Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Secondary Education
Higher Tier
January 2010

Additional Science
Unit Chemistry C2

CHY2H

H

Chemistry
Unit Chemistry C2

Written Paper

Monday 18 January 2010 9.00 am to 9.45 am

For this paper you must have:
- the Data Sheet (enclosed).

You may use a calculator.

Time allowed
- 45 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 45.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

Advice
- In all calculations, show clearly how you work out your answer.

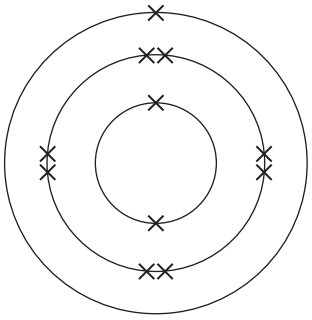
Answer **all** questions in the spaces provided.

1 Sodium chloride is a raw material.

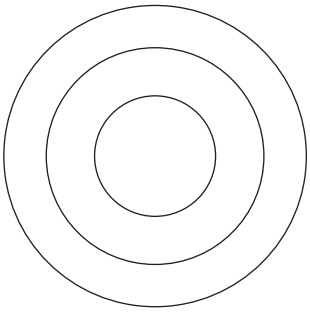
1 (a) The electronic structure of a sodium atom is shown below.

Complete the diagram for the electronic structure of a chlorine atom. A chlorine atom has 17 electrons.

Sodium atom



Chlorine atom



(1 mark)

1 (b) When sodium and chlorine react to form sodium chloride they form sodium ions (Na^+) and chloride ions (Cl^-).

How does a sodium atom change into a sodium ion?

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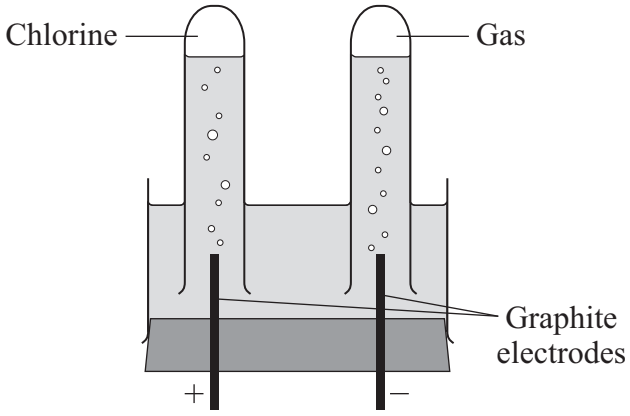
(2 marks)

1 (c) The diagram shows apparatus used in a school laboratory for the electrolysis of sodium chloride solution.



The solution contains sodium ions (Na^+), chloride ions (Cl^-), hydrogen ions (H^+) and hydroxide ions (OH^-).

1 (c) (i) Why do chloride ions move to the positive electrode?

.....

(1 mark)

1 (c) (ii) Name the gas formed at the negative electrode.

.....

(1 mark)

Question 1 continues on the next page

1 (d) Chlorine and chlorine compounds are used to bleach wood pulp that is used to make paper.

The article below is from a newspaper.

> Local people have been protesting outside a paper factory. They say:
> 'We want the company to stop using chlorine compounds. Chlorine compounds release poisons into the environment. The company should use safer compounds.'
>
> The company replied:
> 'Chlorine has been used safely for many years to treat drinking water. Only tiny amounts of chlorine are released, which cause no harm. Using other compounds will be more expensive and may put us out of business.'

1 (d) (i) Why are some local people worried about the use of chlorine compounds?

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.....

(1 mark)

1 (d) (ii) Why might other local people want the company to continue to use chlorine compounds?

.....

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(1 mark)

1 (d) (iii) It is decided to have an enquiry.
Why should this be done by independent scientists?

.....

.....

(1 mark)

8

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

2 Read the article.

In the late eighteenth century the French scientist Nicolas Leblanc invented a process to change sodium chloride into sodium carbonate.

The main steps in the original process were:

Step 1. Sodium chloride was reacted with sulfuric acid to make sodium sulfate. Hydrogen chloride was formed and escaped into the atmosphere. The hydrogen chloride damaged plants over a wide area around the factory.

Step 2. The sodium sulfate was heated with limestone and coal. A solid mixture was formed which contained sodium carbonate, calcium sulfide and unreacted coal. The calcium sulfide gave off a very unpleasant smell.

