OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY (SALTERS) 2851

Minerals to Medicines

Wednesday **29 MAY 2002** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry (Salters)
Scientific calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks 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 an scientific calculator.
- You may use the *Data Sheet for Chemistry (Salters)*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	22	
2	32	
3	16	
4	20	
TOTAL	90	

This question paper consists of 14 printed pages and 2 blank pages.

Registered Charity Number: 1066969
[Turn over

1 This month the Canadian Space Agency should be launching a satellite mission to monitor the chemical processes that control the distribution of ozone in the atmosphere. It will focus on the Arctic winter stratosphere (upper atmosphere). The satellite uses the Sun as a source of infrared, visible and ultraviolet radiation. It will measure how much of each wavelength in these ranges is absorbed by the stratosphere.

(a) **(i)** Describe what can happen to molecules when they absorb infrared radiation and ultraviolet radiation.

(In this question, 1 mark is available for the quality of written communication.)

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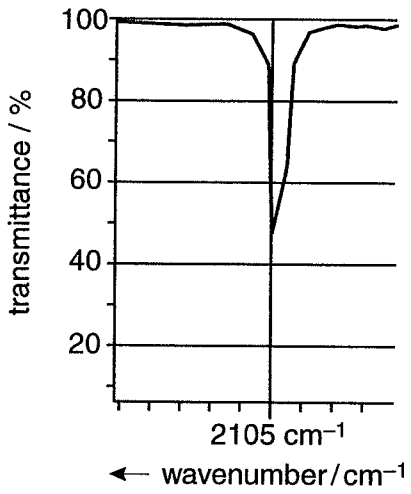
..... [6]

(ii) Previous experiments have shown that in winter the concentration of ozone in the stratosphere falls. The infrared spectrum of ozone contains a peak at 2105 cm^{-1}.

The diagram below shows how this peak looks in the summer.

On the diagram below, draw a peak to represent how this part of the infrared spectrum would appear in winter.



[2]

(b) The Canadian scientists plan to monitor the concentrations of about 30 different gases, such as CF_2Cl_2, in the atmosphere. Some of these gases may break down to produce radicals. Radicals can lead to the thinning of the ozone layer.

(i) What is a *radical*?

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..... [1]

(ii) CF_2Cl_2 can break down in the stratosphere to form radicals. Describe how this occurs.

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..... [3]

(iii) When CF_2Cl_2 breaks down in the stratosphere, chlorine radicals are produced but **not** fluorine radicals. What is the reason for this difference?

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..... [2]

(iv) Chlorine radicals can have a catalytic effect on the destruction of ozone. Complete the **two** equations given below to show this. Underneath, write the **overall** equation.

$$Cl + O_3 \longrightarrow$$

$$\longrightarrow O_2 + Cl$$

---

overall equation $\longrightarrow$ [3]

(c) The molecule Cl_2O is also present in the stratosphere.

(i) Draw a diagram to show the shape of the molecule.

[2]

(ii) Use the electronegativity data given below to deduce the polarity of the C*l*–O bond.

Now use the shape you have drawn for the Cl_2O molecule. Decide whether Cl_2O is a polar molecule or not. Give your reasoning.

[Electronegativity O, 3.4; C*l*, 3.2]

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..... [3]

[Total : 22]

2 Many new medicines are developed as a result of studies of natural products. In the 19th century salicylic acid was prepared from compounds present in the bark of willow trees. Salicylic acid was found to have beneficial effects as a painkiller and in reducing fevers. Before long, chemists modified its structure.

(a) Suggest **two** reasons why chemists might want to modify the structure of a molecule which already has a medicinal effect.

