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

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

*1253499376*

**CHEMISTRY** **9701/22**

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.

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

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




UNIVERSITY of CAMBRIDGE International Examinations

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

*For Examiner's Use*

**1** Ammonium sulfate is a fertiliser which is manufactured by the reaction between ammonia and sulfuric acid.

**(a)** Ammonia is described as a weak base and sulfuric acid as a strong acid.

By using an equation, explain clearly what is meant by the term *weak base*.

.....

.....

.....

.....

..... [3]

**(b)** Ammonia and sulfuric acid are both manufactured by processes which involve chemical equilibria.

**(i)** Sulfuric acid is produced from sulfur trioxide which is made by the Contact process.

State **three** important operating conditions for the Contact process for the manufacture of sulfur trioxide.

For **each** of your conditions, you should avoid the use of vague phrases such as 'high temperature'.

condition 1 .....

.....

condition 2 .....

.....

condition 3 .....

.....

**(ii)** How is the sulfur trioxide produced converted into sulfuric acid?

.....

.....
[4]

*For Examiner's Use*

**(c)** Chloropropanols such as 1,3-dichloropropan-2-ol (1,3-DCP) are present in some foods.

$$Cl CH_2CH(OH)CH_2Cl$$

1,3-DCP

**(i)** What will be produced when 1,3-DCP is reacted separately with the following reagents under suitable conditions?
In each case give the **structural** formula.

concentrated sulfuric acid

an excess of ammonia

**(ii)** Describe as fully as you can what type of reaction occurs with ammonia.

.....

[4]

[Total: 11]

For Examiner's Use

**2** Chile saltpetre is a mineral found in Chile and Peru, and which mainly consists of sodium nitrate, $NaNO_3$. The mineral is purified to concentrate the $NaNO_3$ which is used as a fertiliser and in some fireworks.

In order to find the purity of a sample of sodium nitrate, the compound is heated in NaOH(aq) with Devarda's alloy which contains aluminium. This reduces the sodium nitrate to ammonia which is boiled off and then dissolved in acid.

$$3NaNO_3(aq) + 8Al(s) + 5NaOH(aq) + 18H_2O(l) \rightarrow 3NH_3(g) + 8NaAl(OH)_4(aq)$$

The ammonia gas produced is dissolved in an excess of $H_2SO_4$ of known concentration.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

The amount of unreacted $H_2SO_4$ is then determined by back-titration with NaOH of known concentration.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

**(a)** A 1.64 g sample of impure $NaNO_3$ was reacted with an excess of Devarda's alloy.
The $NH_3$ produced was dissolved in 25.0 $cm^3$ of 1.00 mol $dm^{-3}$ $H_2SO_4$.
When all of the $NH_3$ had dissolved, the resulting solution was titrated with NaOH(aq).
For neutralisation, 16.2 $cm^3$ of 2.00 mol $dm^{-3}$ NaOH were required.

**(i)** Calculate the amount, in moles, of $H_2SO_4$ present in the 25.0 $cm^3$ of 1.00 mol $dm^{-3}$ $H_2SO_4$.

**(ii)** Calculate the amount, in moles, of NaOH present in 16.2 $cm^3$ of 2.00 mol $dm^{-3}$ NaOH.

**(iii)** Use your answer to **(ii)** to calculate the amount, in moles, of $H_2SO_4$ that reacted with 16.2 $cm^3$ of 2.00 mol $dm^{-3}$ NaOH.

**(iv)** Use your answers to **(i)** and **(iii)** to calculate the amount, in moles, of $H_2SO_4$ that reacted with the $NH_3$.

*For Examiner's Use*

**(v)** Use your answer to **(iv)** to calculate the amount, in moles, of $NH_3$ that reacted with the $H_2SO_4$.

**(vi)** Use your answer to **(v)** to calculate the amount, in moles, of $NaNO_3$ that reacted with the Devarda's alloy.

**(vii)** Hence calculate the mass of $NaNO_3$ that reacted.

**(viii)** Use your answer to **(vii)** to calculate the percentage by mass of $NaNO_3$ present in the impure sample.
Write your answer to a suitable number of significant figures.

[9]

**(b)** The above reaction is an example of a redox reaction.
What are the oxidation numbers of nitrogen in $NaNO_3$ and in $NH_3$?

$NaNO_3$ ..... $NH_3$ ..... [1]

[Total: 10]

*For Examiner's Use*

**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 when placed in cold water sinks and reacts readily.

.....

**(ii)** An element whose molecules contain $\pi$ bonding.

.....