Step 3. The sodium carbonate was dissolved in water and separated from the insoluble calcium sulfide and unreacted coal.

Step 4. Crystals of sodium carbonate were obtained from the solution of sodium carbonate.

The process was later improved.

- The hydrogen chloride produced in **Step 1** was changed into chlorine which was used to make bleach.
- The calcium sulfide produced in **Step 2** was converted into sulfur. This sulfur was used to make sulfuric acid.

2 (a) The symbol equation for the reaction in **Step 1** is shown below.

$$2NaCl(s) + H_2SO_4(l) \rightarrow Na_2SO_4(s) + 2HCl(g)$$

What property of hydrogen chloride allowed it to escape into the atmosphere?

.....

(1 mark)

2 (b) The insoluble solids, calcium sulfide and unreacted coal were separated from the sodium carbonate solution in **Step 3**.

Suggest how this was done.

.....

.....

(1 mark)

2 (c) Sodium carbonate crystals were obtained from sodium carbonate solution in **Step 4**.

Suggest how this was done.

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.....

(1 mark)

2 (d) It has been stated that: 'the Chemical Industry can turn problems into profit'.

State **two** problems with the original process and explain how they were turned into profit.

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(4 marks)

7

Turn over for the next question

3 (a) The table gives information about two isotopes of hydrogen, hydrogen-1 and hydrogen-2.

	Hydrogen-1	**Hydrogen-2**
Atomic number	1	1
Mass number	1	2

An atom of hydrogen-1 is represented as: $^{1}_{1}\mathbf{H}$

Show how an atom of hydrogen-2 is represented.

(1 mark)

3 (b) (i) Calculate the relative formula mass (M_r) of water, H_2O

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

.....

.....

Relative formula mass (M_r) = ...

(1 mark)

3 (b) (ii) Simple molecules like water have low boiling points.

Explain why, in terms of molecules.

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(2 marks)

3 (c) Molecules of heavy water contain two atoms of hydrogen-2 instead of two atoms of hydrogen-1.

Explain why a molecule of heavy water has more mass than a normal water molecule. You should refer to the particles in the nucleus of the two different hydrogen atoms in your answer.

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(2 marks)

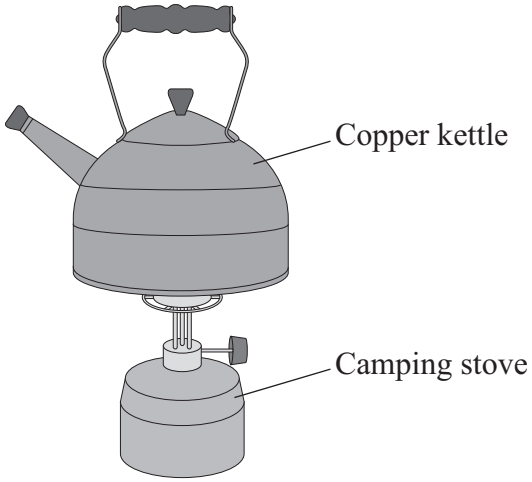
6

Turn over for the next question

4 The picture shows a copper kettle being heated on a camping stove.

Copper is a good material for making a kettle because:

- it has a high melting point
- it is a very good conductor of heat.



4 (a) Explain why copper, like many other metals, has a high melting point.
You should describe the structure and bonding of a metal in your answer.

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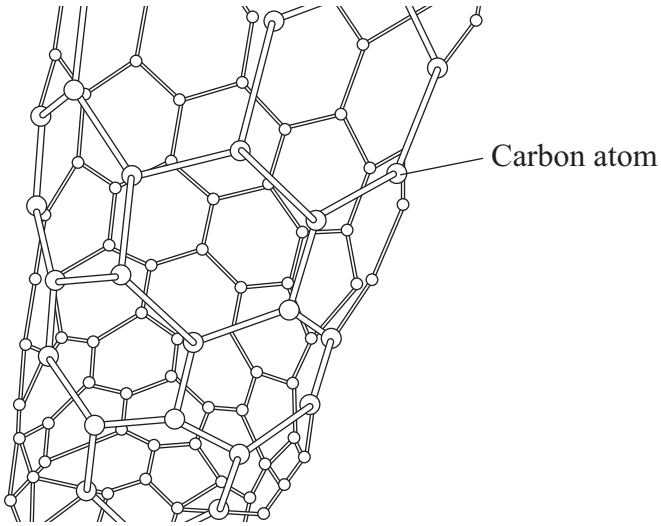
(4 marks)

4 (b) An aeroplane contains many miles of electrical wiring made from copper. This adds to the mass of the aeroplane.

