OCR
Oxford Cambridge and RSA

# Friday 10 June 2016 – Afternoon

## AS GCE CHEMISTRY B (SALTERS)

**F332/01/TEST** Chemistry of Natural Resources

*5987223014*

Candidates answer on the Question Paper.

**OCR supplied materials:**
- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Radical changes in our atmosphere'* (inserted)

**Other materials required:**
- Scientific calculator

**Duration:** 1 hour 45 minutes

*F3320 1*

| Candidate forename | | Candidate surname | |
|---|---|---|---|

| Centre number | | | | | | Candidate number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

**INSTRUCTIONS TO CANDIDATES**

- The Inserts will be found inside 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.
- Answer **all** the questions.
- 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 page(s) at the end of this booklet. The question number(s) must be clearly shown.
- 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.
- The total number of marks for this paper is **100**.
- 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 'Radical changes in our atmosphere' 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.
- This document consists of **24** pages. Any blank pages are indicated.

Answer **all** the questions.

**1** Carbon atoms can bond to each other to produce a variety of different structures, including diamond, graphite and buckminsterfullerene. Graphite consists of layers of carbon atoms arranged in hexagons.

**(a)** There are similarities and differences in the structure and bonding in diamond and graphite.

**(i)** Describe **two** features of the structure and bonding in diamond that are **similar** to graphite.

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

**(ii)** Describe **two** features of the structure and bonding in diamond that are **different** from graphite.

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

**(b)** Buckminsterfullerene is a form of carbon with the formula $C_{60}$. If it is burned completely in oxygen, it forms carbon dioxide as the only product.

Calculate the mass of carbon dioxide that is released when 51 g of buckminsterfullerene is completely burned in oxygen.

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

mass of carbon dioxide = ..... g **[2]**

**(c)** Coal burns to form carbon dioxide, some of which is released into the atmosphere.

**(i)** One method that could be used to reduce the amount of atmospheric carbon dioxide is to pump it onto the ocean floor.

Suggest why is it unlikely that carbon dioxide stored under the ocean would escape back into the atmosphere.

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

**(ii)** Give **two** ways, other than the one described in part **(i)**, that can be used to remove carbon dioxide from the atmosphere.

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

**(iii)** When coal burns, some carbon monoxide may form as well as carbon dioxide.

Give **one** polluting effect of carbon monoxide and of carbon dioxide in the atmosphere.

Carbon monoxide .....

.....

Carbon dioxide .....

.....

**[2]**

**(d)** Some of the carbon dioxide released into the atmosphere dissolves in seawater (**equation 1.1**). The dissolved carbon dioxide then reacts, as shown in **equation 1.2**.
Seawater becomes more acidic if the concentration of $H^+$ ions in the water increases.

$CO_2\ (g) \rightleftharpoons CO_2\ (aq)$ **equation 1.1**

$CO_2\ (aq) + H_2O\ (l) \rightleftharpoons HCO_3^-\ (aq) + H^+\ (aq)$ **equation 1.2**

Explain what would happen to the concentration of carbon dioxide in the atmosphere if the seawater became more acidic. Use **equations 1.1** and **1.2**, and le Chatelier's principle in your answer.

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

**(e)** Carbon dioxide in the atmosphere can be detected using infrared spectroscopy.

**(i)** Explain how the interaction of infrared radiation with carbon dioxide molecules enables the identification of carbon dioxide.

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

**(ii)** Carbon dioxide molecules absorb infrared radiation with an energy value of 21.7 kJ mol$^{-1}$.

Calculate the frequency of this infrared radiation.

Planck constant, $h = 6.63 \times 10^{-34}$ JHz$^{-1}$

Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol$^{-1}$

frequency = ..... Hz **[3]**

**[Total: 19]**

**2** At the Eden Project, plants grow in transparent domes that are made from ETFE.
ETFE is a polymer made by reacting ethene with tetrafluoroethene.

**(a)** Ethene and tetrafluoroethene, which are both gases at room temperature, have different boiling points.

| Chemical | Boiling point / K |
|---|---|
| Ethene | 169 |
| Tetrafluoroethene | 197 |

Explain, in terms of intermolecular bonds, the difference in boiling points of ethene and tetrafluoroethene.

