OCR
RECOGNISING ACHIEVEMENT

# Thursday 19 January 2012 – Afternoon

## AS GCE CHEMISTRY B (SALTERS)

**F332/TEST** Chemistry of Natural Resources

*F31452011 2*

Candidates answer on the Question Paper.

**OCR supplied materials:**
- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Chlorine dioxide'* (inserted)

**Other materials required:**
- Scientific calculator

**Duration:** 1 hour 45 minutes

*F332TEST*

| Candidate forename | | Candidate surname | |
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| Centre number | | | | | | Candidate number | | | | |
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**INSTRUCTIONS TO CANDIDATES**

- The inserts will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- The insert *'Chlorine dioxide'* is provided for use with question 5.
- A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **100**.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

**1** Snottites are slimy colonies of bacteria that live in extreme conditions in caves. They take in hydrogen sulfide gas, $H_2S$, and oxygen gas and form sulfuric acid, $H_2SO_4$, in their slime.

**(a)** Hydrogen sulfide is produced by sulfur springs and stagnant water.

**(i)** Draw a '*dot-and-cross*' diagram to represent the bonding in a molecule of hydrogen sulfide.

Show outer electron shells only.

**[1]**

**(ii)** Suggest and explain the shape of the hydrogen sulfide molecule. Give the bond angle.

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..... **[4]**

**(b)** Use your answer to part **(a)(ii)** to help explain whether or not the molecule of hydrogen sulfide is polar.

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..... **[2]**

**(c)** Give the oxidation state of sulfur in hydrogen sulfide and in sulfuric acid.

$H_2S$ .....

$H_2SO_4$ ..... **[2]**

**(d)** Name the substance that has been reduced during the reaction of hydrogen sulfide with oxygen gas to form sulfuric acid. Explain your answer.

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..... **[2]**

**QUESTION 1 CONTINUES ON PAGE 4**

**(e)** A sample of the sulfuric acid formed by snottites was collected in order to find its concentration.

A scientist measured out a 10.0 $cm^3$ sample of cave water containing sulfuric acid using a volumetric pipette and then diluted it to 250 $cm^3$ in a volumetric flask.

The scientist then carried out a titration of the diluted acid with sodium hydroxide solution.

In the titration, 20.0 $cm^3$ of the diluted sulfuric acid solution was found to react exactly with 26.40 $cm^3$ of 0.0500 mol $dm^{-3}$ sodium hydroxide solution.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) \qquad \textbf{equation 1.1}$$

**(i)** Name the piece of apparatus that the scientist would use to add the sodium hydroxide solution to the sulfuric acid during the titration.

..... **[1]**

**(ii)** Calculate the number of moles of NaOH used in the titration.

moles of NaOH = ..... mol **[1]**

**(iii)** Use **equation 1.1** to calculate the number of moles of $H_2SO_4$ that took part in the titration.

moles of $H_2SO_4$ = ..... mol **[1]**

**(iv)** Calculate the concentration of the diluted sulfuric acid used in the titration.

concentration of sulfuric acid = ..... mol $dm^{-3}$ **[2]**

**(v)** Calculate the concentration of the sulfuric acid in the cave water.

Give your answer to **three** significant figures.

concentration of sulfuric acid = ..... mol $dm^{-3}$ **[2]**

**[Total: 18]**

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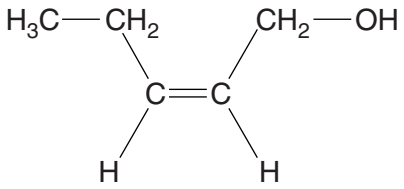
**PLEASE DO NOT WRITE ON THIS PAGE**

**PLEASE TURN OVER FOR QUESTIONS 2, 3, 4 AND 5**

**2** 'Violet oil' is sometimes used in aromatherapy treatments for its mild pain-killing properties. The oil has a strong 'leafy' odour due partly to the presence of compound **A**.



