ethanol.

(i) What is meant by an *homologous series*?

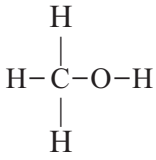
.....

.....

.....

(2 marks)

(ii) The structure of methanol, CH_3OH can be represented as shown.



Draw the structure of ethanol, C_2H_5OH.

(1 mark)

(b) Ethanol is made on a large scale by two different processes.

- Batch process: fermentation of sugar with yeast.
- Continuous process: hydration of ethene (produced from crude oil) with steam.

Compare the two processes for making ethanol in terms of:

- the rate of reaction;
- the purity of the product;
- the use of finite resources.

.....

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(3 marks)

(c) A balanced symbol equation which represents the fermentation of sugar is

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

1800 kg of this sugar were completely fermented in a batch reaction.

(i) Calculate the number of moles of this sugar, $C_6H_{12}O_6$, that were fermented.

Relative atomic masses: H = 1; C = 12; O = 16.

.....

.....

Answer = ... moles
(2 marks)

(ii) Calculate the number of moles of ethanol produced in this reaction.

.....

Answer = ... moles
(1 mark)

(iii) Calculate the volume, at room temperature and pressure, of carbon dioxide gas produced in this reaction.

1 mole of any gas has a volume of 24 dm^3 at room temperature and pressure.

.....

.....

Answer = ... dm^3
(2 marks)

(d) Clenbuterol is sometimes used illegally as a growth hormone. Clenbuterol molecules contain an alcohol group.

(i) Name **one** instrumental method of analysis that could be used to detect clenbuterol.

.....
(1 mark)

(ii) Describe **two** advantages of using modern instrumental methods of analysis.

1 .....

.....

2 .....

.....
(2 marks)

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END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE