Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/04**

Paper 4 Structured Questions

For Examination from 2007

SPECIMEN PAPER

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1 hour 45 minutes

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

You may lose marks if you do not show your workings or if you do not use appropriate units.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **17** printed pages and **1** blank page.

Section A

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

1 Bromine can react with methanoic acid according to the following equation.

$$Br_2(aq) + HCO_2H(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$

(a) **(i)** What maximum volume of gas, measured at r.t.p., would be produced by reacting 3.2 g of bromine?

(ii) Suggest how the rate of the reaction might be followed.

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[5]

(b) The graph opposite contains information about this reaction.

(i) What evidence is there to suggest that this reaction is first order with respect to bromine?

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(ii) Write a simple equation relating the rate of reaction to the concentration of bromine under these conditions.

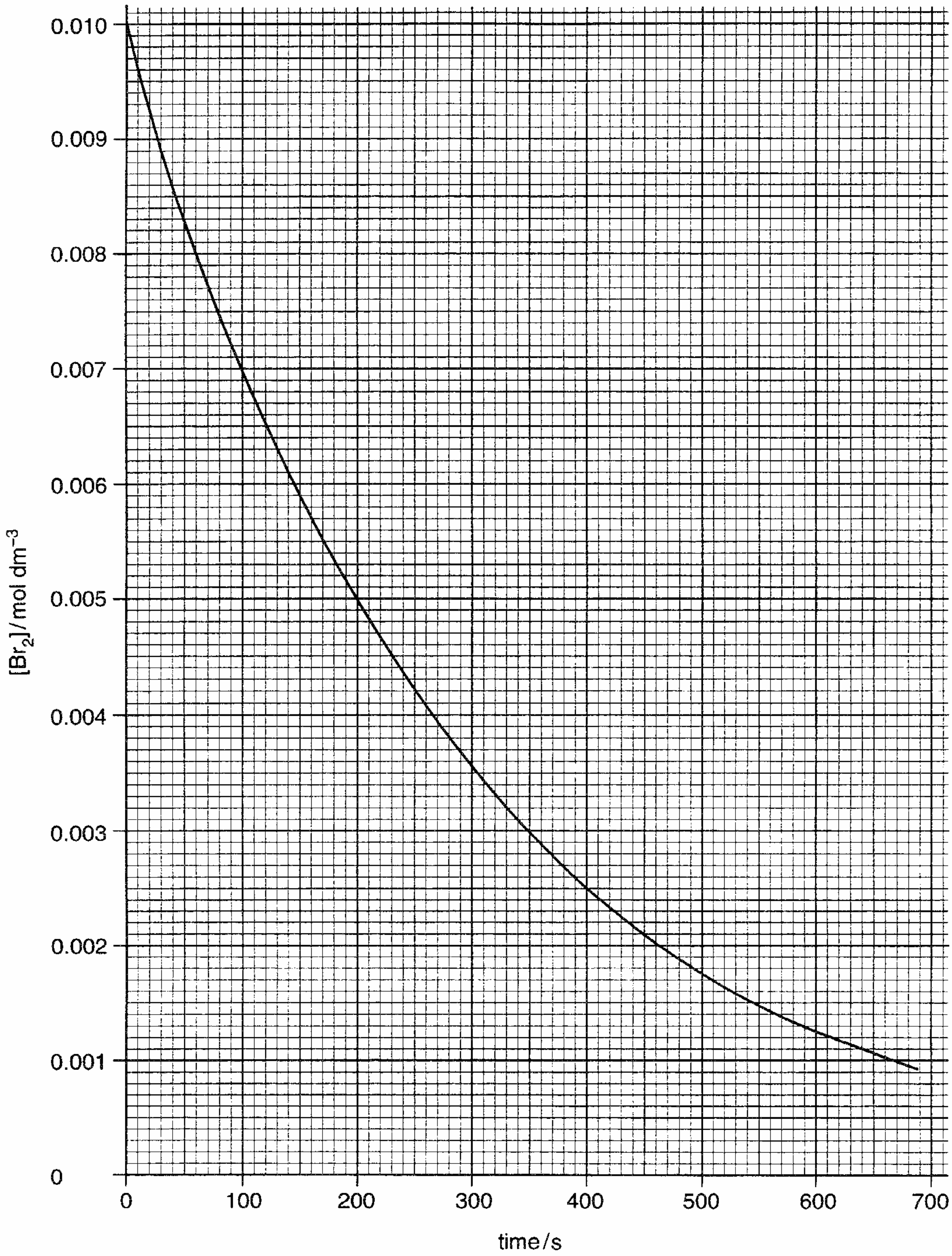
....

