OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

CHEMISTRY (SALTERS) 2851

Minerals to Medicines

Friday **18 JANUARY 2002** Morning 2 hours

Candidates answer on the question paper.
Additional materials:
Scientific calculator
Data Sheet for Chemistry (Salters)

Candidate Name	Centre Number	Candidate Number

TIME 2 hours

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You are advised to show all the steps in any calculations.
- You may use the *Data Sheet for Chemistry (Salters).*

FOR EXAMINER'S USE		
Qu	Max.	Mark
1	13	
2	29	
3	32	
4	26	
5	20	
TOTAL	120	

This question paper consists of 16 printed pages.

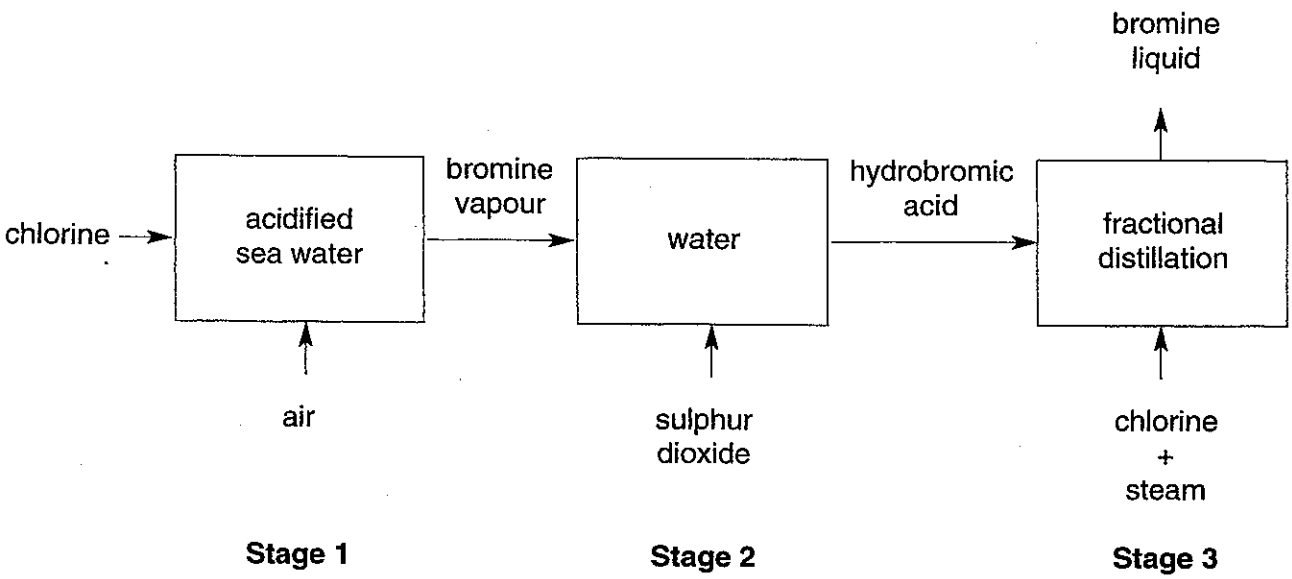
Registered Charity Number:1066969
[Turn over

1 Bromine was discovered by accident in 1826. Antoine Balard was experimenting with sea water and noticed the yellow-orange colour that bromine gives when chlorine gas is bubbled through sea water.

(a) Write an ionic equation for the reaction of chlorine with bromide ions in sea water. Include state symbols in your equation.

.....[3]

This reaction remains at the heart of the modern commercial production of bromine from sea water. One method of making bromine is described in the flow diagram shown below.



(b) In **Stage 1**, air is blown through the sea water after the chlorine has been added. Suggest a reason for blowing air through this mixture.

.....[1]

(c) In **Stage 2**, bromine vapour is treated with sulphur dioxide and water to produce an aqueous solution containing bromide ions according to the equation below.

$$\mathbf{Br}_2 + \mathbf{SO}_2 + 2H_2O \rightarrow 2\mathbf{Br}^- + \mathbf{SO}_4^{2-} + 4H^+$$

Oxidation state .... [4]

(i) For the **Br** and **S** atoms in bold, write their oxidation states on the lines provided above.

(ii) Give the formula of the reducing agent in this reaction. Explain your answer.

Formula of reducing agent .....

Explanation .....

.....[2]

(iii) Bromide ions are hydrated in aqueous solution. Draw a diagram to show how a water molecule interacts with a bromide ion.

[2]

(d) Great care has to be taken when storing or transporting liquid bromine. Give a reason for this.

.....

.....[1]

[Total: 13]

2 In the early years of the twentieth century, a chemist called Niewland discovered how ethyne, C_2H_2, could be used for manufacturing a synthetic rubber, now known as neoprene.

