OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2848/01**

CHEMISTRY (SALTERS)

Chemistry of Natural Resources

THURSDAY 11 JANUARY 2007 Morning

Time: 1 hour 30 minutes

Additional materials: *Data Sheet for Chemistry (Salters)* (Inserted)
Scientific calculator

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry (Salters)* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

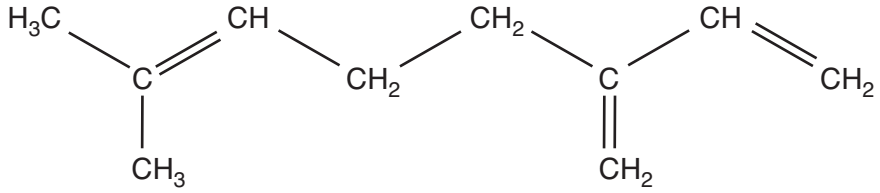
FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	23	
2	18	
3	24	
4	25	
TOTAL	90	

This document consists of **14** printed pages, **2** blank pages and a *Data Sheet for Chemistry (Salters)*.

[Turn over

Answer **all** the questions.

1 Myrcene is a naturally-occurring oil present in bay leaves. It can be used in perfumes to give a spicy character. The structure of myrcene is shown below.



myrcene

(a) Name the functional group present in myrcene.

..... [1]

(b) Information about the structure of myrcene can be obtained by reacting it with bromine to produce the **saturated** organic compound **A**.

(i) State the colour change you would see when bromine reacts with myrcene.

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

(ii) Circle **two** words from the following list that best describe what is happening in the reaction of myrcene with bromine.

addition electrophilic elimination nucleophilic radical substitution

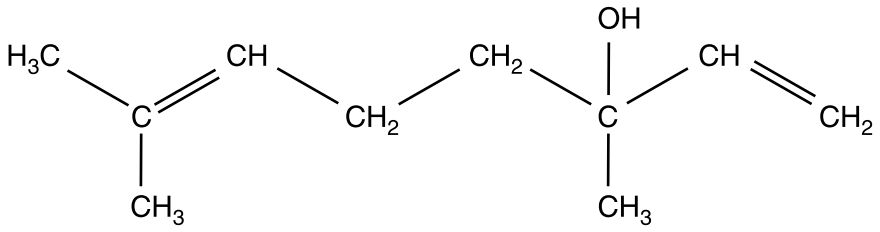
[2]

(iii) Write a balanced equation for the reaction of myrcene, $C_{10}H_{16}$, with bromine to produce the **fully saturated** compound **A**. Use the molecular formulae of the molecules.

→

[2]

(c) Myrcene can be used to make linalool, which is used for flavouring foods. The structure of linalool is shown below.



linalool

(i) Name the molecule that would need to be added to myrcene to form linalool.

..... [1]

(ii) The linalool molecule contains an alcohol functional group. Is this alcohol group primary, secondary or tertiary? Explain your answer.

.....

..... [2]

(iii) What, if anything, would you expect to happen if linalool were heated with acidified potassium dichromate(VI) solution? Explain your answer.

.....

.....

..... [2]

(d) Linalool could be converted back to myrcene.

(i) What **type** of reaction would need to be carried out to convert linalool back to myrcene?

..... [1]

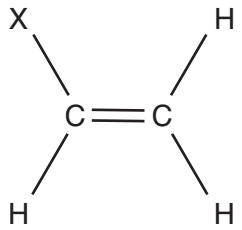
(ii) What reagent(s) and conditions would be required for this reaction?

.....

.....

..... [3]

(e) When products containing myrcene are stored for long periods, they can become cloudy. This is because the myrcene forms a polymer. Using the structure

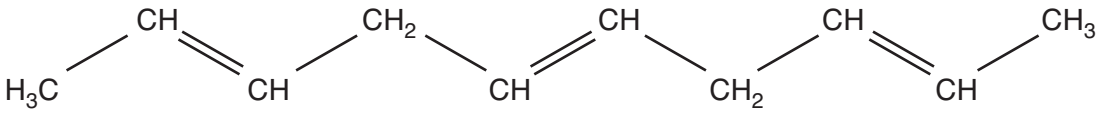


to represent a molecule of myrcene, draw the structure of the repeating unit of the polymer.