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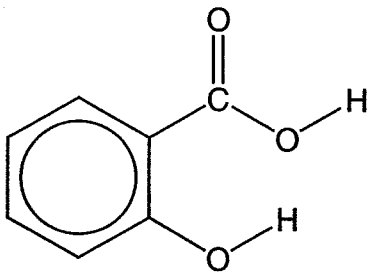
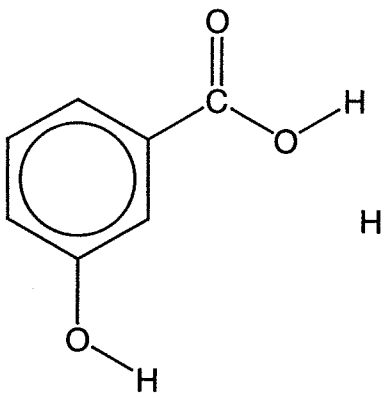
..... [2]

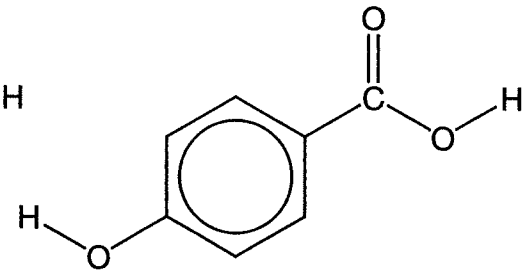
(b) Before chemists can prepare a natural product such as salicylic acid in the laboratory, they must first work out its structure. Chemical tests and infrared spectroscopy show that salicylic acid has one of the structures shown below.



compound A



compound B



compound C

Compound **A** has a much lower melting point than either compound **B** or compound **C**. This is because it can form hydrogen bonds internally within the molecule.

(i) Complete the diagram above of compound **A** to show how this molecule can form an internal hydrogen bond. Show the partial charges ($\delta+$ and $\delta-$) on your diagram. [2]

(ii) Explain why the melting points of compound **B** and compound **C** are higher than compound **A**.

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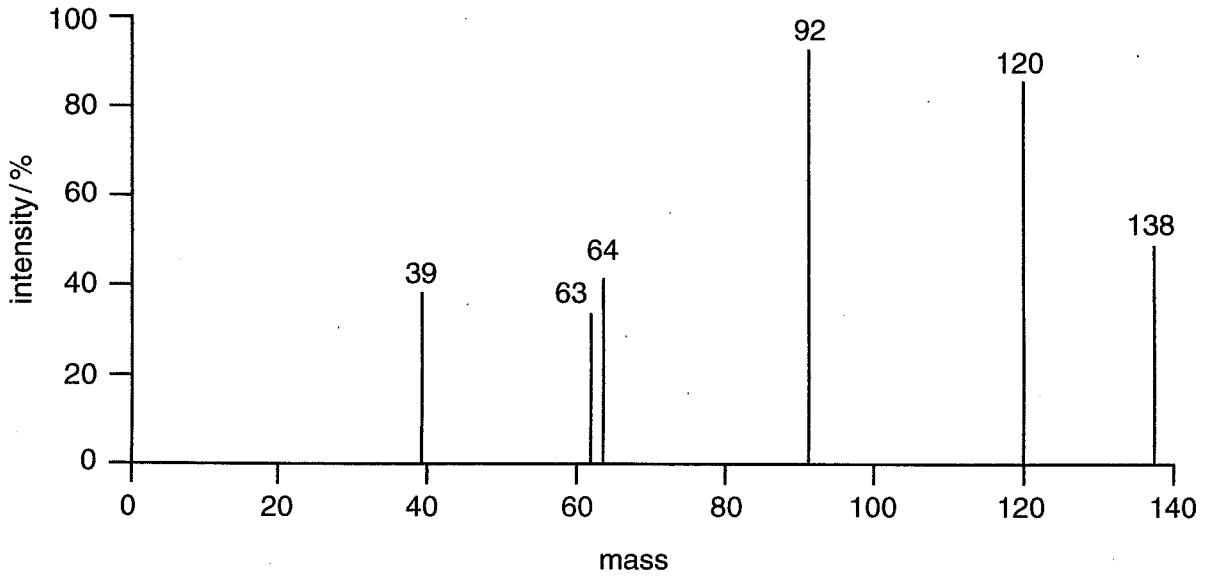
..... [3]

(c) The mass spectrum for salicylic acid is shown below.



