Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*0728412024*

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

Paper 2 Structured Questions AS Core **May/June 2015**

**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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.



This document consists of **8** printed pages.




CAMBRIDGE International Examinations

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

**1** **(a)** Chemists recognise that atoms are made of three types of particle.

Complete the following table with their names and properties.

| name of particle | relative mass | relative charge |
|---|---|---|
| | | +1 |
| | 1/1836 | |
| | | |

[3]

**(b)** Most elements exist naturally as a mixture of isotopes, each with their own relative isotopic mass. The mass spectrum of an element reveals the abundances of these isotopes, which can be used to calculate the relative atomic mass of the element.

Magnesium has three stable isotopes. Information about two of these isotopes is given.

| isotope | relative isotopic mass | percentage abundance |
|---|---|---|
| $^{24}$Mg | 24.0 | 79.0 |
| $^{26}$Mg | 26.0 | 11.0 |

**(i)** Define the term *relative isotopic mass*.

.....

.....

..... [2]

**(ii)** The relative atomic mass of magnesium is 24.3.

Calculate the percentage abundance and hence the relative isotopic mass of the third isotope of magnesium. Give your answer to **three** significant figures

percentage abundance = .....

isotopic mass = .....

[3]

**(c)** Magnesium can be produced by electrolysis of magnesium chloride in a molten mixture of salts.

**(i)** Give equations for the anode and cathode reactions during the electrolysis of molten magnesium chloride, $MgCl_2$.

anode .....

cathode .....
[2]

The electrolysis is carried out under an atmosphere of hydrogen chloride gas to convert any magnesium oxide impurity into magnesium chloride.

**(ii)** An investigation of the reaction between magnesium oxide and hydrogen chloride gas showed that an intermediate product was formed with the composition by mass Mg, 31.65%; O, 20.84%; H, 1.31% and C*l*, 46.20%.

Calculate the empirical formula of this intermediate compound.

empirical formula ..... [2]

**(d)** The acid/base behaviour of the oxides in the third period varies across the period.

**(i)** Describe this behaviour and explain it with reference to the structure and bonding of sodium oxide, $Na_2O$, aluminium oxide, $Al_2O_3$, and sulfur trioxide, $SO_3$.

.....

.....

..... [2]

**(ii)** Write equations for reactions of these three oxides with hydrochloric acid and/or sodium hydroxide as appropriate.

.....

.....

.....

..... [4]

[Total: 18]



**[Turn over**

**2** Sulfuric acid is an important chemical with a variety of uses.

It is manufactured by the Contact process, the first stage of which involves the conversion of sulfur or a sulfide ore, such as galena, PbS, into sulfur dioxide, $SO_2$.

**(a) (i)** Write an equation for the reaction between galena and oxygen to form sulfur dioxide and lead(II) oxide.

..... [2]

**(ii)** Identify the oxidation number changes that take place during this reaction.

.....

..... [2]

**(b)** The second stage of the Contact process involves the production of sulfur trioxide, $SO_3$, from sulfur dioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197\,kJ\,mol^{-1}$$

**(i)** State the temperature usually chosen for this conversion and explain this in terms of reaction rates and Le Chatelier's principle.

temperature .....

explanation .....

.....

.....

..... [3]

**(ii)** State and explain the pressure conditions that would give the best rate and best yield of sulfur trioxide. Explain why these conditions are **not** actually used.

.....

.....

.....

.....

..... [3]

**(c)** In the third stage of the process the sulfur trioxide is dissolved in 98% sulfuric acid followed by carefully controlled addition of water.

**(i)** Explain why the sulfur trioxide is not dissolved directly in water to produce sulfuric acid.

.....

..... [1]

**(ii)** Write equations for the reaction of sulfur trioxide with sulfuric acid and for the subsequent reaction with water.

.....

..... [2]

**(d)** Explain why sulfur dioxide is used as an additive in some foods and wines.

.....

.....

..... [2]

**(e)** The sulfur dioxide content of wine is most commonly measured by the Ripper Method which involves titration with iodine in the presence of starch as an indicator.

$$SO_2(aq) + I_2(aq) + 2H_2O(l) \rightarrow 2I^-(aq) + SO_4^{2-}(aq) + 4H^+(aq)$$

A 50.0 $cm^3$ sample of wine required 12.35 $cm^3$ of 0.010 mol $dm^{-3}$ $I_2(aq)$ for complete reaction with the $SO_2$.

**(i)** How many moles of $SO_2$ are present in 50.0 $cm^3$ of wine?

moles of $SO_2$ in 50.0 $cm^3$ = ..... [1]

**(ii)** How many moles of $SO_2$ are present in 1 $dm^3$ of wine?

moles of $SO_2$ in 1 $dm^3$ = ..... [1]

**(iii)** How many milligrams, mg, of $SO_2$ are present in 1 $dm^3$ of wine? Give your answer to **three** significant figures. (1 g = 1000 mg)

mass of $SO_2$ in 1 $dm^3$ = ..... mg [1]

[Total: 18]



**[Turn over**

**3** Ethane reacts with chlorine to form chloroethane.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

**(a) (i)** Use bond energies from the *Data Booklet* to calculate the enthalpy change for this reaction. Include a sign in your answer.

enthalpy change = ..... $kJ\,mol^{-1}$ [3]

**(ii)** State the conditions needed for this reaction to occur.

..... [1]

**(iii)** Use a series of equations to describe the mechanism of this reaction including the names of each stage and an indication of how butane can be produced as a minor by-product.

.....

.....

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.....

.....

..... [5]

**(b)** Chloroethane can be converted back into ethane by a two-stage process via an intermediate compound, **X**.

$$C_2H_5Cl \xrightarrow{\text{reaction 1}} \mathbf{X} \xrightarrow{\text{reaction 2}} C_2H_6$$

**(i)** Give the name of **X**.

..... [1]

**(ii)** Suggest the reagent and conditions needed for reaction 1.

..... [2]

**(iii)** Suggest the reagent and conditions needed for reaction 2.

..... [1]

[Total: 13]

**4** There are seven structural isomers with the molecular formula $C_5H_{10}O$ that are carbonyl compounds. Four of these are aldehydes.

These four aldehydes, **A**, **B**, **C** and **D**, have the following properties.

- Aldehyde **A** has a straight chain while **B**, **C** and **D** are branched.
- Aldehyde **B** is the only one of the four isomers with a chiral centre and it exists as a pair of optical isomers.
- Aldehyde **C** has two methyl groups in its structure but **D** has three.

**(a) (i)** Give the structure of each of the four isomers.

**A**

**B**

**C**

**D**

[4]

**(ii)** Draw the three-dimensional structures of the two optical isomers of **B**.

[2]

**(b) (i)** Describe a chemical test that would allow you to distinguish between any of the four isomers **A** to **D** and any of the other three structural isomers of $C_5H_{10}O$, that are carbonyl compounds.

In your answer you should describe any necessary reagents and conditions as well as explaining what you would **see** in each case.

.....

.....

.....

.....

..... [3]

**(ii)** Describe a test that would give the same result with all seven carbonyl isomers of $C_5H_{10}O$.

.....

.....

..... [2]

[Total: 11]