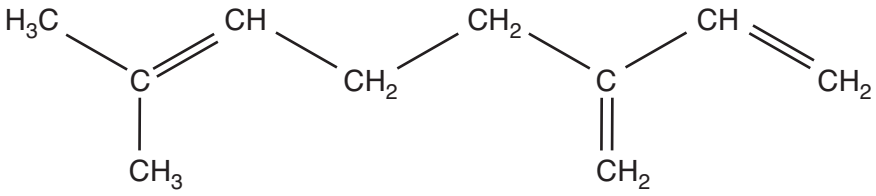
[1]

(f) In this question, one mark is available for the quality of the use and organisation of scientific terms.

Compound C is an isomer of myrcene. It has the structure shown below.



compound C



myrcene

Both **compound C** and myrcene have instantaneous dipole–induced dipole forces of attraction between their molecules. **Compound C** has a higher boiling point than myrcene. Explain this in terms of intermolecular forces.

In your answer you should refer to:

- how instantaneous dipole–induced dipole forces arise;
- how these forces can be used to account for the higher boiling point of **compound C** compared to that of myrcene.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

Quality of Written Communication [1]

[Total: 23]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

2 Natural mineral water contains a range of dissolved minerals. Sparkling mineral water can be produced by pumping pressurised carbon dioxide into the water.

(a) The following equations show the reactions that occur when carbon dioxide dissolves in the mineral water.

$$CO_2(g) \rightleftharpoons CO_2(aq) \qquad \textbf{equation 2.1}$$

$$CO_2(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq) \qquad \textbf{equation 2.2}$$

(i) Use Le Chatelier's principle to explain the effect that the high pressure of the carbon dioxide gas in **equation 2.1** has on the concentration of dissolved carbon dioxide.

.....

.....

..... [2]

(ii) In a bottle of sparkling mineral water a dynamic equilibrium is established between the gaseous and aqueous carbon dioxide. Explain what is meant by the terms *dynamic* and *equilibrium*.

.....

.....

.....

..... [2]

(iii) Use **equation 2.2** to explain why the water becomes more acidic as the concentration of dissolved carbon dioxide increases.

.....

..... [1]

(iv) Give the formula of a base in **equation 2.2**.

..... [1]

(b) A student decides to analyse a mineral water sample to check the amount of dissolved sulphate ions (SO_4^{2-}) it contains.

(i) The student adds barium chloride solution to the water to precipitate out the sulphate ions as barium sulphate. Write the **ionic** equation that describes the precipitation of the barium sulphate, showing state symbols.

$\rightarrow$

[2]

(ii) The student collects the barium sulphate by vacuum filtration. This is then dried and weighed. Draw a labelled diagram of the vacuum filtration apparatus.

[2]

(iii) From his results, he calculates that the mineral water contained sulphate ions at a concentration of 7.4×10^{-5} mol dm^{-3}. When he compares this with the label on the bottle, he finds the information is quoted in g dm^{-3}. Calculate the concentration of sulphate ions in the water in g dm^{-3}. Give your answer to **two** significant figures.

A_r: S, 32; O, 16.

concentration = ... g dm^{-3} [3]

(c) The mineral water also contains trace amounts of iron(III) ions, Fe^{3+}.

(i) The iron(III) ions are hydrated in solution. Draw a diagram to show how water molecules surround an iron(III) ion, showing charges and partial charges.

[3]

(ii) Complete the electron configuration for an iron **atom**.

$1s^2\,2s^2\,2p^6\,3s^2\,3p^6$

[2]

[Total: 18]

3 Scientists have worked out how the atmosphere of the Earth is likely to have changed in composition since the Earth formed. Some of this information has come from the analysis of air bubbles that have been trapped in Antarctic ice.

(a) Early in the Earth's history the atmosphere is thought to have contained large amounts of methane and carbon dioxide. These are present in our current atmosphere in small percentages.

(i) Name the **two** most abundant gases in the troposphere (lower atmosphere) today.

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

(ii) Our troposphere also contains some trace components that are pollutants. These include some compounds of nitrogen and of sulphur. Complete the table below to show **one** nitrogen compound and **one** sulphur compound each of which results from a **different** human activity.

	name of pollutant	human activity
nitrogen compound		
sulphur compound		

[4]

(b) Today, the Earth's atmosphere contains relatively small amounts of methane. The atmosphere also contains small amounts of chloromethane, which is given off during forest fires. If this chloromethane reaches the stratosphere (upper atmosphere) it is responsible for the breakdown of some of the stratospheric ozone. This happens when chlorine radicals are produced from the chloromethane molecule.

