UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

8308397844

CHEMISTRY **9701/41**

Paper 4 Structured Questions **May/June 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.

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

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.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

This document consists of **15** printed pages and **1** blank page.

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For Examiner's Use

Section A

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

1 **(a)** What is meant by the term *standard electrode potential*, SEP?

.....

.....
[2]

(b) Draw a fully labelled diagram of the apparatus you could use to measure the SEP of the Fe^{3+}/Fe^{2+} electrode.

[5]

(c) The reaction between Fe^{3+} ions and I^- ions is an equilibrium reaction.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

(i) Use the *Data Booklet* to calculate the $E^{\ominus}_{cell}$ for this reaction.

.....

(ii) Hence state, with a reason, whether there will be more products or more reactants at equilibrium.

.....

.....

(iii) Write the expression for K_c for this reaction, and state its units.

K_c =

units .....

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An experiment was carried out using solutions of $Fe^{3+}(aq)$ and $I^-(aq)$ of equal concentrations. 100 cm^3 of each solution were mixed together, and allowed to reach equilibrium.

The concentrations at equilibrium of $Fe^{3+}(aq)$ and $I_2(aq)$ were as follows.

$[Fe^{3+}(aq)] = 2.0 \times 10^{-4}\,mol\,dm^{-3}$

$[I_2(aq)] = 1.0 \times 10^{-2}\,mol\,dm^{-3}$

(iv) Use these data, together with the equation given in **(c)**, to calculate the concentrations of $Fe^{2+}(aq)$ and $I^-(aq)$ at equilibrium.

$[Fe^{2+}(aq)]$ = ... $mol\,dm^{-3}$

$[I^-(aq)]$ = ... $mol\,dm^{-3}$

(v) Calculate the K_c for this reaction.

K_c = ...

[8]

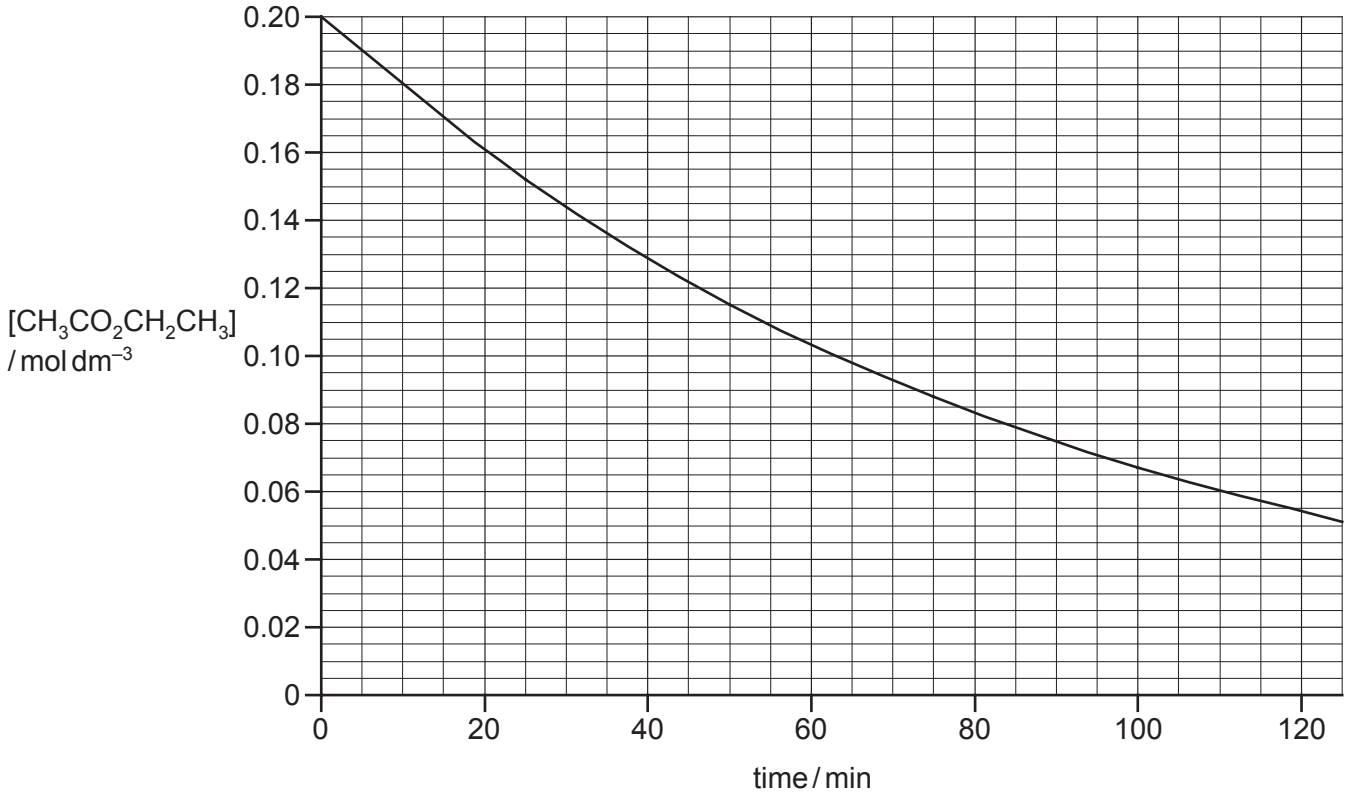
[Total: 15]

