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

| | |
|---|---|
| CANDIDATE NAME | |
| CENTRE NUMBER | |
| CANDIDATE NUMBER | |

*8538429177*

**CHEMISTRY** **9701/21**

Paper 2 Structured Questions AS Core **October/November 2012**

**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.
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.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| Total | |

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


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

*For Examiner's Use*

**1** Zinc is an essential trace element which is necessary for the healthy growth of animals and plants. Zinc deficiency in humans can be easily treated by using zinc salts as dietary supplements.

**(a)** One salt which is used as a dietary supplement is a hydrated zinc sulfate, $ZnSO_4.xH_2O$, which is a colourless crystalline solid.

Crystals of zinc sulfate may be prepared in a school or college laboratory by reacting dilute sulfuric acid with a suitable compound of zinc.

Give the formulae of **two** simple compounds of zinc that could **each** react with dilute sulfuric acid to produce zinc sulfate.

..... and ..... [2]

**(b)** A simple experiment to determine the value of $x$ in the formula $ZnSO_4.xH_2O$ is to heat it carefully to drive off the water.

$$ZnSO_4.xH_2O(s) \rightarrow ZnSO_4(s) + xH_2O(g)$$

A student placed a sample of the hydrated zinc sulfate in a weighed boiling tube and reweighed it. He then heated the tube for a short time, cooled it and reweighed it when cool. This process was repeated four times. The final results are shown below.

| mass of empty tube / g | mass of tube + hydrated salt / g | mass of tube + salt after fourth heating / g |
|---|---|---|
| 74.25 | 77.97 | 76.34 |

**(i)** Why was the boiling tube heated, cooled and reweighed four times?

.....

.....

**(ii)** Calculate the amount, **in moles**, of the anhydrous salt produced.

**(iii)** Calculate the amount, **in moles**, of water driven off by heating.

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**(iv)** Use your results to **(ii)** and **(iii)** to calculate the value of $x$ in $ZnSO_4.xH_2O$.

[7]

**(c)** For many people, an intake of approximately 15 mg per day of zinc will be sufficient to prevent deficiencies.

Zinc ethanoate crystals, $(CH_3CO_2)_2Zn.2H_2O$, may be used in this way.

**(i)** What mass of pure crystalline zinc ethanoate ($M_r$ = 219.4) will need to be taken to obtain a dose of 15 mg of zinc?

**(ii)** If this dose is taken in solution as 5 $cm^3$ of aqueous zinc ethanoate, what would be the concentration of the solution used?
Give your answer in mol $dm^{-3}$.

[4]

[Total: 13]

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**[Turn over**

*For Examiner's Use*

**2** Each of the Group VII elements chlorine, bromine and iodine forms a hydride.

**(a) (i)** Outline how the relative thermal stabilities of these hydrides change from HC*l* to HI.

.....

.....

**(ii)** Explain the variation you have outlined in **(i)**.

.....

.....

.....

[3]

Hydrogen iodide can be made by heating together hydrogen gas and iodine vapour. The reaction is incomplete.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

**(b)** Write an expression for $K_c$ and state the units.

$K_c$ = ..... units ..... [2]

**(c)** For this equilibrium, the numerical value of the equilibrium constant $K_c$ is 140 at 500 K and 59 at 650 K.

Use this information to state and explain the effect of the following changes on the equilibrium position.

**(i)** increasing the pressure applied to the equilibrium

.....

.....

**(ii)** decreasing the temperature of the equilibrium

.....

.....

[4]

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**(d)** A mixture of 0.02 mol of hydrogen and 0.02 mol of iodine was placed in a 1 $dm^3$ flask and allowed to come to equilibrium at 650 K.

Calculate the amount, in moles, of each substance present in the equilibrium mixture at 650 K.

| | $H_2(g)$ | + | $I_2(g)$ | $\rightleftharpoons$ | 2HI(g) |
|---|---|---|---|---|---|
| initial moles | 0.02 | | 0.02 | | 0 |

[4]

[Total: 13]

*For Examiner's Use*

**3** Ammonia is an important industrial chemical which is manufactured on a large scale by using the Haber process.

**(a) (i)** Write a balanced equation, with state symbols, for the reaction occurring in the Haber process.

.....

**(ii)** Give **three** essential operating conditions that are used in the Haber process.

.....

.....

