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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

7635733974

CHEMISTRY **9701/21**

Paper 2 Structured Questions AS Core **May/June 2013**

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.
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.

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	
3	
4	
5	
Total	

This document consists of **10** printed pages and **2** blank pages.

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

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1 A sample of a fertiliser was known to contain ammonium sulfate, $(NH_4)_2SO_4$, and sand only.

A 2.96 g sample of the solid fertiliser was heated with 40.0 cm^3 of NaOH(aq), an excess, and all of the ammonia produced was boiled away.

After cooling, the remaining NaOH(aq) was exactly neutralised by 29.5 cm^3 of 2.00 mol dm^{-3} HC*l*.

In a separate experiment, 40.0 cm^3 of the original NaOH(aq) was exactly neutralised by 39.2 cm^3 of the 2.00 mol dm^{-3} HC*l*.

(a) (i) Write balanced equations for the following reactions.

NaOH with HC*l*

.....

$(NH_4)_2SO_4$ with NaOH

.....

(ii) Calculate the amount, in moles, of NaOH present in the 40.0 cm^3 of the original NaOH(aq) that was neutralised by 39.2 cm^3 of 2.00 mol dm^{-3} HC*l*.

(iii) Calculate the amount, in moles, of NaOH present in the 40.0 cm^3 of NaOH(aq) that remained after boiling the $(NH_4)_2SO_4$.

(iv) Use your answers to **(ii)** and **(iii)** to calculate the amount, in moles, of NaOH that reacted with the $(NH_4)_2SO_4$.

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(v) Use your answers to **(i)** and **(iv)** to calculate the amount, in moles, of $(NH_4)_2SO_4$ that reacted with the NaOH.

(vi) Hence calculate the mass of $(NH_4)_2SO_4$ that reacted.

(vii) Use your answer to **(vi)** to calculate the percentage, by mass, of $(NH_4)_2SO_4$ present in the fertiliser.
Write your answer to a suitable number of significant figures.

[9]

(b) The uncontrolled use of nitrogenous fertilisers can cause environmental damage to lakes and streams. This is known as *eutrophication*.

What are the processes that occur when excessive amounts of nitrogenous fertilisers get into lakes and streams?

.....

.....

..... [2]

(c) Large quantities of ammonia are manufactured by the Haber process.
Not all of this ammonia is used to make fertilisers.
State **one** large-scale use for ammonia, **other than** in the production of nitrogenous fertilisers.

..... [1]

[Total: 12]

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[Turn over

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2 Ammonium nitrate fertiliser is manufactured from ammonia. The first reaction in the manufacture of the fertiliser is the catalytic oxidation of ammonia to form nitrogen monoxide, NO. This is carried out at about 1×10^3 kPa (10 atmospheres) pressure and a temperature of 700 to 850 °C.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H^{\ominus} = -906\,kJ\,mol^{-1}$$

(a) Write the expression for the equilibrium constant, K_p, stating the units.

K_p =

units ..... [2]

(b) What will be the effect on the yield of NO of **each** of the following?
In each case, explain your answer.

(i) increasing the temperature

.....

.....

.....

(ii) decreasing the applied pressure

.....

.....

.....
[4]

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(c) The standard enthalpy changes of formation of $NH_3(g)$ and $H_2O(g)$ are as follows.

$NH_3(g)$, $\Delta H_f^{\ominus} = -46.0\,kJ\,mol^{-1}$ $\quad$ $H_2O(g)$, $\Delta H_f^{\ominus} = -242\,kJ\,mol^{-1}$

Use these data and the value of $\Delta H^{\ominus}_{reaction}$ given below to calculate the standard enthalpy change of formation of NO(g).
Include a sign in your answer.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H^{\ominus} = -906\,kJ\,mol^{-1}$$

[4]

[Total: 10]

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3 This question refers to the elements in the section of the Periodic Table shown below.

		H						He
Li	Be		B	C	N	O	F	Ne
Na	Mg		A*l*	Si	P	S	C*l*	Ar
K	Ca	..... transition elements	Ga	Ge	As	Se	Br	Kr

(a) From this list of elements, identify in **each** case **one** element that has the property described. Give the **symbol** of the element.

(i) An element that floats on cold water and reacts readily with it.

.....

(ii) An element that forms an oxide that is a reducing agent.

.....

(iii) The element that has the smallest first ionisation energy.

.....

(iv) The element which has a giant molecular structure **and** forms an oxide which has a simple molecular structure.

.....

(v) The element in Period 3 (Na to Ar) that has the smallest anion.

.....

(vi) The element in Period 3 (Na to Ar) which forms a chloride with a low melting point and an oxide with a very high melting point.

.....

[6]

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(b) Use the elements in Period 3 (Na to Ar) in the section of the Periodic Table opposite to identify the oxide(s) referred to below.
In **each** case, give the **formula** of the oxide(s).

(i) An oxide which when placed in water for a long time has no reaction with it.

.....

(ii) An oxide which dissolves readily in water to give a strongly alkaline solution.

.....

(iii) Two acidic oxides formed by the same element.

..... and .....

(iv) An oxide which is amphoteric.

.....

[5]

(c) Fluorine reacts with other elements in Group VII to form a number of different compounds. Two such compounds and their boiling points are given in the table.

compound	ClF_3	BrF_3
boiling point / °C	12	127

(i) The two molecules have similar electronic configurations.
Showing outer electrons only, draw a 'dot-and-cross' diagram of the bonding in ClF_3.

(ii) The two molecules have the same shape.
Suggest why the boiling points are significantly different.

.....

.....

.....

.....

[4]

[Total: 15]

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4 Organic chemistry is the chemistry of carbon compounds. The types of organic reactions that you have studied are listed below.

addition	elimination	hydrolysis
oxidation	reduction	substitution

Addition and substitution reactions are further described as follows.

electrophilic	nucleophilic	free radical

Complete the table below.
Fill in the central column by using **only** the types of reaction given in the lists above.
Use **both** lists when appropriate.
In the right hand column give the formula(e) of the reagent(s) you would use to carry out the reaction given.

organic reaction	type of reaction	reagent(s)
$CH_3CH_2CH_2CH_2Br \rightarrow$ $CH_3CH_2CH_2CH_2NH_2$		
$CH_3CH_2CH_2CH_2OH \rightarrow$ $BrCH_2CH_2CH_2CH_2OH$		
$CH_3COCH_3 \rightarrow$ $CH_3C(OH)(CN)CH_3$		
$CH_3CH(OH)CH_2CH_3 \rightarrow$ $CH_3CH{=}CHCH_3$		

[Total: 11]

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5 Crotonaldehyde, $CH_3CH=CHCHO$, occurs in soybean oils.

(a) In the boxes below, write the **structural formula** of the organic compound formed when crotonaldehyde is reacted separately with each reagent under suitable conditions.
If you think no reaction occurs, write 'NO REACTION' in the box.

reaction	reagent	product
A	Br_2 in an inert organic solvent	
B	PCl_3	
C	H_2 and Ni catalyst	
D	$NaBH_4$	
E	$K_2Cr_2O_7 / H^+$	

[5]

(b) Crotonaldehyde exists in more than one stereoisomeric form.
Draw the **displayed formulae** of the **stereoisomers** of crotonaldehyde.
Label **each** isomer.

[3]

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(c) Draw the **skeletal formula** of crotonaldehyde.

[1]

(d) The product of reaction E in the table opposite will react with a solution containing acidified manganate(VII) ions.
Draw the **structural formulae** of the organic products when the reagent is

(i) cold, dilute;

(ii) hot, concentrated.

[3]

[Total: 12]

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