For Examiner's Use

2 Ethyl ethanoate is hydrolysed slowly by water in the following acid-catalysed reaction.

$$CH_3CO_2CH_2CH_3 + H_2O \xrightarrow{H^+} CH_3CO_2H + CH_3CH_2OH$$

The concentration of ethyl ethanoate was determined at regular time intervals as the reaction progressed.
Two separate experiments were carried out, with different HCl concentrations.
The following graph shows the results of an experiment using [HCl] = 0.1 mol dm^{-3}.



(a) When the experiment was carried out using [HCl] = 0.2 mol dm^{-3}, the following results were obtained.

time / min	$[CH_3CO_2CH_2CH_3]$ / mol dm^{-3}
0	0.200
10	0.160
25	0.115
50	0.067
75	0.038
100	0.022
125	0.013

(i) Plot these data on the axes above, and draw a line of best fit.

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(ii) Use one of the graphs to show that the reaction is first order with respect to $CH_3CO_2CH_2CH_3$.

Show all your working, and show clearly any construction lines you draw on the graphs.

(iii) Use the graphs to calculate the order of reaction with respect to HC*l*.

Show all your working, and show clearly any construction lines you draw on the graphs.

(iv) Write the rate equation for this reaction, and calculate the value of the rate constant.

rate =

[7]

(b) (i) Why is it **not** possible to determine the order of reaction with respect to water in this experiment?

.....

.....

(ii) Although [$CH_3CO_2CH_2CH_3$] decreases during each experiment, [HC*l*] remains the same as its initial value.

Why is this?

.....

.....

[2]

[Total: 9]

For Examiner's Use

3 (a) (i) What is meant by the *density* of a substance?

.....

(ii) Use data from the *Data Booklet* to explain why the density of iron is greater than that of calcium.

.....

.....

.....

[3]

(b) In general, reactions of the compounds of transition elements can be classified under one or more of the following headings.

acid-base

ligand exchange

precipitation

redox

Choose the most suitable heading to describe each of the following reactions, by placing a tick (✓) in the appropriate column in the table below.
Only one tick should be placed against each reaction.

reaction	acid-base	ligand exchange	precipitation	redox
$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 6H_2O$				
$[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow [CuCl_4]^{2-} + 4H^+ + 6H_2O$				
$2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$				
$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$				
$2Fe(OH)_2 + ½O_2 + H_2O \rightarrow 2Fe(OH)_3$				
$CrO_3 + 2HCl \rightarrow CrO_2Cl_2 + H_2O$				
$Cr(H_2O)_3(OH)_3 + OH^- \rightarrow [Cr(H_2O)_2(OH)_4]^- + H_2O$				
$[Cr(OH)_4]^- + 1½H_2O_2 + OH^- \rightarrow CrO_4^{2-} + 4H_2O$				

[8]

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(c) Alloys of aluminium, titanium and vanadium are used in aerospace and marine equipment, and in medicine.