(a) Ethyne was originally produced from calcium carbide, a white solid. Calcium carbide, CaC_2, is made by heating calcium oxide with coke at a very high temperature. Carbon monoxide is also formed.

(i) Complete and balance the equation for the formation of calcium carbide and carbon monoxide. State symbols are not required.

CaO + ... C → ..... + ... [2]

(ii) Calculate the maximum mass of calcium carbide that could be made from 1 tonne of coke (carbon).

[A_r: C, 12; Ca, 40]

Answer ..... tonnes [4]

(b) The production of calcium carbide from calcium oxide and carbon was a very expensive process. Suggest a reason for this.

.....[1]

(c) When calcium carbide is mixed with water, ethyne gas is produced. The gas is insoluble in water. The equation for the reaction is shown below.

$$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$$ **Equation 2.1.**

(i) Draw a labelled diagram showing how you could prepare and collect a few test-tubes of ethyne gas in the laboratory.

[4]

(ii) In **Equation 2.1** water acts as an acid. When water acts as an acid a base is formed. This base is called the conjugate base.

1. Describe how water acts as an acid.

.....

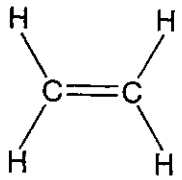
.....[2]

2. Give the formula of the conjugate base formed from water.

.....[1]

(iii) Ethyne is an unsaturated compound containing a carbon-carbon triple bond. The triple bond reacts in a similar way to the carbon-carbon double bond in ethene.

ethyne



ethene

Bromine can react with ethyne to form a completely saturated compound, $C_2H_2Br_4$.

1. Give the structural formula of this compound.

[1]

2. Give the systematic name for this compound.

.....[2]

(iv) Name the **type** of mechanism by which ethene reacts with bromine.

.....[2]

(v) Suggest why bromine molecules are attracted more strongly to ethyne than to ethene.

.....

.....

.....[2]

(d) Carbon monoxide and calcium hydroxide are co-products of the process and the manufacturers of ethyne had no use for them at the time. The carbon monoxide was burnt and the resulting gas, carbon dioxide, released into the atmosphere. The calcium hydroxide was stored in heaps and eventually used to make other chemicals.

State and briefly explain an environmental problem caused by each of the following:

(i) releasing carbon dioxide into the atmosphere,

.....

.....

.....[2]

(ii) storing calcium hydroxide.

.....

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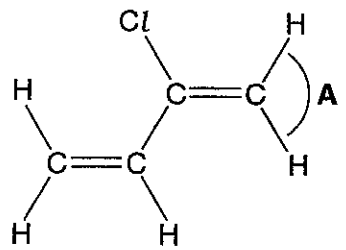
.....[2]

(e) Ethyne was used to produce another unsaturated compound commonly called chloroprene. The structure of chloroprene is shown below.



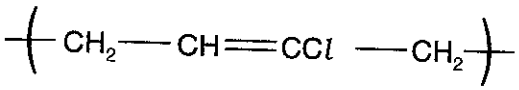
chloroprene

(i) Give an approximate value for the bond angle, labelled **A**, in the chloroprene molecule above .

Bond angle **A** ..... [1]

For Examiner's Use

(ii) Chlororoprene polymerises to give the polymer, neoprene. The repeating unit of neoprene is shown below.



repeating unit of neoprene

Draw two possible structures for the neoprene repeating unit and use them to explain why neoprene shows *cis-trans* (geometric) isomerism.

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.....[3]

[Total: 29]

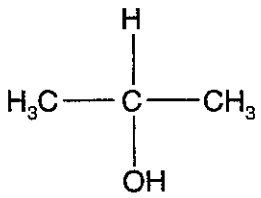
3 Ethanoic acid is an important chemical intermediate in the manufacture of a wide range of products such as acrylic fibres and paints, and some agrochemicals. It was originally made by oxidising ethanol.

(a) (i) Give the reagents and the conditions for the laboratory oxidation of ethanol to ethanoic acid.

Reagents .....[2]

Conditions .....[1]

(ii) Some alcohols do not form carboxylic acids when they are oxidised in this way. Give the formula of the organic product formed when propan-2-ol is oxidised.



propan-2-ol **oxidation product** [1]

(b) Ethanol and ethanoic acid, CH_3COOH, both contain an –OH group.

(i) Draw the full structural formulae for ethanol and ethanoic acid.

ethanol **ethanoic acid**

[2]

(ii) Ethanoic acid dissolves in water to form an acidic solution whereas ethanol dissolves in water to form a neutral solution. Explain why the –OH group shows acid properties in ethanoic acid but not in ethanol.