(iii) Calculate the half-life of this reaction.

[5]

[Total : 10]

For Examiner's Use



2 **(a)** Define the *standard enthalpy change of formation* of a compound.

....

.... [2]

The standard enthalpy change of formation of $SiCl_4$(g) is –610 kJ mol^{-1}.

The standard enthalpy changes of atomisation of the elements silicon and chlorine are +338 and +122 kJ mol^{-1} of atoms respectively.

(b) Use these values to construct an energy cycle to show the formation of $SiCl_4$(g).

[2]

(c) **(i)** Hence calculate the average bond energy of the Si-Cl bond from these data.

(ii) Suggest why the calculated value is different from the value given in the *Data Booklet*.

....

....

[2]

For Examiner's Use

(d) Pure silicon is made by reducing $SiCl_3H$ with hydrogen at a high temperature.

(i) Construct a balanced equation for this reaction.

....

(ii) The bond energy of the Si-Br bond is 298 kJ mol^{-1}. Use this value, and other bond energy values given in the *Data Booklet* to suggest whether the reaction between $SiBr_3H$ and hydrogen would be more or less endothermic than the reaction between $SiCl_3H$ and hydrogen.

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(iii) State a use of pure silicon.

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[4]

[Total : 10]

For Examiner's Use

3 Agricultural lime is manufactured from limestone (calcium carbonate) by first heating the rock to a high temperature in a lime kiln. The product is allowed to cool and a calculated amount of water is added. A highly exothermic reaction takes place and a white powder called 'slaked lime' is produced.

(a) Write balanced equations for these **two** reactions.

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.... [2]

(b) Give **two** reasons why lime is used in agriculture.

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.... [2]

(c) How does the temperature required to decompose the carbonates of Group II elements vary down the group, and why is this so?

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.... [3]

(d) The mineral dolomite is a double carbonate of magnesium and calcium, with the formula $CaMg(CO_3)_2$. When 1.000 g of an impure sample of dolomite was completely dissolved in an excess of hydrochloric acid, 0.450 g of carbon dioxide was given off.

(i) Write a balanced equation for the reaction.

....

(ii) Calculate the percentage purity of the dolomite.

[3]

[Total : 10]

For Examiner's Use

4 **(a)** State the electronic configurations of

(i) the Cu atom, ...

(ii) the Cu^{+} ion, ...

(iii) the Cu^{2+} ion. ....

[2]

(b) Explain the origin of colour in transition metal compounds, and use your explanation to suggest why copper(I) chloride is white, whereas copper(II) chloride is blue.

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.... [4]

(c) **(i)** Write equations to show the reactions that occur when dilute ammonia solution is slowly added to a solution of $CuCl_2$ until the ammonia is in excess.

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(ii) What type of chemical reaction is occurring? Explain your answer.

....

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....

[4]

[Total: 10]

For Examiner's Use

5 The elements in Group VII show trends in a number of their physical and chemical properties.

(a) Explain the trend in boiling points of the elements as shown.

element	boiling point/°C
chlorine	-35
bromine	+59
iodine	+184

....

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....

.... [2]

(b) There are also clear trends in both the H-*X* bond energy and the E^{θ} values for the cell ½X_2(aq)/X^-(aq), where *X* = C*l*, Br, I.