When a powdered sample of one such alloy is heated with an excess of aqueous NaOH, only the aluminium reacts, according to the following equation.

$$2Al(s) + 2OH^-(aq) + 6H_2O(l) \rightarrow 2[Al(OH)_4]^-(aq) + 3H_2(g)$$

Reacting 100 g of alloy in this way produced 8.0 dm^3 of hydrogen, measured under room conditions.

Calculate the percentage by mass of aluminium in the alloy.

percentage = ... %
[3]

[Total: 14]

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4 Because of the lack of reactivity of the nitrogen molecule, extreme conditions need to be used to synthesise ammonia from nitrogen in the Haber process.

(a) Suggest an explanation for the lack of reactivity of the nitrogen molecule, N_2.

.....

.....

[1]

(b) Under conditions of high temperature, nitrogen and oxygen react together to give oxides of nitrogen.

(i) Write an equation for a possible reaction between nitrogen and oxygen.

.....

(ii) State **two** situations, one natural and one as a result of human activities, in which nitrogen and oxygen react together.

.....

.....

(iii) What is the main environmental effect of the presence of nitrogen oxides in the atmosphere?

.....

[4]

(c) Describe and explain how the basicities of ethylamine and phenylamine compare to that of ammonia.

.....

.....

.....

.....

.....

[4]

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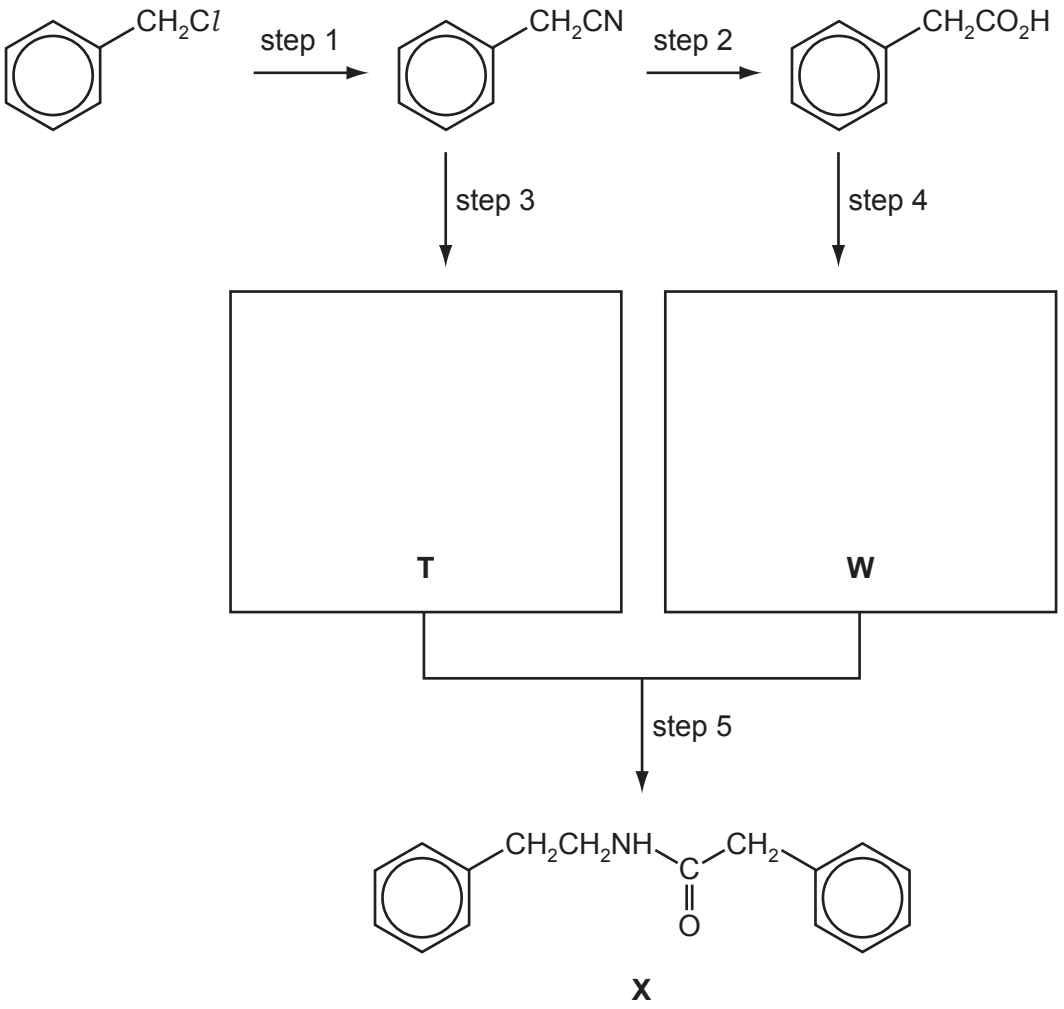
(d) Compound **X** is a useful intermediate in the synthesis of pharmaceuticals.
X can be synthesised from chloromethylbenzene according to the following scheme.