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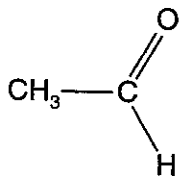
.....[3]

An intermediate compound in the oxidation of ethanol is ethanal.



ethanal

(c) Describe and explain how you would use an infrared spectrum to show if any traces of ethanoic acid are present in ethanal.

A table of characteristic infrared absorptions is given in the Data Sheet accompanying this paper.

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.....[3]

Some early manufacturing processes for ethanoic acid involved catalytic oxidation of hydrocarbons such as butane. A mixture of oxidation products, including ethanoic acid, was formed.

(d) Suggest **two** reasons why the formation of a mixture of products made the early processes expensive.

.....

.....[2]

(e) Recently, chemists have discovered ways of controlling such reactions using both heterogeneous and homogeneous catalysis.

In the first stage of the newer process, methane (natural gas) reacts with steam in the presence of a heterogeneous catalyst. The equation for the reaction is given below.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$ **Equation 3.1**

(i) Suggest the **physical** state of the catalyst in this reaction.

.....[1]

(ii) What effect, if any, will increasing the pressure have on the **rate** of reaction?

.....[1]

(iii) What effect, if any, will increasing the pressure have on the **yield** of carbon monoxide?

.....[1]

(f) Carbon monoxide (produced in **Equation 3.1**) then reacts with methanol to form ethanoic acid. Recently, chemists have developed an improved catalyst for this reaction involving a compound of the element iridium. This compound is a homogeneous catalyst.

(i) Iridium is element number 77. In which block of the Periodic Table is it?

.....[1]

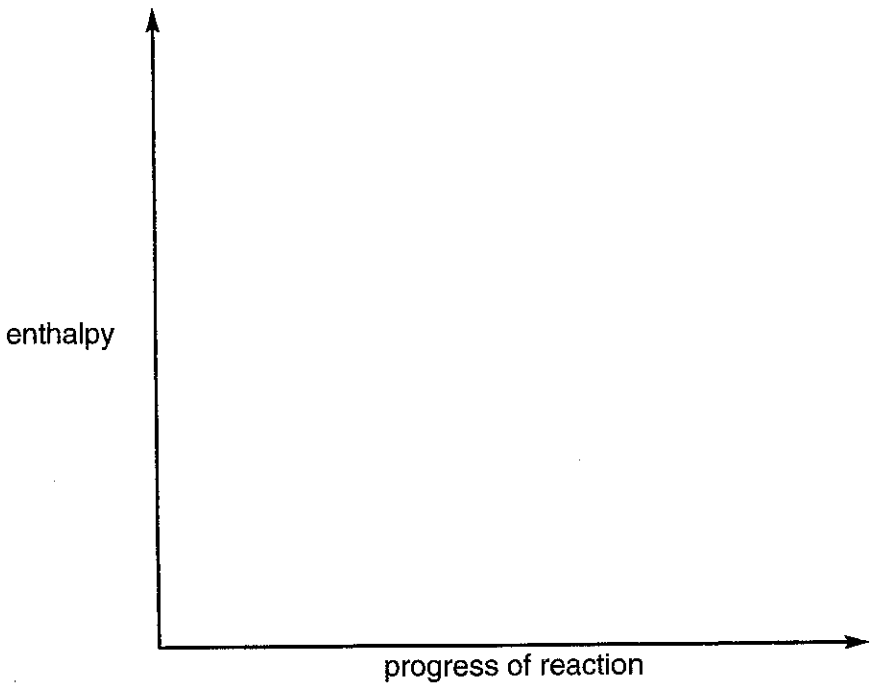
(ii) Explain what the term *homogeneous catalyst* means.

.....

.....[2]

(iii) Complete the enthalpy profile diagram below to explain how a homogeneous catalyst speeds up an **exothermic** chemical reaction. The uncatalysed reaction occurs in a single step. Include the following labels:

- activation enthalpy of uncatalysed reaction,
- activation enthalpy of catalysed reaction,
- enthalpy change of reaction,
- intermediate.



[6]

For Examiner's Use

(g) One use of ethanoic acid is in lime descalers because it reacts with calcium carbonate (lime-scale). The equation is given below.

$$CaCO_3 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + H_2O + CO_2$$

In an experiment it is found that 20.0 cm^3 aqueous ethanoic acid are neutralised by 0.100 g of solid $CaCO_3$.
[A_r: C, 12.0; O, 16.0; Ca, 40.1]

(i) Calculate the number of moles of $CaCO_3$ that will neutralise this ethanoic acid.

Answer .....mol [2]

(ii) Deduce the number of moles of ethanoic acid present in the 20.0 cm^3 aqueous ethanoic acid.

Answer .....mol [1]

(iii) Calculate the concentration in mol dm^{-3} of the ethanoic acid solution. Give your answer to an appropriate number of significant figures.