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

**(b)** Draw a section of the ETFE chain that includes **one** unit from ethene and **two** units from tetrafluoroethene.

**[1]**

**(c)** Give the **name** that is used to describe a polymer formed from two different monomers.

.....

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

**(d)** One property of ETFE is that it is insoluble in water. This makes ETFE a suitable material for the domes at the Eden project.

Explain, using ideas of intermolecular bonds, why ETFE is insoluble in water.

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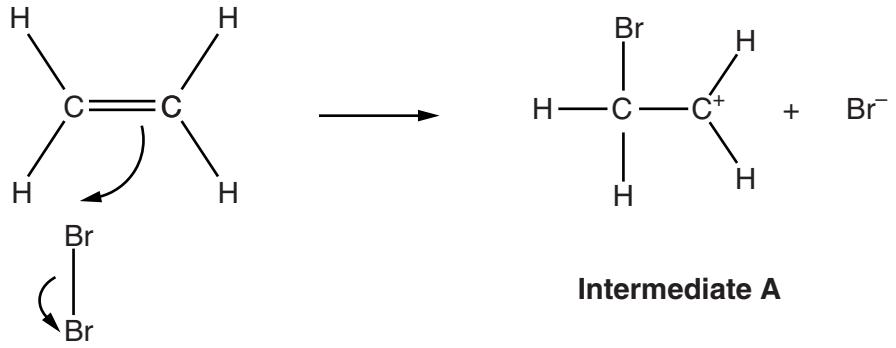
..... **[1]**

**(e)** Most reactions of ethene are addition reactions. The diagram below shows **step 1** of the mechanism for the reaction of ethene with bromine.




**Intermediate A**

**Mechanism 2.1**

**(i)** Give the name of the **type** of intermediate, such as **intermediate A**, that forms in this reaction.

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

**(ii)** The reaction in **step 1** involves attack by an electrophile.

Explain what is meant by the term *electrophile.*

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

**(iii)** A scientist reacts ethene with bromine in a solution that also contains sodium chloride. Two of the products that form are $CH_2BrCH_2Br$ and $CH_2ClCH_2Br$.

Use **Mechanism 2.1** to explain why these two products form.

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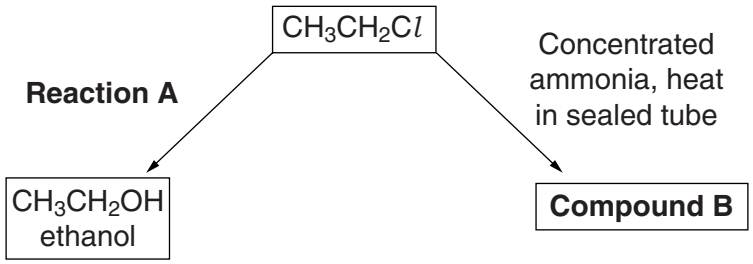
..... **[3]**

**(f)** When ethene reacts with hydrogen chloride, chloroethane is produced. Chloroethane can take part in a number of further reactions. Two of these reactions are shown below.




**(i)** **Reaction A** can be carried out by two different nucleophiles.

Name the **two** different **nucleophiles** that could be used for **reaction A**.

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

**(ii)** Give the **full** structural formula of **compound B**.

**[1]**

**(iii)** Which homologous series includes **compound B**?

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

**(iv)** The rate of the reaction of chloromethane with ammonia increases if the temperature is increased.

Explain why the rate of a reaction increases if the temperature increases.

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

**(g)** Infrared spectroscopy can be used to check the purity of the ethanol formed in **reaction A**.

**(i)** Use the *Data Sheet* to give two absorption ranges that are present in the infrared spectrum of ethanol.

Complete the table below to show these absorption ranges and the relevant bonds.

| **Absorption range/cm$^{-1}$** | **Bond** |
|---|---|
| | |
| | |

**[2]**

**(ii)** Name the region of an infrared spectrum below 1500 cm$^{-1}$ and explain the significance of this region.

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

**(h)** Ethanol can be oxidised using acidified potassium dichromate(VI) solution.
Two different organic products are formed depending on the oxidation conditions.

