

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
 Advanced GCE

CHEMISTRY (SALTERS)
Chemistry of Materials

Unit 2849

Wednesday 19 JUNE 2002 Afternoon 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										
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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 a 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	15	
2	20	
3	15	
4	12	
5	10	
6	18	
7	32	
TOTAL	122	

This question paper consists of 16 printed pages.

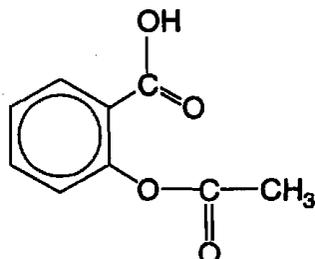
- 1 Endorphins are peptides found in our brains. They come to the aid of the brain when our bodies have to cope with pain over a long period of time.

(a) Explain what is meant by the term *peptides*.

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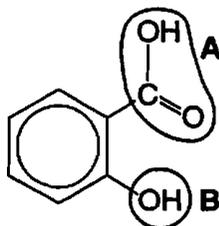
.....[2]

Endorphins cannot be produced to relieve pain immediately and so we buy fast-acting painkillers over the counter. One example of such a pain killer is aspirin.



aspirin

The starting material for the manufacture of aspirin is salicylic acid. The structure of salicylic acid is shown below.



salicylic acid

(b) Name the two functional groups, **A** and **B**, circled on the structure above.

A

B[2]

Aspirin can be prepared in the laboratory by the reaction of an acyl chloride with salicylic acid.

(c) Draw the full structural formula of the acyl chloride you would use in this reaction.

[2]

A solid sample of aspirin prepared using this method was found to be impure.

(d) (i) Name the technique you would use to purify the sample.

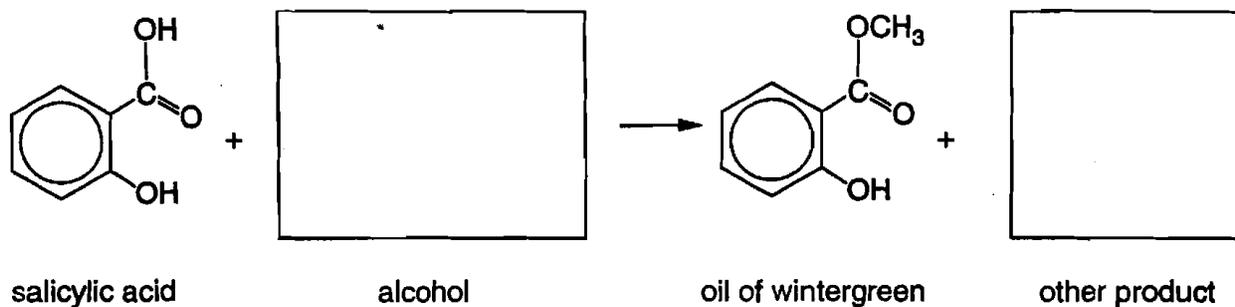
.....[1]

(ii) How would you determine whether the sample is pure?

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

Oil of wintergreen is also a painkiller and is sold as a cream to be applied directly to the skin. It can be made by heating salicylic acid under reflux with an alcohol and a suitable catalyst.

- (e) (i) Complete the equation below to show the structural formula of the alcohol you would use and the formula of the other product formed.



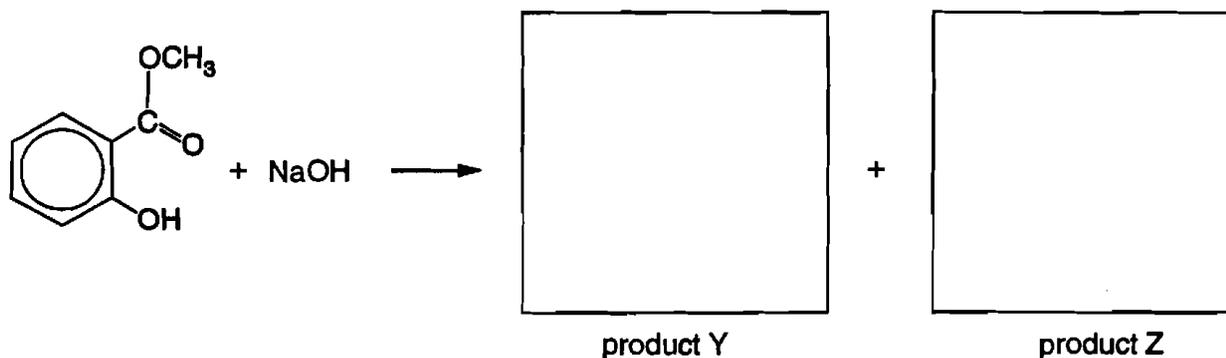
[2]

- (ii) Name a suitable catalyst for this reaction.