**(iii)** An element that forms a gaseous toxic oxide.

.....

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

.....

**(v)** An element that forms a covalent chloride which dissolves in water to give a conducting solution.

.....

**(vi)** The element in Period 3 (Na to Ar) with the greatest electrical conductivity.

.....

[6]

For Examiner's Use

**(b)** Some of the elements in Period 3 (Na to Ar) burn with a coloured flame when heated in oxygen or chlorine.

**(i)** Give the symbol of **one** such element, the formula of the **oxide** formed, and state the flame colour that would be seen.

symbol of element .....

formula of oxide .....

flame colour .....

**(ii)** For the element you have used in **(i)**, give the formula of the chloride formed, and state the pH of the solution produced when this chloride is shaken with water.

formula of chloride .....

pH of solution .....

[4]

**(c)** Chlorine reacts with both bromine and iodine to form BrCl and ICl respectively. The melting points of chlorine and the two chlorides are shown in the table.

| substance | $Cl_2$ | BrCl | ICl |
|---|---|---|---|
| m.p./°C | –101 | –66 | 24 |

**(i)** Showing outer electrons only draw a 'dot-and-cross' diagram of the bonding in ICl.

**(ii)** Suggest why the melting points increase from $Cl_2$ to ICl.

.....

.....

.....

**(iii)** Suggest which of these three molecules has the largest permanent dipole. Explain your answer.

.....

.....

.....

[5]

[Total: 15]

*For Examiner's Use*

**4** Crotyl alcohol, $CH_3CH=CHCH_2OH$, is a colourless liquid which is used as a solvent.

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

| | | |
|---|---|---|
| A | $Br_2$ in an inert organic solvent | |
| B | $PCl_5$ | |
| C | $H_2$ and Ni catalyst | |
| D | $NaBH_4$ | |
| E | $K_2Cr_2O_7 / H^+$ heat under reflux | |

[5]

**(b)** Draw the **displayed formula** of the organic compound formed when crotyl alcohol is reacted with cold, dilute acidified potassium manganate(VII).

[1]

**(c)** Draw the **skeletal formula** of the compound formed in reaction E.

[2]

*For Examiner's Use*

**(d)** Crotyl alcohol is obtained from crotonaldehyde, $CH_3CH=CHCHO$.

**(i)** Describe one test that would confirm the presence of a small amount of unreacted crotonaldehyde in the crotyl alcohol.
Give the name of the reagent used and state what you would see.

reagent .....

observation .....

**(ii)** What *type of reaction* is the conversion of crotonaldehyde into crotyl alcohol?

.....
[3]

**(e)** Compound **P**, another unsaturated compound, is found in some blue cheeses.
The percentage composition by mass of compound **P** is C: 73.7%; H: 12.3%; O: 14.0%.

Calculate the empirical formula of compound **P**.

[2]

[Total: 13]

*For Examiner's Use*

**5** A student reacted together an alcohol and a carboxylic acid under appropriate conditions to produce an ester.
A sweet smelling organic liquid, **Q**, with the empirical formula $C_2H_4O$ was produced.
The $M_r$ of **Q** was found by experiment to be 87.5.

**(a)** What is the molecular formula of **Q**?

..... [1]

**(b)** In the boxes below, draw the structural formulae of **four** isomers with this formula that are esters.

| | |
|---|---|
| **W** | **X** |
| **Y** | **Z** |

[4]

A sample of **Q** was hydrolysed by heating with aqueous sulfuric acid.
The resulting mixture was heated under reflux with acidified potassium dichromate(VI) to give a **single** organic product, **R**.
The product, **R**, was collected and subjected to the following tests.

A sample of **R** gave no reaction with Tollens' reagent.

A second sample of **R** gave no reaction with 2,4-dinitrophenylhydrazine reagent.

A third sample of **R** gave an effervescence with sodium carbonate.

**(c) (i)** What does the result of the test with Tollens' reagent show about **R**?

.....

**(ii)** What does the result of the test with 2,4-dinitrophenylhydrazine reagent show about **R**?

.....

**(iii)** What functional group does the result of the test with sodium carbonate show to be present in **R**?

.....
[3]

**(d) (i)** What is the identity of the single organic compound, **R**?

.....

**(ii)** Which of your structures, **W**, **X**, **Y** or **Z**, represents the ester, **Q**?

.....
[2]

**(e)** Which, if any, of your esters, **W**, **X**, **Y** or **Z**, is chiral?

.....

..... [1]

[Total: 11]

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