UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6615234962

CHEMISTRY **9701/41**

Paper 4 Structured Questions **October/November 2013**

2 hours

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.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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.

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1	
2	
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7	
8	
Total	

This document consists of **16** printed pages and **4** blank pages.

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For Examiner's Use

Section A

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

1 **(a)** Gaseous ammonia reacts with gaseous hydrogen chloride to form solid ammonium chloride.

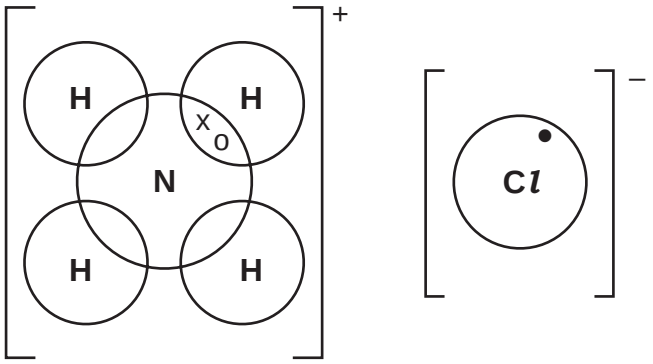
$$NH_3 + HCl \rightarrow NH_4Cl$$

The bonding in ammonium chloride includes ionic, covalent and co-ordinate (dative covalent) bonds.

Complete the following 'dot-and-cross' diagram of the bonding in ammonium chloride. For **each** of the six atoms show **all** the electrons in its outer shell. Three electrons have already been included.

Use the following code for your electrons.

- ● electrons from chlorine
- x electrons from hydrogen
- o electrons from nitrogen



[3]

(b) When a sample of dry ammonia is needed in the laboratory, the gas is passed through a tower containing lumps of solid calcium oxide, CaO.

(i) Suggest why the usual drying agent for gases, concentrated H_2SO_4, is **not** used for ammonia.

.....

(ii) Write an equation for the reaction between CaO and H_2O.

.....

(iii) Suggest why CaO rather than MgO is used to dry ammonia.

.....

[3]

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(c) (i) Write an equation showing the thermal decomposition of calcium nitrate, $Ca(NO_3)_2$.

.....

(ii) State and explain how the thermal stabilities of the nitrates vary down Group II.

.....

.....

.....

.....

[4]

[Total: 10]

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2 **(a)** The melting points of some Group IV elements are given below.

element	melting point / K
C	3925
Si	1683
Ge	1210
Sn	505

Suggest an explanation for each of the following.

(i) The melting point of silicon is less than that of carbon.

.....

.....

(ii) The melting point of tin is less than that of germanium.

.....

.....

[2]

(b) Using data from the *Data Booklet* where appropriate, write equations for the following reactions of compounds of Group IV elements.

(i) $SiCl_4(l) + H_2O(l)$

.....

(ii) the action of heat on $PbCl_4(l)$

.....

(iii) $SnCl_2(aq) + FeCl_3(aq)$

.....

(iv) $SnO_2(s) + NaOH(aq)$

.....

[4]

[Total: 6]

For Examiner's Use

3 **(a)** **(i)** Using the symbol **HZ** to represent a Brønsted-Lowry acid, write equations which show the following substances acting as Brønsted-Lowry bases.

NH_3 + →

CH_3OH + →

(ii) Using the symbol $\mathbf{B}^-$ to represent a Brønsted-Lowry base, write equations which show the following substances acting as Brønsted-Lowry acids.

NH_3 + →

CH_3OH + →

[4]

(b) State briefly what is meant by the following terms.

(i) reversible reaction

.....

(ii) dynamic equilibrium

.....

.....

[2]

(c) **(i)** Explain what is meant by a *buffer solution*.

.....

.....

.....

(ii) Explain how the working of a buffer solution relies on a reversible reaction involving a Brønsted-Lowry acid such as **HZ** and a Brønsted-Lowry base such as $\mathbf{Z}^-$.

.....

.....

.....

.....

[4]

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(d) Propanoic acid, $CH_3CH_2CO_2H$, is a weak acid with $K_a = 1.34 \times 10^{-5}$ mol dm^{-3}.

(i) Calculate the pH of a 0.500 mol dm^{-3} solution of propanoic acid.

Buffer solution **F** was prepared by adding 0.0300 mol of sodium hydroxide to 100 cm^3 of a 0.500 mol dm^{-3} solution of propanoic acid.