**compound A**

**(a)** Name the functional groups present in compound **A**.

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..... **[2]**

**(b)** Give the molecular formula of compound **A**.

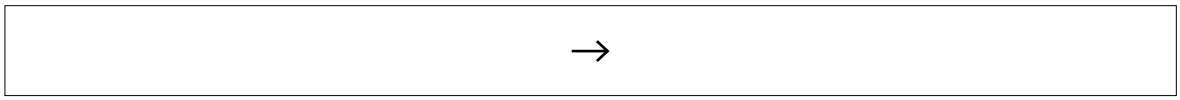
..... **[1]**

**(c)** A student reacts compound **A** with bromine water.

**(i)** Describe the colour change the student would **see** when this reaction takes place.

from ..... to ..... **[2]**

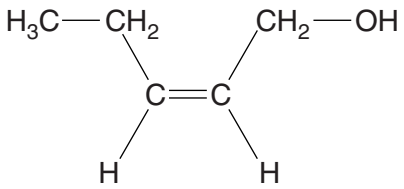
**(ii)** Write the equation for the reaction between compound **A** and bromine, using molecular formulae.



**[1]**

**(iii)** Underline **two** words from the list below that best describe the mechanism for this reaction.

**addition electrophilic nucleophilic radical substitution [2]**



**compound A**

**(d)** Compound **A** is one of a pair of *E*/*Z* isomers.

**(i)** Draw a diagram to show the structure of the other isomer and label it as *E* or *Z*.

**[1]**

**(ii)** Explain why $CH_3CH_2CHCHCH_2OH$ can exist as a pair of *E*/*Z* isomers.

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..... **[2]**

**(e)** Compound **A** reacts with hydrogen chloride to form **two** products with the molecular formula $C_5H_{10}Cl_2$. Draw the structures of **both** of these products.

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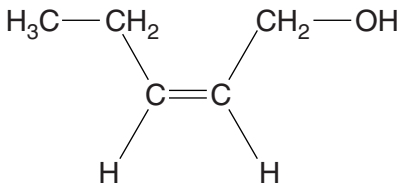
|---|---|
| | |

**[2]**



**compound A**

**(f)** Compound **A** can also be used to produce an addition polymer that is soluble in water.

**(i)** Draw a diagram below to show the repeating unit of the polymer formed from compound **A**.

**[1]**

**(ii)** The polymer formed from compound **A** is soluble in water.

Explain this solubility in terms of the molecular structure of the polymer and the formation of hydrogen bonds.

You should:

- explain how hydrogen bonds form
- suggest why the polymer is soluble in water.

*In your answer, you should make it clear how the structure of the polymer links to its solubility in water.*

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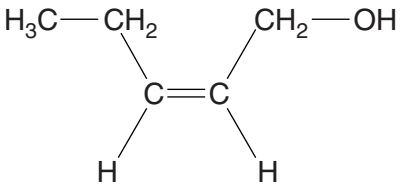
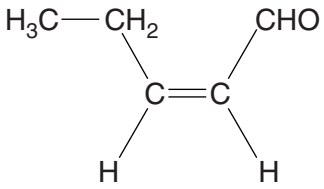
..... **[4]**

**(g)** A student produces compound **B** by gently heating compound **A** with suitable reagents and immediately distilling the product from the mixture.




**compound A**




**compound B**

**(i)** Name the reagents the student uses to convert compound **A** into compound **B**.

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..... **[2]**

**(ii)** Name the functional group that is present in compound **B** that is not present in compound **A**.

..... **[1]**

**(h)** A student carries out a reaction using the same reagents as in part **(g)**, but by heating the reaction mixture under reflux. Compound **C** is produced.

**(i)** Explain what is meant by the term *heating under reflux*.

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..... **[2]**

**(ii)** Draw the **full** structural formula of the new functional group present in compound **C** and name this functional group.

name of functional group: ..... **[2]**

**[Total: 25]**

**3** In 2010, an Icelandic volcano erupted producing ash clouds that stopped plane flights across much of Europe. The volcano also emitted a mixture of gases.

**(a)** The ash produced by the volcano contained silicon dioxide, $SiO_2$, whilst the gas mixture contained carbon dioxide.

Silicon dioxide is a solid but carbon dioxide is a gas at room temperature.