.....[1]

Oil of wintergreen can be hydrolysed to give two products.

- (f) Complete the equation below to show the structure of the products formed when oil of wintergreen is hydrolysed with aqueous sodium hydroxide.



[3]

[Total : 15]

- 2 Cisplatin is a successful anti-cancer drug. It is believed to act by binding to DNA in dividing cancer cells preventing further division. It binds to DNA through a ligand exchange reaction.

Cisplatin contains the complex $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$.

- (a) Explain what is meant by the term *complex*.

.....

[2]

- (b) The complex $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ is square planar. It exists in two isomeric forms.

- (i) Draw the possible isomers.

[2]

- (ii) Name the **type** of isomerism shown by $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$.

.....[1]

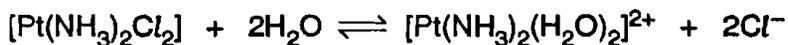
- (iii) What is the coordination number of $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$?

.....[1]

- (iv) State the other possible shape of a complex with this coordination number.

.....[1]

Only the **uncharged** complexes of platinum(II) possess anti-cancer activity.
When cisplatin dissolves in water the following equilibrium exists.



The cisplatin is given to the patient in saline solution (an aqueous solution containing a relatively high concentration of sodium chloride.)

(c) Use this information to suggest why cisplatin is given to the patient in saline solution.

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

The anti-cancer properties of cisplatin are due to the fact that sites on DNA act like ligands. These sites are nitrogen atoms, present on the base guanine, in the DNA structure. The guanine base replaces the two chloride ligands on the cisplatin.

(d) (i) What feature of the nitrogen atom on the guanine base allows it to bond to platinum?

.....[1]

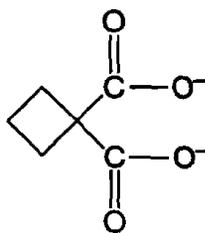
(ii) Briefly describe the structure of DNA.
(In this question 1 mark is available for quality of written communication.)

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.....[4]

Quality of Written Communication [1]

Cisplatin has been found to have toxic side effects, so alternative compounds are being investigated. One of these is called carboplatin.

Carboplatin contains the following ligand, L.



Ligand L

Carboplatin has a similar structure to cisplatin, but with ligand L replacing the two chloride ligands.

(e) Draw the structure of carboplatin below showing how ligand L bonds to the platinum ion.

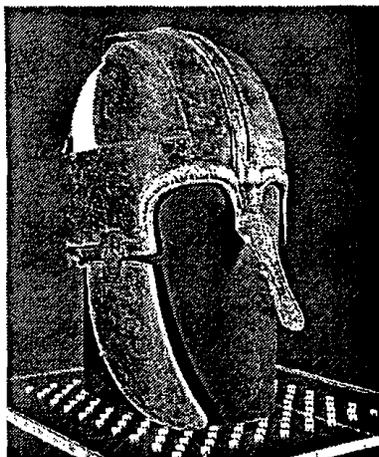
[3]

(f) What name is given to a ligand, such as ligand L, that has **two** points of attachment to the metal ion?

.....[1]

[Total : 20]

- 3 When archaeologists were excavating a Viking settlement in Coppergate, York, they discovered an almost perfectly preserved Anglian helmet.

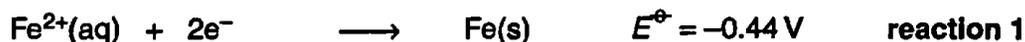


The ground in which the helmet was buried was completely waterlogged which meant that the parts of the helmet made from iron had corroded very slowly. When the helmet was excavated it began to corrode very quickly.