X

(i) What *type of reaction* is each of the following?

step 1 .....

step 2 .....

(ii) Suggest reagents and conditions for

step 1, ...

step 2. .....

(iii) Draw the structures of the intermediates **T** and **W** in the boxes above.

[6]

[Total: 15]

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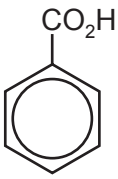
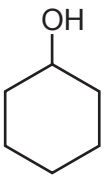
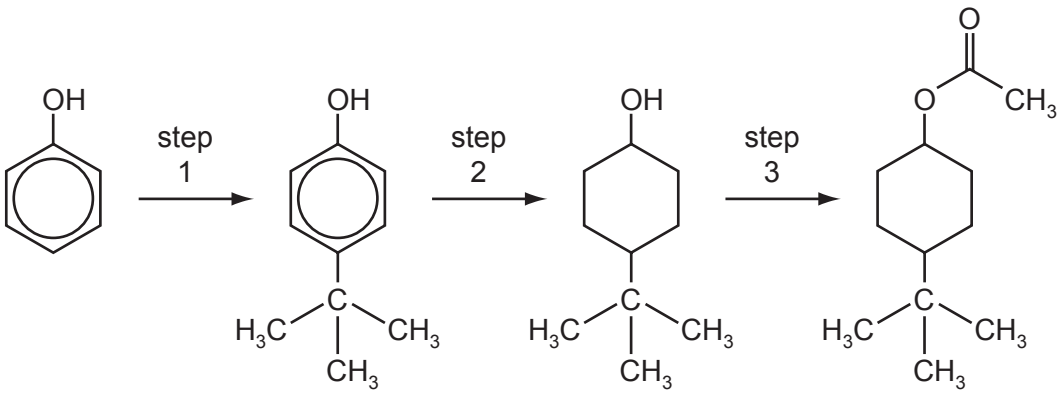
5 **(a)** A series of experiments is carried out in which the reagent shown at the top of the column of the table is mixed, in turn, with each of the reagents at the side.
Complete the following table by writing in each box the formula of any gas produced.
Write **x** in the box if no gas is produced.
The first column has been completed as an illustration.

	H_2O			
Na	H_2			
KOH(aq)	**x**			
Na_2CO_3(aq)	**x**			

[5]

(b) Compound **C** is responsible for the pleasant aroma of apples. It can be prepared from phenol by the following 3-step synthesis.



A **B** **C**

(i) The only by-product of step 1 is HC*l*. Suggest the reagent that was used to react with phenol to produce compound **A**.

.....

(ii) What *type of reaction* is occurring in step 2?

.....

(iii) What reagents and conditions are required for step 3?

.....

