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

May/June 2004

1 hour 15 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 in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.
You may use a calculator.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

For Examiner's Use	
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6	
Total	

This document consists of **11** printed pages and **1** blank page.

SP (NF/GR) S60728/4

UNIVERSITY *of* CAMBRIDGE International Examinations

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

1 Magnesium is used extensively in the form of alloys as a constructional material due to its low density (1.7 g cm^{-3}, compared to 7.8 g cm^{-3} for iron). It is usually prepared by the electrolysis of magnesium chloride, $MgCl_2$, at a temperature a little above its melting point of 715 °C.

(a) Suggest the half-equation that represents the production of magnesium at the cathode during the electrolysis.

....[1]

(b) What will be the product at the other electrode?

....[1]

(c) Suggest **two** properties of its atoms that could explain why magnesium is less dense than iron.

....

....[2]

One of the reasons the melting point of magnesium chloride is quite high is because it has a fairly high lattice energy.

(d) **(i)** Explain the term *lattice energy*.

....

....

(ii) Write a balanced equation including state symbols to represent the lattice energy of magnesium chloride.

....

....[4]

(e) Suggest, with an explanation in each case, how the lattice energy of magnesium chloride might compare with that of

(i) sodium chloride, $NaCl$,

....

....

(ii) calcium chloride, $CaCl_2$.

....

....[4]

(f) Use the following data to calculate a value for the lattice energy of sodium chloride.

ΔH_f (Na*Cl*)	=	$-411\ \mathrm{kJ\,mol^{-1}}$
ΔH_{at} (Na)	=	$107\ \mathrm{kJ\,mol^{-1}}$
ΔH_{at} (C*l*)	=	$122\ \mathrm{kJ\,mol^{-1}}$
first ionisation energy of Na	=	$494\ \mathrm{kJ\,mol^{-1}}$
electron affinity of C*l*	=	$-349\ \mathrm{kJ\,mol^{-1}}$

lattice energy of NaC*l* = ... $\mathrm{kJ\,mol^{-1}}$ [3]

[Total: 15]

2 All the Group IV elements form chlorides with the formula MCl_4.

(a) Describe the bonding in, and the shape of, these chlorides.

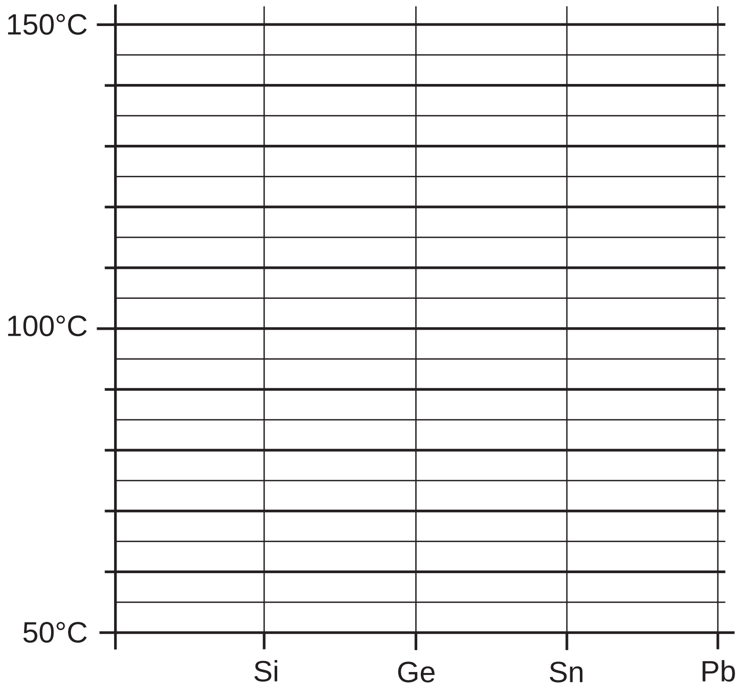
(i) bonding ....

(ii) shape ....[2]

The boiling point of lead(IV) chloride cannot be measured directly because it decomposes on heating. The following table lists the boiling points of three Group IV chlorides.

chloride	b.p. / °C
$SiCl_4$	58
$GeCl_4$	83
$SnCl_4$	114

(b) (i) Plot these data on the following axes and extrapolate your graph to predict what the boiling point of $PbCl_4$ would be if it did not decompose.



(ii) Suggest why the boiling points vary in this way.

....

....

....[4]

(c) $SiCl_4$ reacts vigorously with water whereas CCl_4 is inert.

(i) Suggest a reason for this difference in reactivity.

....

(ii) Write an equation for the reaction between $SiCl_4$ and water.

....

(iii) Suggest, with a reason, whether you would expect $GeCl_4$ to react with water.

....

....

[3]

(d) $SiCl_4$ is used to make high-purity silicon for the semiconductor industry. After it has been purified by several fractional distillations, it is reduced to silicon by heating with pure zinc.

(i) Suggest an equation for the reduction of $SiCl_4$ by zinc.

....

(ii) Use your equation to calculate what mass of zinc is needed to produce 250 g of pure silicon by this method.

mass of zinc = ... g [3]

[Total: 12]

3 By using iron and its compounds as examples, outline the different modes of action of homogeneous and heterogeneous catalysis.
Choose two examples, and for each example you should

- state what the catalyst is, and whether it is acting as a homogeneous or a heterogeneous catalyst,
- write a balanced equation for the reaction.