(ii) Write an equation for the reaction between sodium hydroxide and propanoic acid.

.....

(iii) Calculate the concentrations of propanoic acid and sodium propanoate in buffer solution **F**.

[propanoic acid] = ... mol dm^{-3}

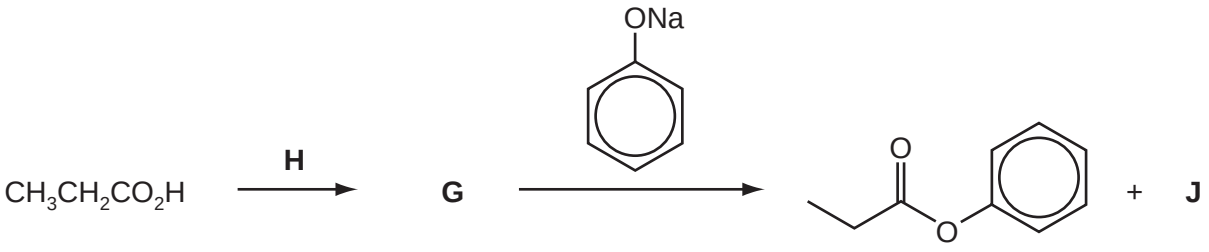
[sodium propanoate] = ... mol dm^{-3}

(iv) Calculate the pH of buffer solution **F**.

pH = ...

[6]

(e) Phenyl propanoate cannot be made directly from propanoic acid and phenol.
Suggest the identities of the intermediate **G**, the reagent **H** and the by-product **J** in the following reaction scheme.



G is .....

H is .....

J is .....

[2]

[Total: 18]

For Examiner's Use

4 **(a)** Explain what is meant by the term *bond energy*.

.....

.....

[2]

(b) **(i)** Describe and explain the trend in bond energies of the C–X bond in halogenoalkanes, where X = F, C*l*, Br or I.

.....

.....

(ii) Describe the relationship between the reactivity of halogenoalkanes, RX, and the bond energies of the C–X bond.

.....

.....

[3]

(c) Use the *Data Booklet* to suggest an explanation as to why CFCs such as CF_2Cl_2 are much more harmful to the ozone layer than fluorocarbons such as CF_4 or hydrocarbons such as butane, C_4H_{10}.

.....

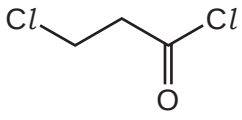
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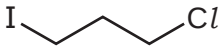
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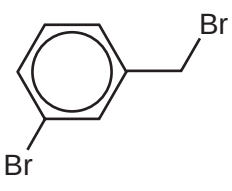
.....

[3]

(d) Predict the products of the following reactions and draw their structures in the boxes below. The molecular formula of each product is given, where X = C*l*, Br or I.

H_2O +  → $C_3H_5O_2X$

H_2O +  → C_3H_7OX

H_2O +  → C_7H_7OX

[3]

For Examiner's Use

(e) Ethane reacts with chlorine according to the following equation.

$$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$$

(i) State the conditions needed for this reaction.

.....

(ii) State the *type of reaction* occurring here.

.....

One of the steps during this reaction is the following process.

$$Cl^{\bullet} + CH_3CH_3 \rightarrow HCl + CH_3CH_2^{\bullet}$$

(iii) Use the *Data Booklet* to calculate the enthalpy change, ΔH, of this step.

ΔH = ... kJ mol^{-1}

(iv) Use the *Data Booklet* to calculate the enthalpy change, ΔH, of the similar reaction:

$$I^{\bullet} + CH_3CH_3 \rightarrow HI + CH_3CH_2^{\bullet}$$

ΔH = ... kJ mol^{-1}

(v) Hence suggest why it is **not** possible to make iodoethane by reacting together iodine and ethane.

.....

(vi) Complete the following equations of some possible steps in the formation of chloroethane.

$Cl_2 \rightarrow$ .....

$Cl^{\bullet} + CH_3CH_3 \rightarrow HCl + CH_3CH_2^{\bullet}$

$CH_3CH_2^{\bullet}$ + ... $\rightarrow$ ..... + ...