Use relevant data from the *Data Booklet* to describe and explain each of the following. Give an equation for each reaction that occurs.

(i) The reactions of the halide ions with concentrated sulphuric acid.

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For Examiner's Use

(ii) The action of heat on the hydrogen halides.

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[8]

[Total : 10]

For Examiner's Use

6 An organic compound, **A**, has the composition by mass C, 40.0%; H, 6.65%; O, 53.3%.

(a) Show that the empirical formula of **A** is CH_2O.

[1]

(b) **A** shows the following properties or reactions. State what can be deduced about **A** from each of these.

(i) It is optically active.

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....

(ii) It gives a brisk effervescence with aqueous sodium carbonate.

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....

(iii) It gives a yellow precipitate when warmed with alkaline aqueous iodine.

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....

[3]

(c) Suggest an identity for **A** and draw its displayed formula.

[1]

(d) Give the displayed formula of the organic product formed when **A** is warmed with acidified potassium dichromate(VI).

[1]

For Examiner's Use

(e) When **A** is warmed with concentrated sulphuric acid, a cyclic compound of molecular formula $C_6H_8O_4$ can be isolated.

Suggest a displayed formula for this cyclic compound, and state what functional group is present in the molecule.

[2]

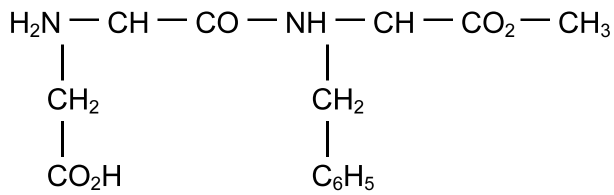
(f) **A** has a non optically active isomer, **B**. Under the reaction conditions described in **(e)**, compound **B** produces compound **C**, $C_3H_4O_2$. Suggest a structure for **C**.

[2]

[Total : 10]

For Examiner's Use

7 *Aspartame* is a synthetic sweetening agent that is 180 times as sweet as sugar.



aspartame

(a) **(i)** Name **four** different functional groups in the *aspartame* molecule.

1 .... 2 ....

3 .... 4 ....

(ii) Identify **two** functional groups in *aspartame* which contribute to its solubility in water. Give a reason for your answer.

1 .... 2 ....

Reason ....

....

[4]

(b) **(i)** Suggest conditions and reagents that could be used to hydrolyse *aspartame* into its constituent parts.

....

....

(ii) Draw the structural formulae of all of the organic molecules obtained by hydrolysing *aspartame*.

[5]

(c) Suggest why *aspartame* is not used as a sweetening agent in baked products.

.... [1]

[Total : 10]

Section B – Applications of Chemistry
Answer **all** the question in the spaces provided.

8 **(a)** Explain how protein synthesis occurs in cells, including in your answer the role of ribosomes.

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.... [6]

(b) Explain why the enzyme lysozyme, which consists of 129 amino acid residues, requires a triplet code of 393 bases.

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.... [2]

(c) **(i)** Name a disease brought about by a mutation in the DNA of the individual.

....

(ii) Give a symptom of the disease.

....

....

[2]

[Total : 10]