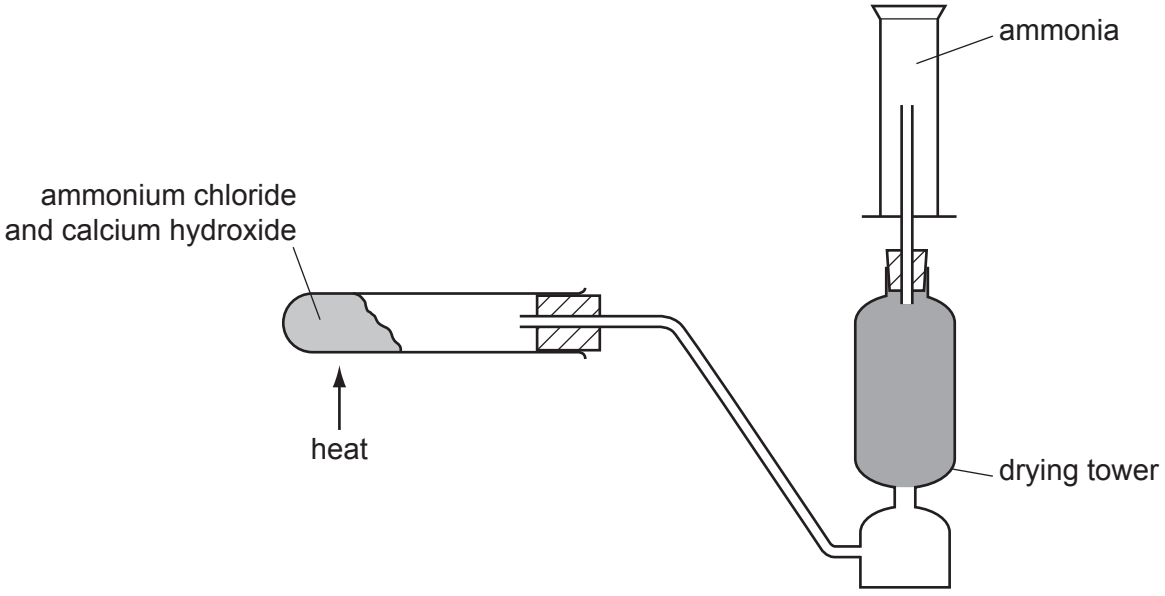
.....

**(iii)** State **one** large scale use of ammonia.

.....

[5]

**(b)** Ammonia may be prepared in a school or college laboratory by using the apparatus below.




The reaction involves the displacement of ammonia from one of its compounds.

**(i)** Give the formulae of the two reactants that are heated together to produce ammonia.

..... and .....

**(ii)** Construct a balanced equation for the reaction between your two reagents.

.....

For Examiner's Use

**(iii)** Common drying agents include calcium oxide, concentrated sulfuric acid and phosphorus(V) oxide.
Which **one** of these would be used in the drying tower in this experiment? Explain your answer.

.....

.....
[5]

**(c)** Ammonia is a weak base which forms salts containing the ammonium ion.

Describe, with the aid of an equation, the formation and structure of the ammonium ion. You should use displayed formulae in your answer.

[3]

[Total: 13]

For Examiner's Use

**4** Many organic compounds, including alcohols, carbonyl compounds, carboxylic acids and esters, contain oxygen.

**(a)** The table below lists some oxygen-containing organic compounds and some common laboratory reagents.

**(i)** Complete the table as fully as you can.
If you think no reaction occurs, write 'no reaction' in the box for the structural formula(e).

| reaction | organic compound | reagent | structural formula(e) of organic product(s) |
|---|---|---|---|
| A | $(CH_3)_3COH$ | $Cr_2O_7^{2-}/H^+$ heat under reflux | |
| B | $CH_3CH_2CHO$ | Fehling's reagent warm | |
| C | $HCO_2CH(CH_3)_2$ | NaOH(aq) warm | |
| D | $CH_2{=}CHCHO$ | $NaBH_4$ | |
| E | $(CH_3)_3COH$ | $NaBH_4$ | |
| F | $CH_3CH_2COCH_3$ | $MnO_4^-/H^+$ heat under reflux | |

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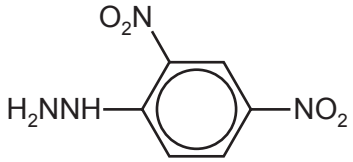
**(ii)** During some of the reactions in **(i)** a colour change occurs.
Complete the table below for any such reactions, stating the letter of the reaction and what the colour change is.

| reaction | colour at the beginning of the reaction | colour at the end of the reaction |
|---|---|---|
| | | |

[10]

**(b)** Some oxygen-containing compounds react with 2,4-dinitrophenylhydrazine.




2,4-dinitrophenylhydrazine

**(i)** Draw the structural formula of the organic compound formed when $HOCH_2CH_2CHO$ reacts with 2,4-dinitrophenylhydrazine reagent.

**(ii)** Suggest the colour of the organic product.

.....

[2]

[Total: 12]

*For Examiner's Use*

**5** Compound **X** has the molecular formula $C_4H_8O_2$.

**(a) (i)** Treatment of **X** with sodium metal produces a colourless flammable gas.
What does this result tell you about the functional groups that could be present in **X**?

.....

.....

**(ii)** There is no reaction when **X** is treated with sodium hydrogencarbonate, $NaHCO_3$.
What does this result tell you about the functional groups that could be present in **X**?

.....

.....

**(iii)** When **X** is shaken with aqueous bromine the orange colour disappears.
What does this result tell you about the functional groups that could be present in **X**?

.....

.....
[3]

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**(b)** The molecule of **X** has the following features.

- The carbon chain is unbranched and the molecule is not cyclic.
- No oxygen atom is attached to any carbon atom which is involved in $\pi$ bonding.
- No carbon atom has more than one oxygen atom joined to it.

There are five possible isomers of **X** which fit these data. Four of these isomers exist as two pairs of stereoisomers.

**(i)** Draw displayed formulae of **each** of these two pairs.

| | | |
|---|---|---|
| pair 1 | | |
| pair 2 | | |

**(ii)** These four isomers of **X** show two types of stereoisomerism.

State which type of isomerism each pair shows.

pair 1 .....

pair 2 .....

[6]

[Total: 9]

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