- (a) Suggest why corrosion of the helmet underground had taken place very slowly.

.....
[1]

- (b) The first stage of rusting is an electrochemical process involving the following half-equations.



- (i) Write an overall equation for the first stage of the rusting process.

.....[2]

- (ii) Calculate E_{cell} for the overall reaction in (b)(i).

.....[1]

- (iii) Suggest a formula for rust and explain how it is formed from the product of the reaction in (b)(i).

.....

[2]

The helmet was found to have a large dent in the cap. After excavation, rust was particularly evident around the dent.

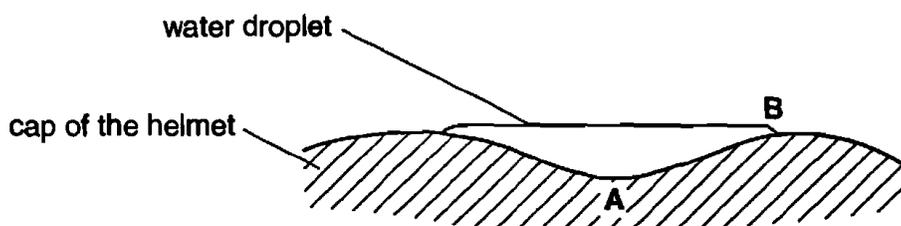
(c) (i) Give the half-equations for the reactions occurring at **A** and **B** on the diagram below.

Half-equation at **A**

Half-equation at **B**

[3]

(ii) On the diagram below label the direction of the electron flow in the surface of the helmet.



[1]

Rusting is also a problem for oil rigs, as their steel supports are surrounded by sea water. Sea water contains dissolved sodium chloride. The presence of dissolved sodium chloride speeds up the rusting process.

(d) Suggest why the presence of dissolved sodium chloride speeds up the rusting process.

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

(e) The steel supports of oil rigs are protected from rusting by bolting blocks of another metal onto them. Using the information below name a metal that could be used to protect the steel supports from rusting. Explain your choice and describe how the rusting process is prevented.

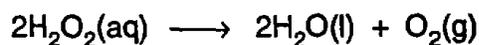


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.....
.....[4]

[Total : 15]

- 4 Permanent hair dyes contain hydrogen peroxide, which is used to bleach hair.

Hydrogen peroxide decomposes very slowly on storage. The equation for its decomposition is shown below.



One method of following this is by titration with acidified potassium manganate(VII).

The reaction can be speeded up by the presence of a catalyst.

A group of students investigated the effect of the catalyst on the rate of decomposition of a solution of hydrogen peroxide. They removed 10 cm^3 portions at timed intervals and titrated each portion with 0.1 mol dm^{-3} acidified potassium manganate(VII) solution.