..... + ... $\rightarrow CH_3CH_2Cl$

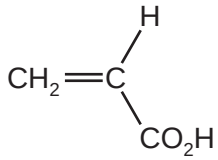
[8]

[Total: 19]

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5 Super-absorbent polymers have the ability to absorb 200-300 times their own mass of water. They are classified as hydrogels and they are widely used in personal disposable hygiene products such as babies' nappies (diapers).
These polymers are commonly made by the polymerisation of compound **K** mixed with sodium hydroxide in the presence of an initiator.



K

(a) (i) Explain what is meant by the term *polymerisation*.

.....

.....

(ii) What type of polymerisation is involved in the formation of hydrogels?

.....

(iii) Describe the changes in chemical bonding that occur during the polymerisation of **K**.

.....

.....
[3]

(b) *Acrylic acid* is the common name for compound **K**.
Suggest the systematic (chemical) name of **K**.

.....
[1]

(c) (i) Draw the structure of at least **two** repeat units of the polymer formed by the above method from acrylic acid, **K**, when mixed with NaOH.

(ii) The C–C–C bond angle in compound **K** changes when the polymer is formed.
State and explain how the C–C–C bond angle differs between a molecule of **K** and the polymer.

angle changes from ..... to .....

explanation .....

.....
[4]

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(d) (i) Draw a detailed diagram of a portion of the polymer you have drawn in **(c)(i)** to explain how it can absorb a large volume of water.

(ii) A student added 0.10 g of the polymer to 10 cm^3 of aqueous copper(II) sulfate solution.
Predict, with a reason, what you expect to observe.

.....

.....
[4]

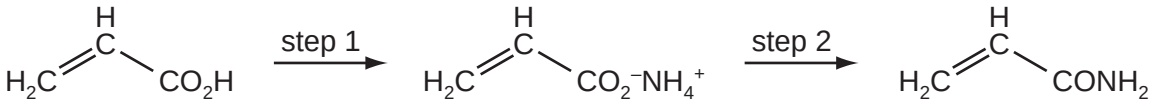
(e) Compound **L**, CH_2=$CHCONH_2$, can also be polymerised to form a super-absorbent polymer.

(i) Name the **two** functional groups in compound **L**.

.....

.....

Compound **K** can be converted into compound **L** by the following two-step route.



K **L**

(ii) Suggest a reagent for step 1.

.....

(iii) What other product is formed in step 2?

.....

(iv) State the reagents and conditions necessary to re-form **K** from **L**.

.....
[5]

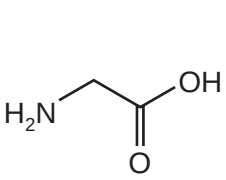
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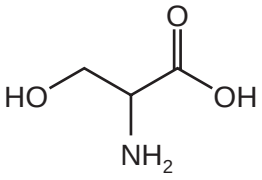
Section B

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

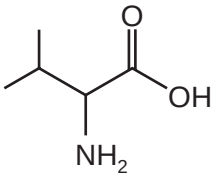
6 **(a)** Protein molecules are formed by the polymerisation of amino acids in the body. The structures of three amino acids are given.



glycine (*gly*)



serine (*ser*)



valine (*val*)

(i) How many different tripeptides can be made using **one** molecule of **each** of the amino acids shown?

.....

(ii) Draw the tripeptide *ser-gly-val*, showing the peptide bonds in displayed form.

(iii) Within the tripeptide, which amino acid provides a hydrophobic side chain?

.....

(iv) Polypeptide chains can form bonds giving proteins their *secondary* and *tertiary* structures.
Using the tripeptide in **(ii)**, state **two** types of bonding that can be formed and the groups in the tripeptide that are involved in this bonding.

bond ..... groups .....

bond ..... groups .....

[6]

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(b) Enzymes are particular types of proteins that catalyse chemical reactions. The efficiency of enzymes can be reduced by the presence of other molecules known as inhibitors. Explain how both *competitive* and *non-competitive* inhibitors prevent enzymes from working efficiently.

(i) competitive inhibitors .....

.....