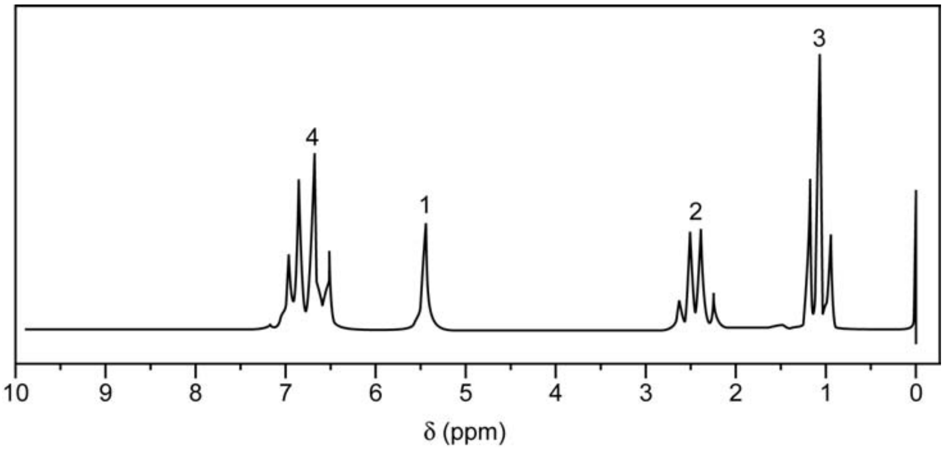
For Examiner's Use

9 **(a)** An aromatic compound **D,** of M_r 122, is a possible sex attractant for insects. It has the following composition by mass: C, 78.7%; H, 8.2%; O, 13.1%.

What is the molecular formula of **D**?

[3]

(b) The NMR spectrum of **D** is shown below.



Identify the parts of the molecule responsible for each group of peaks. Use your answer to deduce a structure for **D**, explaining your reasoning.

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....

.... [5]

For Examiner's Use

(c) Explain what effect you would expect the addition of a small amount of D_2O to have on the NMR spectrum of **D**.

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.... [2]

(d) An isomer of **D** shows no effect on the NMR spectrum on adding D_2O.

Draw the structure of the isomer and suggest how its NMR spectrum would differ from that of **D**.

....

.... [3]

[Total : 13]

10 Read the passage about the production of ethanol for fuel, and then answer the questions.

Sugar cane is the world's largest source of fermentation ethanol. Ethanol can be produced by converting the starch content of biomass feedstocks, such as sugar cane, into alcohol. Yeast is used to break down the complex sugars of starch into simpler sugars, which are fermented to form ethanol. A further advantage is that bagasse, the remains of the cane after the sugar is extracted, and the tops and leaves of the sugar cane can be used as a fuel for electricity production. An efficient ethanol distillery using sugar cane by-products can therefore be self-sufficient and also generate a surplus of electricity.

There is a second process that utilises biomass feedstocks to produce ethanol. The main carbohydrate constituent of these feedstocks is cellulose, which, like starch, is a sugar polymer that can be broken down by hydrolysis into simpler sugars. The new process uses enzymatic hydrolysis or acid hydrolysis of cellulose to produce simple sugars for fermentation.

The use of bagasse as the cellulose source in the new process could allow off-season production of ethanol with very little new equipment. This process is relatively new and is not yet commercially available, but potentially can use a much wider variety of abundant, inexpensive feedstocks. Alcohol fuels have been developed in a number of African countries – Kenya, Malawi, South Africa and Zimbabwe – currently producing sugar, with others, including Mauritius, Swaziland and Zambia also having great potential.

Ethanol has different chemical properties from gasoline. Although one litre of ethanol has about two-thirds of the energy of a litre of gasoline, tuning the engine for ethanol can make up as much as half the difference. Furthermore, should there be a spill, ethanol can be dealt with more quickly and easily than gasoline.

Using ethanol even in low-level blends (e.g. E10 – which is 10% ethanol, 90% gasoline) can have environmental benefits. Tests show that E10 produces less carbon monoxide, sulphur dioxide and carbon dioxide than gasoline. Higher blends (E85 – 15% gasoline), or even neat ethanol burn with less of almost all these pollutants.

(a) Explain **two** ways in which *bagasse* can be used to reduce the cost of ethanol production.

(i) ....

....

....

(ii) ....

....

....

[2]

(b) In addition to ethanol, what other product is formed in the fermentation of sugars by yeast?

.... [1]

(c) Suggest an equation to show the hydrolysis of cellulose in *bagasse* to form fermentable sugars with the molecular formula $C_6H_{12}O_6$.

[1]

(d) Using your knowledge of chemical bonding, suggest why a spill of ethanol is more easily dealt with than a spill of gasoline.

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.... [3]

[Total : 7]

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