(i) What is meant by the term *radical*?

..... [1]

(ii) Write the balanced chemical equation for the production of a chlorine radical from a chloromethane molecule.

$\rightarrow$

[2]

(iii) The chlorine radical is a homogeneous catalyst for the breakdown of ozone. Explain why this catalysis is classified as *homogeneous*.

.....

..... [1]

(iv) The presence of a catalyst makes a reaction go faster because it provides an alternative route with a lower activation enthalpy. Explain what is meant by *activation enthalpy*.

.....

.....

..... [2]

(v) State what happens to the rate of a reaction if the temperature increases. Explain this change in terms of the reacting particles.

.....

.....

.....

..... [3]

(vi) The energy needed to break one C–C*l* bond, and so form a chlorine radical, is 7.69×10^{-19} J.

Calculate the minimum frequency of radiation needed to form a chlorine radical.

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

minimum frequency = ... Hz [2]

(vii) Suggest why chlorine radicals are not produced from chloromethane molecules in the troposphere (lower atmosphere).

.....

.....

..... [2]

(c) One way to analyse the air bubbles from Antarctic ice is to use infrared spectroscopy. This process involves passing infrared radiation of known frequencies through the gas mixture and measuring the amount of radiation that is absorbed at each frequency value.

(i) The air must be dried before it can be put into the infrared spectrometer. Name a drying agent that could be used.

..... [1]

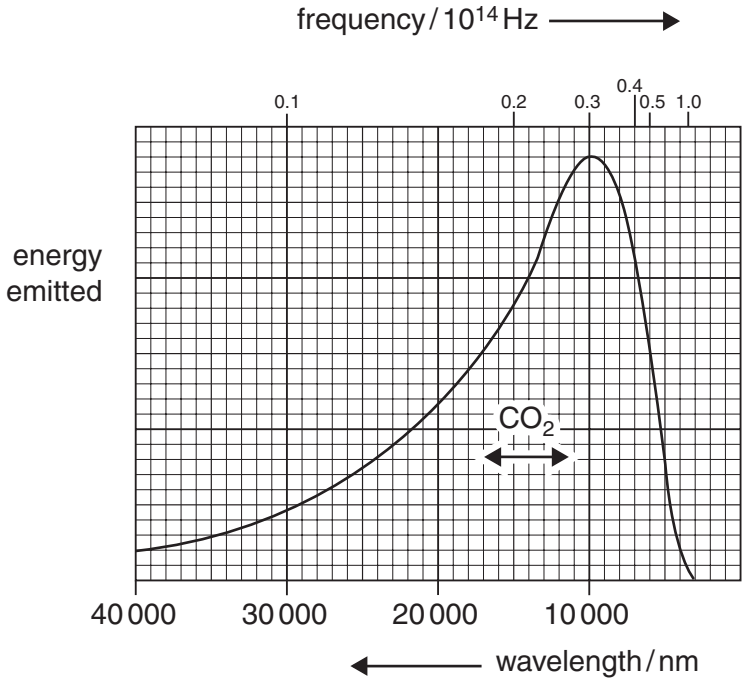
(ii) Explain why molecules absorb infrared radiation of specific frequencies.

.....

.....

..... [2]

(iii) The following chart shows the radiation given off from the surface of the Earth and indicates the range of frequencies that are absorbed by carbon dioxide.



Use this information to explain how carbon dioxide contributes to the greenhouse effect that keeps the Earth's atmosphere warm.

.....

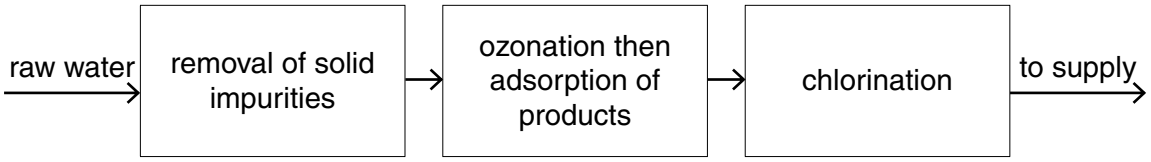
.....