Complete the table below.

| **Oxidation conditions** | **Formula of functional group of product** | **Homologous series of product** |
|---|---|---|
| Heat and immediately distil | | |
| Heat under reflux | | |

**[2]**

**[Total: 24]**

**3** In industry, hydrogen and chlorine can be made from sodium chloride solution by electrolysis in a membrane cell. The membrane has negatively charged groups that attract sodium ions.
The sodium ions then pass through the membrane.

**(a)** Chloride ions form when a chlorine atom gains one electron.

Complete the diagram below, using arrows to indicate the arrangement of electrons in atomic orbitals for a chloride ion.

[Ne] 3s ☐ 3p ☐ ☐ ☐

**[1]**

**(b)** Suggest a completion of the equation below for the overall reaction when sodium chloride solution is electrolysed.

2 NaC$l$ + ..... $H_2O \rightarrow$

**[1]**

**(c)** $Mg^{2+}$ and $Ca^{2+}$ ions are often found in the sodium chloride solution.

**(i)** Suggest a reason for removing the $Mg^{2+}$ and $Ca^{2+}$ ions from the solution before electrolysis.

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

**(ii)** Write an equation representing the second ionisation enthalpy of magnesium.

Include state symbols.

$\rightarrow$

**[2]**

**(iii)** The second ionisation enthalpy for magnesium is greater than that for calcium.

Explain why.

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

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

**(d)** The hydrogen and chlorine produced in this electrolysis are often combined to make hydrogen chloride. Chloromethane can be made from the reaction of methanol with hydrogen chloride.

**(i)** Draw a diagram to show how one hydrogen chloride molecule attacks a molecule of methanol.

Add 'curly arrows' to show the attack and the resulting electron pair movements.

**[3]**

**(ii)** Underline the **two** words that describe the mechanism of the reaction between hydrogen chloride and methanol.

| | | |
|---|---|---|
| **addition** | **electrophilic** | **elimination** |
| **nucleophilic** | **radical** | **substitution** |

**[2]**

**(e)** Hydrogen chloride dissolves in water to form hydrochloric acid. The hydrochloric acid is analysed to find its concentration by titrating 50.0 $cm^3$ of the acid with a standard solution of barium hydroxide, $Ba(OH)_2$.

**(i)** Name a suitable piece of equipment for the student to use to add the barium hydroxide solution to the hydrochloric acid.

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

**(ii)** Write the equation for the reaction of barium hydroxide with hydrochloric acid.

**[1]**

**(iii)** The titration requires 19.6 $cm^3$ of a 0.100 mol $dm^{-3}$ solution of barium hydroxide.

Calculate the concentration of $H^+$ ions in the hydrochloric acid in mol $dm^{-3}$.

concentration = ..... mol $dm^{-3}$ **[3]**

**[Total: 17]**

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**Turn over for the next question**

**4** A sample of air was taken close to a busy motorway. The water vapour was removed from the air and the air was then analysed. Some of the components in the air sample are shown in the table below.

| Component gas formula | Abundance by volume | |
|---|---|---|
| | % | ppm |
| $N_2$ | 78.0 | |
| NO | | 76.0 |
| $N_2O$ | | $3.80 \times 10^{-1}$ |
| $CH_3CH{=}CHCH_3$ | | $4.00 \times 10^{-3}$ |
| $O_3$ | | 12.0 |

**(a)** Name a **solid** that could be used to dry the air.

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

**(b)** The compounds of nitrogen given in the table are atmospheric pollutants. These can occur naturally or as a result of human activities.

**(i)** Give a **natural** source of NO in the atmosphere.

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

**(ii)** Give a **human activity** that could result in the production of nitrogen oxides in the atmosphere.

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

**(iii)** Give the systematic name for $N_2O$.

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

**(c)** A molecule of $N_2O$ has a central N atom forming a dative covalent bond.

Draw a '*dot-and-cross*' diagram to represent the bonding in $N_2O$.