Explain this difference in terms of the bonding and structure in both compounds.

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..... **[3]**

**(b)** Most scientists are concerned about the increasing amount of carbon dioxide in the Earth's atmosphere.

Give **two** different processes, other than volcanic activity, that are causing an increase in the amount of carbon dioxide in the atmosphere.

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..... **[2]**

**(c)** Most carbon dioxide from industrial processes is allowed to escape into the atmosphere.

**(i)** Carrying out capture and storage of carbon dioxide is one way that a chemical manufacturing process could be changed to slow down the increase in carbon dioxide levels in the atmosphere.

Suggest **TWO** other changes that a chemical company could make to its processes to achieve a reduction in the rate of increase of carbon dioxide levels.

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..... **[2]**

**(ii)** Suggest why capture and storage of carbon dioxide is expensive.

.....

..... **[1]**

**(d)** The Earth absorbs visible radiation from the Sun and emits radiation from a different part of the electromagnetic spectrum. Carbon dioxide molecules absorb some of the emitted radiation.

**(i)** Name the type of electromagnetic radiation that is emitted from the Earth's surface.

..... **[1]**

**(ii)** Explain what happens to carbon dioxide molecules when they absorb the radiation emitted from the Earth.

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..... **[1]**

**(iii)** Explain how the changes that happen after the process in **(ii)** result in the warming of the atmosphere.

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..... **[2]**

**(e)** The amount of carbon dioxide in the troposphere is affected by the fact that it can dissolve in ocean water. The following equations describe the main reactions that occur.

$$CO_2(g) \rightleftharpoons CO_2(aq) \qquad \textbf{equation 3.1}$$

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \qquad \textbf{equation 3.2}$$

**(i)** Using these equations, explain the effect that an increase in carbon dioxide concentration in the troposphere will have on the $HCO_3^-$ concentration in the oceans.

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..... **[3]**

**(ii)** Suggest why the balance between gaseous $CO_2$ in the troposphere and $CO_2(aq)$ in the oceans cannot be regarded as a true dynamic equilibrium.

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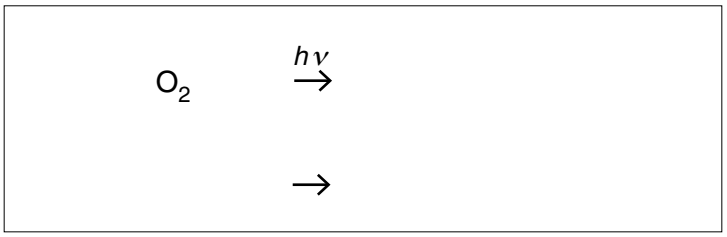
..... **[1]**

**(f)** There has also been concern about the amount of ozone in the atmosphere. The overall equation for the formation of ozone in the Earth's atmosphere is shown below.

$$3O_2 \rightarrow 2O_3$$

**(i)** Complete and balance **two** equations to show how oxygen is converted into ozone in the stratosphere.




**[2]**

**(ii)** Explain why the formation of ozone you have described in **(i)** takes place in the stratosphere but **not** usually in the troposphere.

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..... **[2]**

**(g)** Ozone can be broken down by nitrogen monoxide. The mechanism for this process is shown below.

**step 1** $NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$ **equation 3.3**

**step 2** $NO_2(g) + O(g) \longrightarrow NO(g) + O_2(g)$ **equation 3.4**

**(i)** Combine **equations 3.3** and **3.4** to produce the overall equation for the reaction.

**[1]**

**(ii)** In the mechanism shown above for the breakdown of ozone, NO is acting as a homogeneous catalyst.

Explain what is meant by the term *homogeneous* in the context of catalysis.

How can you tell from **equation 3.3** and **equation 3.4** that NO is a catalyst?

homogeneous: .....

.....

NO is a catalyst because: .....

.....

..... **[2]**

**[Total: 23]**

**4** Chlorofluorocarbons, CFCs, were originally regarded as very useful compounds. Their physical and chemical properties meant that they could be used for a wide range of applications, including as refrigerants and cleaning solvents.