.....

..... [2]

[Total: 24]

4 In the 1990s, British water companies started to use a new process for purifying water for domestic supplies. They introduced an extra step in the purification process that involved treating the water with ozone.



(a) What process would be used to remove the solid impurities in the first stage of this purification?

..... [1]

(b) The ozone for this water treatment is produced by the action of a powerful electrical discharge on the oxygen molecules, O_2, contained in the air. Write the overall balanced equation for the production of ozone, O_3, from oxygen molecules.

$\rightarrow$

[1]

Ozone for water treatment cannot be used for lasting protection as it decomposes quickly. For this reason, purification plants using ozone add a trace of chlorine to water as it is put into distribution.

(c) Some of the bacteria present in water are able to convert dissolved sulphates into hydrogen sulphide gas. The chlorine is also used to remove this unpleasant smelling impurity.

The reaction equation is given below.

$$H_2S(g) + Cl_2(aq) \longrightarrow 2HCl(aq) + S(s) \qquad \textbf{equation 4.1}$$

(i) Write down the oxidation states of chlorine before and after the reaction.

Cl_2 ..... HCl ..... [2]

(ii) Explain why the reaction in **equation 4.1** is classified as *redox*.

.....

.....

..... [2]

(d) The concentration of chlorine in drinking water can be monitored by testing water samples. Excess potassium iodide is added to a 1000 cm^3 sample of water. The iodine that forms is reacted with sodium thiosulphate solution of a known concentration.

(i) Complete **equation 4.2** below for the reaction between chlorine molecules and iodide ions. Explain why this reaction happens by reference to the reactivity of halogens.

$Cl_2(aq) + 2I^-(aq) \rightarrow$ **equation 4.2**

explanation .....

..... [2]

(ii) Write a **half-equation** that shows what happens to the chlorine molecules in **equation 4.2**.

$\rightarrow$

[2]

(iii) The ionic equation for the reaction between iodine and sodium thiosulphate is given below.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq) \qquad \textbf{equation 4.3}$$

The iodine formed reacts with 14.0 cm^3 of 0.00100 mol dm^{-3} sodium thiosulphate solution.

Calculate the number of moles of sodium thiosulphate, $Na_2S_2O_3$, used in the reaction.

number of moles of $Na_2S_2O_3$ = ... [2]

(iv) Name the piece of equipment that would be used to add the sodium thiosulphate solution during the titration.

..... [1]

(v) Use your answer to **(iii)** to calculate the number of moles of iodine molecules, I_2, used in the reaction in **equation 4.3**.

number of moles of I_2 = ... [1]

(vi) Use your answers to **(i)** and **(v)** to write down the number of moles of chlorine molecules in the sample.

number of moles Cl_2 = ... [1]

(e) Chlorine concentrations in water are not allowed to rise above certain levels. Suggest **one** reason why the concentration of chlorine in water is kept very low.

.....

..... [1]

(f) Large amounts of chlorine are manufactured each year. Water treatment is one of the major uses for chlorine. State **one** other large-scale use of chlorine, apart from water treatment.

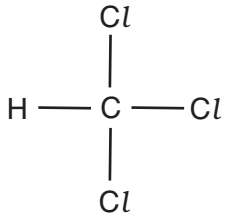
..... [1]

(g) One reason for the new treatment of water with ozone was the concern that domestic water supplies were being contaminated with halogenoalkanes, such as $CHCl_3$. These form when plant matter decays. The organic compounds then enter the river water. Ozone breaks down these organic contaminants.

(i) Give the systematic name for $CHCl_3$.

..... [1]

(ii) The C–C*l* bond is polar. On the diagram of the $CHCl_3$ molecule shown below, mark the partial charges on the C and C*l* atoms.



[1]

(iii) Draw a diagram to represent the **shape** of a molecule of $CHCl_3$.

[1]

(iv) In this question, one mark is available for the quality of spelling, punctuation and grammar.

- Explain why the molecule $CHCl_3$ has the partial charges you have shown in **(ii)**.
- Describe the shape you drew in **(iii)** and explain whether or not this leads to an overall permanent dipole for the molecule.

.....

.....

.....

.....

.....

..... [4]

Quality of Written Communication [1]

[Total: 25]

END OF QUESTION PAPER

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

PLEASE DO NOT WRITE ON THIS PAGE