(i) What is the mass of the molecular ion peak?

mass ..... [1]

(ii) The mass spectrometer breaks the molecule into fragments. What is the mass of the fragment lost when the ion of mass 120 is formed?

..... [1]

(iii) Suggest a formula for a simple molecule having the mass calculated in **(c)(ii)**.

..... [1]

(iv) The mass spectrum of compound **A** has a peak at 120. This peak is absent in the mass spectra of compounds **B** and **C.** Suggest a reason for this.

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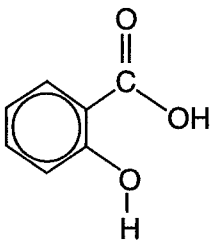
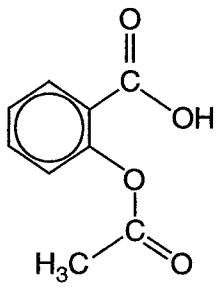
..... [3]

(d) One of the modifications chemists made to the structure of salicylic acid resulted in the formation of aspirin.



salicylic acid



aspirin

(i) Name the functional group present in aspirin but not in salicylic acid.

..... [1]

(ii) Aspirin can be made by heating, under reflux, salicylic acid and ethanoic anhydride.

Draw a labelled diagram of the apparatus used.

[3]

(iii) Ethanoic acid, CH_3COOH, is formed in the reaction in **(ii)**. Draw the full structural formula of ethanoic acid.

[2]

(iv) One way to test if all the salicylic acid has reacted is to add aqueous iron(III) chloride to the product mixture in **(ii)**.

Describe the colour of the resulting solution if salicylic acid remains.

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..... [1]

(v) **Name** the functional group in salicylic acid responsible for the colour change in **(iv)**.

..... [1]

(e) The amount of aspirin in an aspirin tablet can be determined in the laboratory by titration with aqueous sodium hydroxide.

(i) One mole of sodium hydroxide reacts with one mole of aspirin (represented by R-COOH) to form a salt.

Complete the equation below giving the formula of the salt. Include the charges on the ions.

$$\underset{\text{aspirin}}{\text{R-COOH}} + \text{NaOH} \longrightarrow \qquad\qquad + H_2O$$

[2]

(ii) The first step is to make up a solution of the aspirin tablet of known concentration. A student weighed out a powdered sample of the tablet and made it up to a 250 cm^3 solution with distilled water. The student took a 25.0 cm^3 sample of the aspirin solution and titrated it with the aqueous sodium hydroxide until all of the aspirin had been neutralised.

How would the student decide when all of the aspirin had been neutralised?

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..... [2]

(iii) The student found that 27.5 cm^3 of 0.025 mol dm^{-3} aqueous sodium hydroxide exactly neutralised the 25.0 cm^3 sample of the aspirin solution. Calculate the number of moles of sodium hydroxide used in the titration.

Answer ..... moles [2]

(iv) What is the number of moles of aspirin present in the 25.0 cm^3 sample?

Answer ..... moles [1]

(v) What is the number of moles of aspirin in the 250 cm^3 of solution?

Answer ..... moles [1]

(vi) The molecular formula of aspirin is $C_9H_8O_4$. Calculate the mass of 1 mole of aspirin.

[A_r: H, 1; C, 12; O, 16]

Answer ..... g [1]

(vii) Calculate the mass of aspirin in 250 cm^3 of solution.

Answer ..... g [1]

(viii) The mass of the aspirin tablet used by the student to make the 250 cm^3 solution was 1.450 g. Calculate the percentage purity of the aspirin tablet.

Answer ..... % [1]

[Total : 32]

3 Two halogen-containing polymers in everyday use are PVC, poly(chloroethene), and PTFE, poly(tetrafluoroethene). PTFE, marketed as 'Teflon', was discovered by accident.

(a) Name another polymer that was discovered by accident.