It has been suggested that the electrical wiring made from copper could be replaced by lighter carbon nanotubes.

The diagram shows the structure of a carbon nanotube.



4 (b) (i) What does the term 'nano' tell you about the carbon nanotubes?

.....

.....

(1 mark)

4 (b) (ii) Like graphite, each carbon atom is joined to three other carbon atoms.

Explain why the carbon nanotube can conduct electricity.

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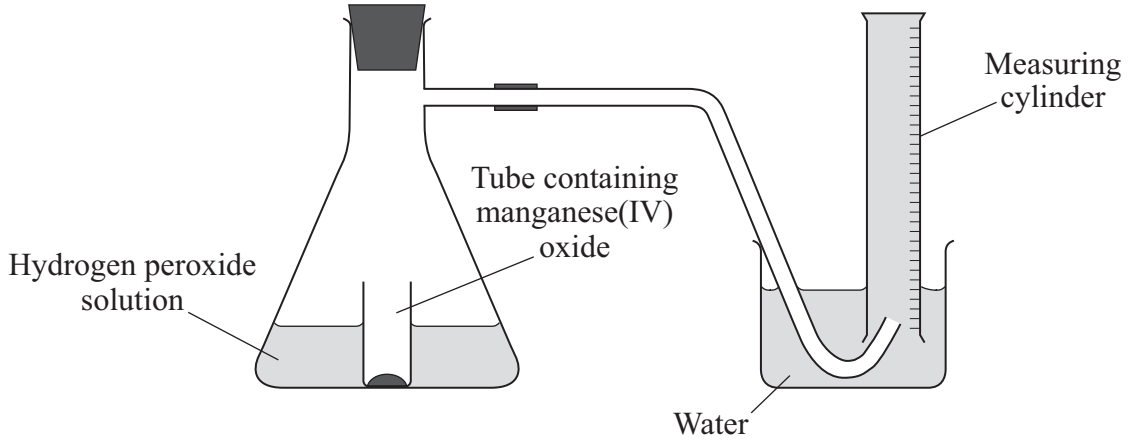
(2 marks)

7

5 A student investigated the effect of temperature on the decomposition of hydrogen peroxide. Hydrogen peroxide decomposes to oxygen and water when a manganese(IV) oxide catalyst is added.

The student measured the time taken to collect 5 cm^3 of oxygen gas.

The apparatus shown below was used for the investigation. The reaction was started by shaking the flask so that the manganese(IV) oxide and hydrogen peroxide were mixed.



The student did the investigation at two different temperatures. All the other variables were kept constant.

The student's results are shown in the table.

Temperature of the hydrogen peroxide solution in °C	**Volume of oxygen collected in cm^3**	**Time taken to collect the oxygen in seconds**	**Rate of reaction in cm^3 per second**
20	5	40	0.125
25	5	25	

5 (a) (i) Calculate the rate of reaction at 25 °C.

.....

Rate of reaction = ... cm^3 per second

(2 marks)

5 (a) (ii) The teacher said that the student should repeat the investigation to get more results.

Suggest why.

.....

.....

(1 mark)

5 (b) The student concluded that:

'the rate of reaction increases when the temperature is increased'.

Explain, in terms of particles, why the rate of reaction increases.