(iv) State the reagent and conditions needed to convert **C** back to **B**, the reverse of step 3.

.....

[5]

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(c) (i) Either compound **A** or compound **B**, or both, react with the following reagents. For each reagent draw the structure of the organic product formed with **A**, and with **B**. If no reaction occurs, write 'no reaction' in the relevant box.

reagent and conditions	product with **A**	product with **B**
an excess of $Br_2(aq)$		
heat with HBr		
pass vapour over heated Al_2O_3		
heat with acidified $K_2Cr_2O_7$		

(ii) Choose **one** of the above reactions to enable you to distinguish between **A** and **B**.

State below the observations you would make with each compound.

reagent	observation with **A**	observation with **B**

[7]

[Total: 17]

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Section B

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

6 There are two important polymerisations that occur within living organisms – protein synthesis and the formation of DNA.

(a) Complete the table placing a tick (✓) in the correct column to indicate in which process each substance could be used.

substance	protein synthesis	formation of DNA
adenine		
alanine		
aspartate		
phosphate		

[3]

(b) Proteins and DNA form different helical structures. Briefly describe the bonding that maintains the shape of each of these helical structures.

protein .....

.....

.....

DNA .....

.....

.....

[4]

(c) Describe the differences in bonding in the *primary* and *tertiary* structures of proteins. Your answer should include reference both to the nature of the bonding and the types of amino acid causing it.

.....

.....

.....

.....

.....

[3]

[Total: 10]

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7 Modern methods of analysis have had far-reaching effects on a number of branches of science including medicine, forensic science, environmental monitoring and archaeology.

(a) Outline, in simple terms, the technique of DNA fingerprinting.

.....

.....

.....

.....

.....

.....

[4]

(b) Complete the table by indicating whether the items can be used for DNA fingerprinting. Use a tick (✓) for items which can be used for DNA fingerprinting and a cross (**x**) for items which cannot.

item for testing	suitable for DNA fingerprinting
human hair	
piece of a flint tool	
piece of Iron Age pot	
piece of Roman leather	

[3]

(c) Various forms of chromatography can be used to separate and analyse mixtures. HPLC (high performance liquid chromatography) can be used to separate each of the following mixtures. State another method of chromatography which would separate each mixture.

insecticides in a sample of water .....

dyes present in a foodstuff .....

drug residue in an athlete's urine .....

[3]

[Total: 10]

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[Turn over

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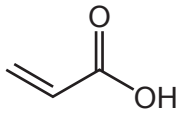
8 In recent years there has been a lot of interest in polymers in the form of gels that absorb aqueous materials. One of the largest uses of these polymers is in disposable nappies (diapers). The gel which is used in this case is a polymer of propenoic acid.



propenoic acid

(a) (i) Draw a section of the polymer of propenoic acid showing **two** repeat units.

(ii) By what type of chemical reaction is this polymer formed?

.....

(iii) By what type of bonding is water held on the polymer?

.....

[3]

(b) For some disposable nappies (diapers), the monomer is a mixture of propenoic acid and sodium propenoate. The properties of the polymer are influenced by the proportion of sodium salt in the monomer mixture.

(i) Suggest and explain how the difference in the structure of this polymer compared to one formed only from propenoic acid might affect the water absorbing properties of the polymer.

.....

.....

.....

(ii) Suggest a property the polymer should have in order to be used in disposable products.

.....

[3]

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(c) A variation on the gel used for disposable nappies (diapers) containing more sodium propenoate has been used to treat soils contaminated by heavy metals such as lead (Pb^{2+}) and cadmium (Cd^{2+}). Suggest why the gel is effective.

.....

.....

.....

[2]

(d) Another variation on this type of polymer is used in hair gels. In these, the polymer chains are cross-linked by a compound known as pentaerythritol.



pentaerythritol

(i) By what type of chemical reaction are the cross-links in this polymer formed?

.....

(ii) It is important that the gel should be easily washed out of hair. What is it about the structure of the polymer that allows this to happen?

.....

[2]

[Total: 10]

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