..... [1]

(b) PVC and PTFE are both formed by the same type of polymerisation reaction. Name this **type** of reaction.

..... [1]

(c) The mechanism for this type of reaction involves radicals. The reaction is started by adding a small amount of chemical initiator. Use your knowledge of radical mechanisms to suggest why only a small amount of initiator is needed to bring about complete polymerisation.

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..... [3]

(d) Radical polymerisations are highly exothermic and very rapid. One way to slow the reaction down is to carry out the polymerisation at a lower temperature.

Explain, in terms of collision theory and activation enthalpy, why lowering the temperature of a reaction leads to a drop in its rate of reaction.

(In this question, 1 mark is available for the quality of written communication.)

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..... [5]

(e) Chloroethene has the formula C_2H_3Cl. Draw the structure of the **repeating unit** for PVC, poly(chloroethene).

[1]

(f) Both polymers can be used to make solid rods. The rods from PVC are rigid whereas the PTFE rods are flexible. Explain this difference in terms of the arrangement and behaviour of the polymer chains.

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..... [2]

(g) Chloroethene, C_2H_3Cl reacts with hydrogen bromide to form a mixture of **two** organic products.

(i) Give the structural formulae of the **two** organic products formed in the reaction.

[2]

(ii) What method would you use in the school laboratory to show that **two** organic products were present?

..... [1]

[Total : 16]

4 Bromomethane gas is used as a fumigant to protect young plants against insects and rodents. Bromomethane is highly toxic to humans.

(a) Safety regulations state that concentrations above 5 ppm (by volume) of bromomethane are harmful.

(i) The volume of air in a laboratory is $5 \times 10^5\,dm^3$. Show that the maximum allowed volume of bromomethane in the laboratory to stay within the safety regulations is $2.5\,dm^3$.

[1]

(ii) Estimate the number of bromomethane molecules present in $2.5\,dm^3$ of bromomethane.

[1 mole of gas molecules at room temperature and pressure occupy $24.0\,dm^3$.

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

Answer ..... molecules [2]

(b) Bromomethane is slightly soluble in water but completely miscible with most organic solvents.

What type of intermolecular force between bromomethane and water molecules is responsible for the solubility of bromomethane in water?

..... [1]

(c) Bromomethane, CH_3Br, is made by treating methanol with hydrobromic acid (HBr).

(i) Write a balanced equation for this reaction. Use **full structural formulae** for the organic compounds.

[2]

(ii) In this reaction, bromide ions (from HBr) attack the carbon atom in methanol. Classify the mechanism for the reaction by underlining **two** words from the list below.

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

(d) A student thought that iodomethane might be safer to use as a fumigant than bromomethane. Iodomethane is a volatile liquid whereas bromomethane is a gas.

(i) Use this information to decide which of these two halogenoalkanes has stronger intermolecular forces. Give the reason for your choice.

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..... [1]

(ii) Explain why the strengths of the instantaneous dipole-induced dipole forces are different in the two halogenoalkanes.

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..... [1]

(e) The student remembered that iodoalkanes are more rapidly hydrolysed than bromoalkanes. To show this she set up two test tubes each containing aqueous silver nitrate and ethanol. She added a few drops of iodomethane to one and at the same time a few drops of bromomethane in ethanol to the other. Both test tubes were then placed in a water bath at 60 °C. In these reactions halogenoalkanes are hydrolysed by water, forming halide ions.

(i) What would the student **see** as the two reactions progressed?

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..... [3]

(ii) Suggest why ethanol is added to the aqueous silver nitrate/halogenoalkane mixture.

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..... [2]

(iii) Write an ionic equation to show how silver ions react with iodide ions. Give state symbols.

..... [3]

(iv) Use the bond enthalpies given below to explain why iodomethane hydrolyses more rapidly than bromomethane.

[E(C–C*l*) = +290 kJ mol^{-1}; E(C–I) = +228 kJ mol^{-1}]

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..... [2]

[Total : 20]