**(a)** Unfortunately, we now know that CFCs break down in the stratosphere, starting a sequence of reactions that lead to ozone depletion.

$$CCl_2F_2 \xrightarrow{h\nu} CClF_2 + Cl \qquad \textbf{equation 4.1}$$

$$Cl + O_3 \rightarrow ClO + O_2 \qquad \textbf{equation 4.2}$$

$$ClO + O \rightarrow Cl + O_2 \qquad \textbf{equation 4.3}$$

**(i)** Underline the term from the list below that describes the type of process shown in **equation 4.3**.

**initiation** **propagation** **termination** **[1]**

**(ii)** Explain why it is important that there is a certain minimum amount of ozone in the stratosphere.

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..... **[3]**

**(b)** The table below shows two CFCs and a former use for each of them.

Complete the table by choosing **one** property from the list below that is **essential** for the given use of **each** CFC:

**non-flammable** **low boiling point** **high ozone depletion potential** **low reactivity**

| **CFC** | **use** | **essential property linked to use** |
|---|---|---|
| $CCl_2F_2$ | refrigerant | |
| $CCl_3F$ | blowing agent | |

**[2]**

**(c)** Scientists have decided that hydrofluorocarbons, or HFCs, like $F_3CCFH_2$, will make good long-term replacements for CFCs.

**(i)** Explain, in terms of the reactivity of HFCs in the **stratosphere**, why scientists think HFCs are a good long-term solution as replacements for CFCs.

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..... **[2]**

**(ii)** Give **one** advantage and **one** disadvantage, not linked to their ozone depleting potential, which scientists would take into account when considering the use of HFCs in place of CFCs.

Advantage: .....

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Disadvantage:.....

..... **[2]**

**(d)** The hydrofluorocarbon, $F_3CCFH_2$, can be prepared industrially by reacting hydrogen fluoride with $Cl_2C{=}CClH$.

$$Cl_2C{=}CClH + 4HF \longrightarrow F_3CCFH_2 + 3HCl \qquad \textbf{equation 4.4}$$

**(i)** In the reaction shown in **equation 4.4**, some of the hydrogen fluoride takes part in a nucleophilic substitution reaction with the $Cl_2C{=}CClH$.

Explain how HF can act as a *nucleophile* in this reaction.

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..... **[2]**

**(ii)** The reaction shown in **equation 4.4** can be catalysed by chromium(III) fluoride.

Explain why the use of a catalyst speeds up the reaction rate.

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..... **[2]**

**[Total: 14]**

**5** This question is based on the Advance Notice article '**Chlorine dioxide**' which is provided as an insert to this paper.

**(a)** Explain what is meant by the term *radical* and name the type of bond breaking that forms radicals. Give an example of a radical from the article, other than chlorine dioxide.

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Example: .....

..... **[3]**

**(b)** Write the **ionic** equation for the reaction of sodium chlorate(V) with HC*l*.

$\rightarrow$

**[2]**

**(c)** By reference to the types of intermolecular bonds that are present, explain why chlorine dioxide has a higher boiling point than chlorine.

*In your answer, you should use appropriate technical terms, spelled correctly.*

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..... **[4]**

**(d)** Chlorine dioxide can oxidise some organic compounds.

**(i)** Suggest a **hydrocarbon** with three carbon atoms that might be oxidised by chlorine dioxide, giving your reason.

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..... **[2]**

**(ii)** Explain why, in the reaction of chlorine dioxide with organic molecules, the chlorine dioxide is said to have been reduced.

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..... **[1]**

**(e)** Calculate the percentage of 'available chlorine' in chlorine dioxide when it is reduced to chloride.

available chlorine = ..... % **[2]**

**QUESTION 5 CONTINUES ON PAGE 18**

**(f)** Explain why chlorine dioxide is preferred to chlorine as a disinfectant.

*In your answer you should make clear the chemical theory behind some of the comparisons you make.*

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..... **[6]**

**[Total: 20]**

**END OF QUESTION PAPER**

## ADDITIONAL PAGE

**If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.**

## ADDITIONAL PAGE