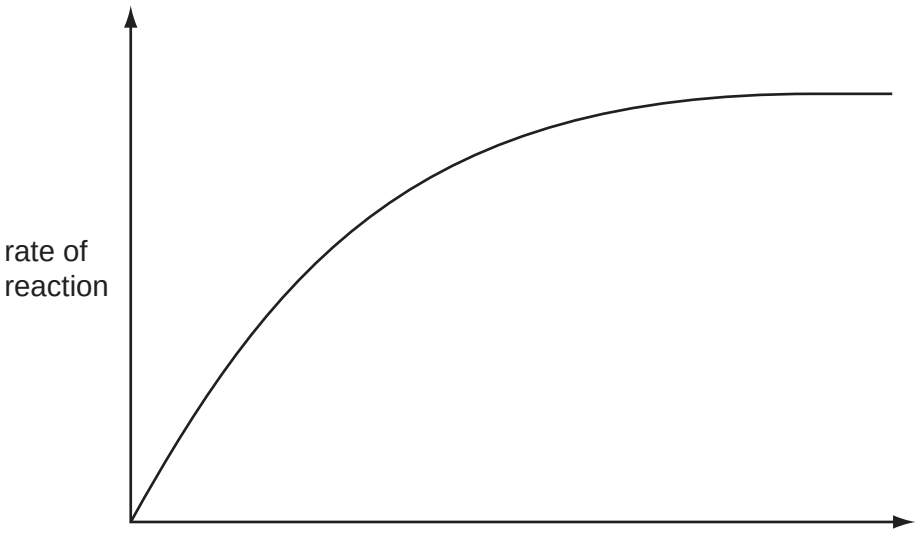
.....

(ii) non-competitive inhibitors .....

.....

.....

(iii) The graph shows the rate of an enzyme-catalysed reaction against the substrate concentration in the absence of an inhibitor.



On the same axes, sketch a graph showing the rate of this reaction if a *non-competitive inhibitor* was present.

[4]

[Total: 10]

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7 Electrophoresis is a technique which can be used to separate amino acids or peptide fragments present in a mixture.

(a) Draw a diagram to show the apparatus used to carry out electrophoresis. You should label each of the relevant parts of the apparatus.

[4]

(b) How far an amino acid will travel during electrophoresis depends on the pH of the solution. For a given potential difference, state **two other** factors that will affect how far a given amino acid travels in a fixed time during electrophoresis.

1. .....

.....

2. .....

.....

[2]

(c) A number of analytical and separation techniques rely on substances having different partition coefficients.

State what is meant by the term *partition coefficient*.

.....

.....

.....

[1]

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(d) The partition coefficient of **X** between ethoxyethane and water is 40.0.
A solution contains 4.00 g of **X** dissolved in 0.500 dm^3 of water.

Calculate the mass of **X** that can be extracted from this aqueous solution by shaking it with

(i) 0.050 dm^3 of ethoxyethane,

(ii) two successive portions of 0.025 dm^3 of ethoxyethane.

[4]

[Total: 11]

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[Turn over

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8 In a world with a rapidly increasing population, access to clean drinking water is critical. For many countries, groundwater sources, rather than stored rainwater or river-water, are vital. *Groundwater* is water that exists in the pore spaces and fractures in rock and sediment beneath the Earth's surface. The World Health Organisation (WHO) provides maximum recommended concentrations for different ions present in drinking water.

(a) The geological nature of the soil determines the chemical composition of the groundwater. The table shows some ions which may contaminate groundwater.

ion present	WHO maximum permitted concentration / mg dm^{-3}
Ba^{2+}	0.30
Cl^{-}	250.00
NO_3^{-}	50.00
Pb^{2+}	0.01
Na^{+}	20.00
SO_4^{2-}	500.00

(i) Nitrate, NO_3^{-}, ions are difficult to remove from groundwater.
What is the reason for this?

.....

(ii) State which ions in the table above are likely to be removed from the water by treatment with powdered limestone, $CaCO_3$, giving reasons for each of your answers.

.....

.....

.....
[4]

(b) Nitrates and phosphates can enter water courses such as rivers or streams as a result of human activity. Both of these ions are nutrients for algae.

(i) What is the origin of these nitrates?

.....

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(ii) Suggest an origin for the phosphates found in water courses.

.....

(iii) What effect do nitrates and phosphates have on water courses?

.....

.....

[3]

(c) Acid rain can have a major impact on natural waters, particularly lakes. In recent years there has been a worldwide effort to reduce the amount of acid rain produced.

(i) Write equations to show the production of acid rain from sulfur dioxide, SO_2.

.....

.....

(ii) The use of fossil fuels is one major source of sulfur dioxide.
Name another major industrial source.

.....

[2]

[Total: 9]

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