....

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....

....

....[8]

[Total: 8]

4 This question is about the reactions of some functional groups.

(a) **(i)** Draw the structural formula of an amide of your choice containing **four** carbon atoms.

(ii) What reagents and conditions are needed to hydrolyse this amide?

....

(iii) Write a balanced equation showing the hydrolysis of the amide whose structural formula you drew in part **(i)**.

....[4]

(b) **(i)** Draw the structural formula of an acyl chloride containing three carbon atoms.

(ii) What starting material and reagent are needed to form this acyl chloride?

....

(iii) Write a balanced equation showing the formation of an ester containing five carbon atoms from the acyl chloride you drew in part **(i)**.

....[3]

[Total: 7]

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5 **(a)** State the reagents and conditions needed to convert benzene into

(i) chlorobenzene,

....

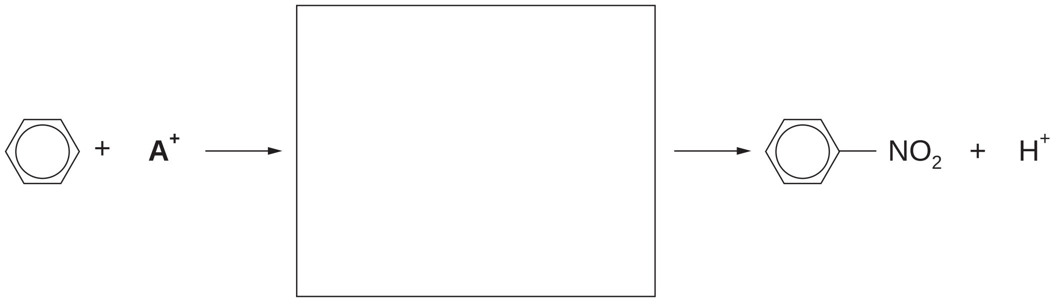
(ii) bromobenzene,

....

(iii) nitrobenzene.

....
[4]

(b) The nitration of benzene is a two-step reaction that can be represented as follows.



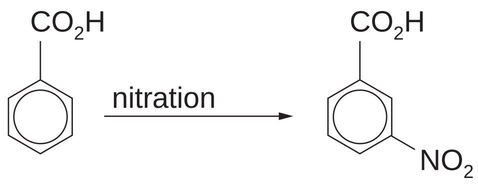
B

(i) Identify the cation **A^+**. ....

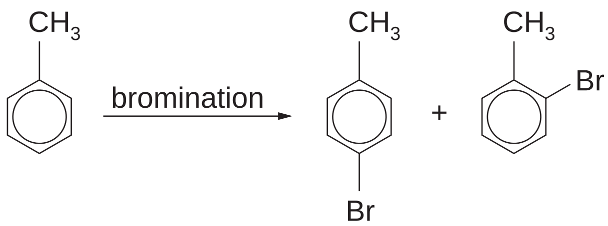
(ii) Draw the structure of the intermediate **B** in the box. [2]

(c) The position of substitution during the electrophilic substitution of arenes is determined by the nature of the group already attached to the ring.

Electron-withdrawing groups such as $–CO_2H$ or $–NO_2$ direct the incoming group to the 3-position.

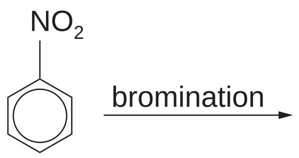


On the other hand, electron-donating groups such as $–CH_3$ or $–NH_2$ direct the incoming group to the 2- or 4- positions.

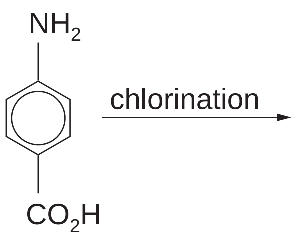


Use this information to suggest a likely structure for the organic product of each of the following reactions.

(i)



(ii)



[2]

[Total: 8]

6 Much research has been carried out in recent years investigating the exact structure of silk. The silk of a spider's web is at least five times as strong as steel, and twice as elastic as nylon. A silk fibre is composed of many identical protein chains, which are mainly made from the amino acids glycine, alanine and serine, with smaller amounts of four other amino acids.

$NH_2\text{–}CH_2\text{–}CO_2H$	$NH_2\text{–}\underset{CH_3}{\underset{\vert}{CH}}\text{–}CO_2H$	$NH_2\text{–}\underset{CH_2OH}{\underset{\vert}{CH}}\text{–}CO_2H$
glycine	alanine	serine

(a) Amino acids can exist as zwitterions. Draw the zwitterionic structure for glycine.

[1]

(b) Amino acids can act as acids or bases. Write equations to show:

(i) the reaction between alanine and HC*l*(aq),

....

(ii) the reaction between serine and NaOH(aq).

....
[2]

(c) Draw the structural formula of a portion of the silk protein, showing three amino acid residues. Label a peptide bond on your structure.

[3]

(d) What *type* of polymer is silk protein?

....[1]

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(e) The M_r of a silk protein molecule is about 600,000. Assuming it is made from equal amounts of the above three amino acids, calculate the average number of amino acid residues in the protein chain. [M_r (glycine) = 75; M_r (alanine) = 89; M_r (serine) = 105]

number of residues = ... [3]

[Total: 10]

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