**[2]**

**(d)** How much more abundant is $N_2$ than $N_2O$ in this sample of air?

answer = ..... times more abundant **[2]**

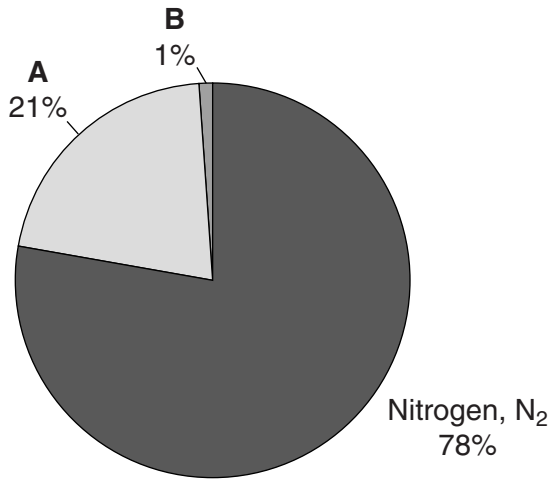
**(e)** $CH_3CH=CHCH_3$ exists as two stereoisomers.

Draw structures of the **two** stereoisomers and give their systematic names.

| | | |
|---|---|---|
| **Structure** | | |
| **Name** | | |

**[3]**

**(f)** The pie chart below shows the major components of tropospheric air and their percentage by volume.




Complete the table to show the names and formulae of **A** and **B**.

| Component of air | Name | Formula |
|---|---|---|
| **A** | | |
| **B** | | |

**[1]**

**(g)** Ozone is present in both the troposphere and the stratosphere. Ozone in the stratosphere is essential to life on Earth.

**(i)** In the 1980s, scientists found there were abnormally low concentrations of ozone above the Antarctic. The scientists concluded that ozone depletion was occurring in the atmosphere.

Explain why the evidence for ozone depletion was accepted by scientists as being correct.

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

**(ii)** Ozone depletion is catalysed by gaseous chlorine atoms in the atmosphere.

What **type** of catalysis is this?

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

**(h)** Earth's atmosphere also contains water vapour. This water vapour often condenses into liquid water or forms ice particles. The density of ice is less than the density of water.

Explain the difference in density of liquid water and ice, in terms of intermolecular bonds.

You should include the name of the intermolecular bonds that form in liquid water and ice and explain how they form.

*In your answer, you should make it clear how the structures of liquid water and ice lead to the difference in density.*

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

**[Total: 20]**

**5** This question is based on the article: 'Radical changes in our atmosphere', which is provided as an insert in this paper.

**(a)** Ozone that is present in the atmosphere can cause environmental problems.

Name **one** example from the article of an environmental problem to which ozone contributes.

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

**(b)** The article describes the way that ozone reacts with alkenes in the atmosphere.

**(i)** Give **two** sources of alkenes in the atmosphere that are mentioned in the article.

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

**(ii)** Deduce an equation for the reaction of ozone with propene to produce a biradical and another molecule.

Use structural formulae for the organic molecules in your equation.

**[2]**

**(c)** The article describes a sequence of reactions involving methane and irradiated chlorine.

**(i)** The initiation reaction is described as being endothermic.

Give an example of an **exothermic** reaction from the sequence of reactions in the article that involve methane and irradiated chlorine.

**[1]**

**(ii)** Explain how you know that this reaction must be exothermic, without needing any energy data.

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

**(iii)** Write a **propagation** reaction for the last step in the production of $CCl_4$ in the mixture.

→

**[1]**

**(d)** The reaction of methane with irradiated chlorine is a process that occurs in the atmosphere and involves radicals.

Name **two** other processes from the article that involve radicals in the atmosphere.

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

**(e)** The article gives information about a type of radical called a 'Criegee biradical'.

**(i)** Explain what a Criegee biradical is.

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

**(ii)** Criegee biradicals can be generated in a laboratory. A first step involves breaking bonds in halogenoalkanes.

The frequency of radiation needed to break the bond in $CH_2Cl_2$ is different from that of the frequency needed to break a bond in $CH_2I_2$.

Describe and explain this difference.

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

**(f)** Describe how Criegee biradicals form in the atmosphere and how and why they have only recently been detected.

Include the formula of one Criegee biradical given in the article.

*In your answer you should include a link between the structure of a Criegee biradical and why they have only recently been detected.*

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..... **[7]**

**[Total: 20]**

**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).