Answer ..... mol dm^{-3} [3]

[Total: 32]

4 In the 1980s many horses in the US died after eating the leaves of the white snakeroot plant. The leaves contained a suspected toxin, called 'tremetol'.

(a) Chemists found that 'tremetol' was in fact a mixture of three different compounds. Describe how you would use thin-layer chromatography to show this.

(In this question 1 mark is available for the quality of written communication.)

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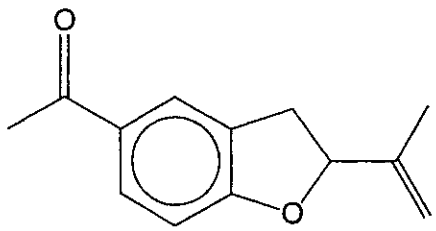
.....[6]

(b) All three compounds in tremetol are ketones. The most abundant of these was named tremetone. The skeletal structure of tremetone is shown below.



tremetone

(i) On the skeletal structure above, draw a circle around the **ketone** group. [1]

(ii) Name **two** other functional groups present in tremetone.

..... and ..... [2]

(iii) Mass spectrometry was used to confirm the molecular mass of tremetone.
It also helped to show the structure of tremetone.
Describe how the printout from a mass spectrometer is used to determine the molecular mass and structure of an organic compound.

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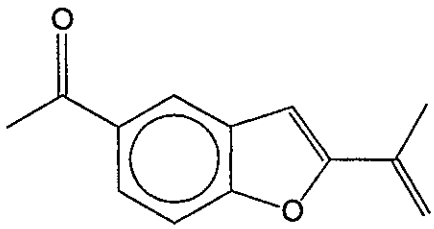
..... [4]

(c) Tremetone slowly changes into the non-toxic compound **A**. The structure of **A** is shown below.



compound **A**

(i) Underline the **type** of reaction in which compound **A** is formed from tremetone.

addition **elimination** **hydrolysis** **substitution**

[1]

(ii) A chemist reacted compound **A** with hydrogen in an attempt to convert it back to tremetone. What conditions would be used in the laboratory to do this?

.....[2]

(iii) The main product of the hydrogenation reaction in **(ii)** was **not** tremetone. Draw a possible skeletal formula for this product.

[2]

(d) Tremetone itself is not toxic, but it can be converted in the body into a toxin. One of the effects of this toxin is to increase the acidity of the blood stream. Changes in blood acidity are controlled by the reactions given in **Equations 4.1 and 4.2**.

$$H^+(aq) + HCO_3^-(aq) \rightleftharpoons H_2CO_3(aq) \qquad \textbf{Equation 4.1}$$

$$H_2CO_3(aq) \rightleftharpoons H_2O(l) + CO_2(aq) \qquad \textbf{Equation 4.2}$$

In blood

(i) Use these equations and Le Chatelier's Principle to explain how the body reduces excess acidity.

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.....[4]

(ii) If the pH of blood falls below 7, a life threatening situation arises. Patients with this condition are given a solution that contains hydrogencarbonate ions. Explain how hydrogencarbonate ions, HCO_3^-, will help.

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.....[2]

(iii) Suggest how a high concentration of carbon dioxide in blood eventually returns to normal.

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.....[2]

[Total: 26]

5 Deodorant sprays used to be powered by CFCs. The use of CFCs in aerosols was banned in Europe in the early 1990s. Most aerosol products now use butane or propane as the propellant. Since changing the propellant there have been many accidents including extensive burn damage and death from hydrocarbon poisoning. There were no such accidents whilst CFCs were used as propellants.

(a) Draw the structure of the CFC chlorotrifluoromethane to show the three-dimensional shape of the molecule.

[2]

(b) Alkanes and CFCs can be used as aerosol propellants because of their volatility.

Name the **type** of intermolecular force present in **butane**.

.....[1]

(c) **(i)** Draw a digram to show whether **chlorotrifluoromethane** has any polar bonds. [Electronegativity values: C, 2.6; F, 4.0; Cl, 3.2]

[2]

(ii) State with your reasons whether the molecule of chlorotrifluoromethane is polar or non-polar.

.....

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.....[2]

(iii) Name the **types** of intermolecular force between the molecules of chlorotrifluoromethane.

.....

.....[2]

(d) State **two** advantages that CFCs had over alkanes as propellants.

.....

.....[2]

(e) CFCs were banned because of the problem they caused to the ozone layer in the upper atmosphere.

Give a balanced equation for each of the following processes, indicating on the equation arrow if ultraviolet radiation is involved.

(i) The formation of ozone in the upper atmosphere.

(ii) The natural destruction of ozone in the upper atmosphere.

[3]

(f) Describe and explain how CFCs have had such a devastating effect on the ozone layer.

(In this question 1 mark is available for the quality of written communication.)

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.....[6]

[Total: 20]