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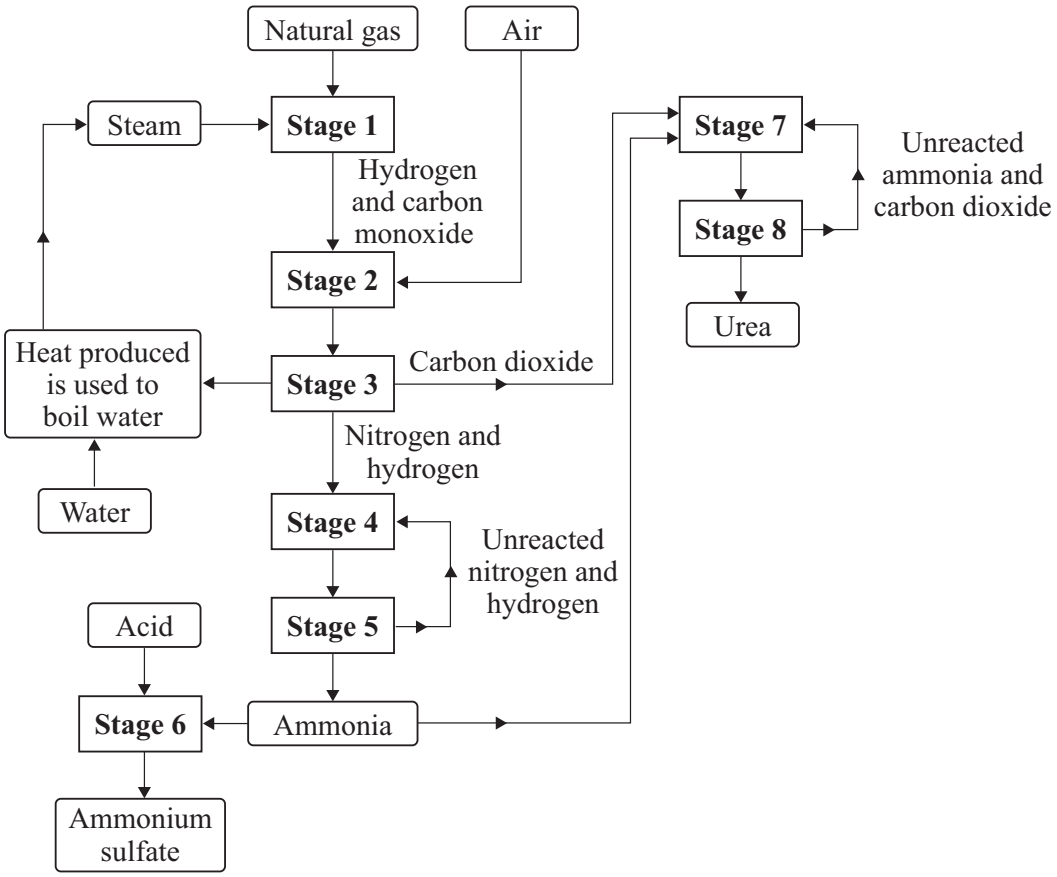
(2 marks)

5

Turn over for the next question

6 Ammonium sulfate and urea are made from ammonia.
These compounds are used by farmers.

The flow diagram shows the stages to make ammonium sulfate and urea.



6 (a) Give **two** examples from the flow diagram of efficient use of energy or materials.

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.....

(2 marks)

6 (b) Why do farmers use ammonium compounds?

.....

.....

(1 mark)

6 (c) The equation for a reaction that takes place in **Stage 1** is given below.

Balance this equation by putting the correct number on the dotted line.

$$CH_4 + H_2O \rightarrow CO + \ldots\ldots H_2$$

(1 mark)

6 (d) The equation for the reaction in **Stage 4** is shown below.

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

The forward reaction is exothermic.

6 (d) (i) Explain why, at equilibrium, the yield of ammonia for this reaction is greater at **low** temperatures.

.....

.....

(1 mark)

6 (d) (ii) Explain why a high temperature, 450 °C, is used in **Stage 4**.

.....

.....

(1 mark)

6 (e) Name the acid used in **Stage 6** to make ammonium sulfate.

..... acid

(1 mark)

Question 6 continues on the next page

6 (f) **Stage 7** can be represented by this equation.

$$\underset{\text{ammonia}}{2NH_3} + CO_2 \rightarrow \underset{\text{urea}}{NH_2CONH_2} + H_2O$$

The table gives the relative formula masses (M_r) of the reactants and the products for this reaction.

Formula of reactant or product	**Relative formula masses (M_r)**
NH_3	17
CO_2	44
NH_2CONH_2	60
H_2O	18

Use information from the table to help you answer (f)(i) and (f)(ii).

6 (f) (i) One factory produces 6000 g of urea each second. Calculate the mass of ammonia needed to make 6000 g of urea.

.....

.....

.....

.....

Mass of ammonia needed = ... g

(3 marks)

6 (f) (ii) Percentage atom economy can be calculated using:

$$\text{Percentage atom economy} = \frac{M_r \text{ of useful product}}{\text{total } M_r \text{ of all reactants added together}} \times 100\%$$

Calculate the percentage atom economy for the reaction in **Stage 7**

.....

.....

.....

Percentage atom economy = ... %

(2 marks)

12

END OF QUESTIONS