5 moles of H_2O_2 react with 2 moles of KMnO_4

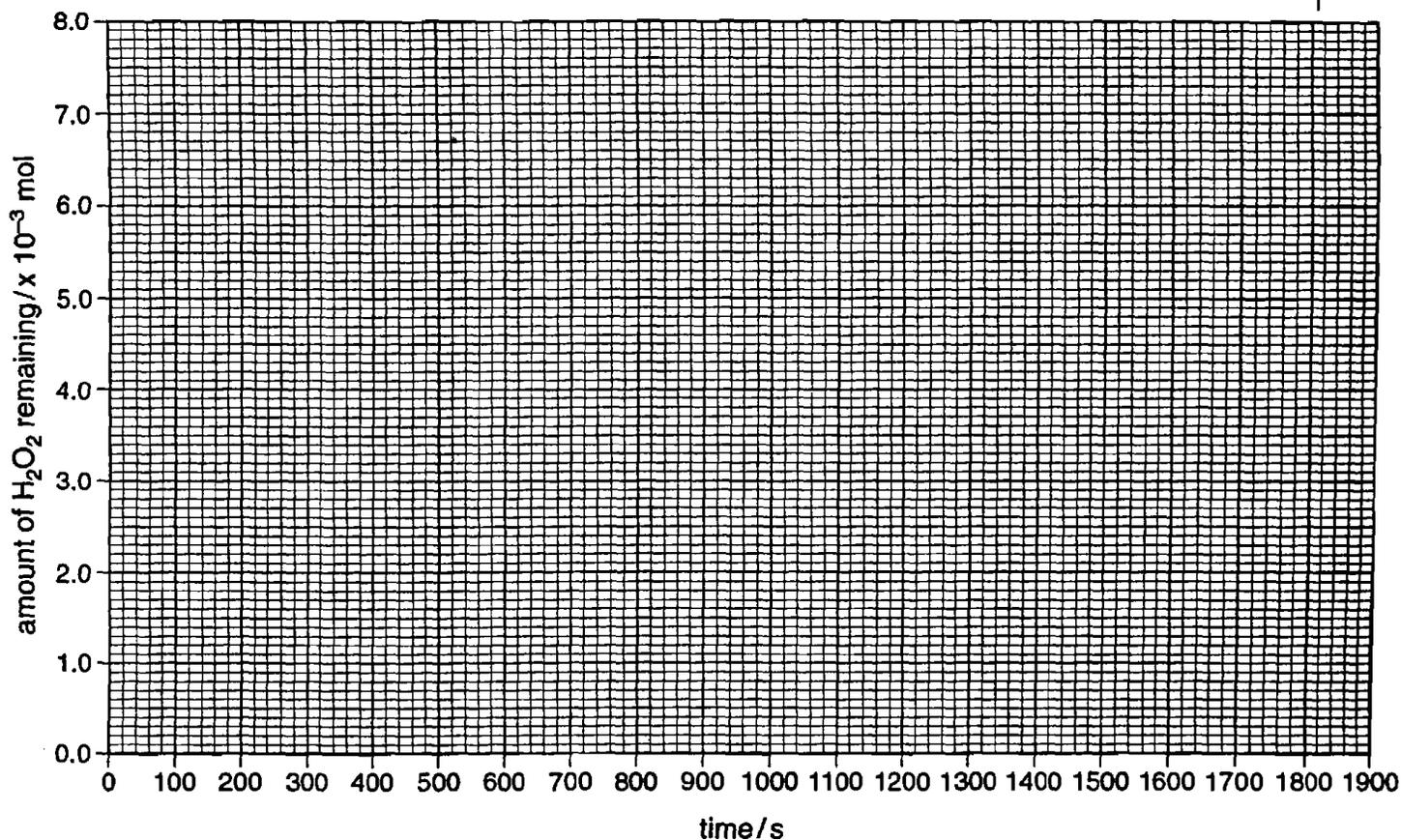
The following data were obtained.

time /seconds	volume of 0.1 mol dm^{-3} $\text{KMnO}_4(\text{aq}) / \text{cm}^3$	amount of H_2O_2 remaining in 10 cm^3 of solution / $\times 10^{-3}\text{ mol}$
0	30.0	7.50
300	23.4	5.90
600	18.3	4.60
900	14.2	3.60
1200	11.1	2.80
1500	8.70	2.18
1800	6.80	

- (a) Complete the table above to show the amount of hydrogen peroxide remaining in 10 cm^3 of the reaction mixture after 1800 seconds.
Show your working below.

[2]

(b) (i) Plot a graph of the amount of hydrogen peroxide remaining in 10 cm³ of reaction mixture against time on the grid below.



[3]

(ii) How does your graph confirm that the reaction is first order with respect to the concentration of hydrogen peroxide? Show clearly how you arrived at your answer.

.....

 [3]

In a separate set of experiments, the students found that the order of reaction with respect to the catalyst was zero.

(c) (i) Write the rate equation for the reaction.

..... [2]

(ii) The rate is measured in mol dm⁻³ s⁻¹. Work out the units of the rate constant, showing your working.

Units of rate constant are [2]

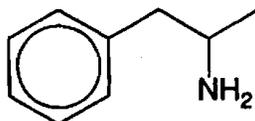
[Total : 12]

[Turn over

- 5 Amphetamines are synthetic chemicals which can act as stimulants.

The first amphetamine to be marketed was called *Benzedrine*, which was used in World War II to enable soldiers to stay awake for long periods of time.

The structure of *Benzedrine* is shown below.



Benzedrine

- (a) Draw an asterisk(*) next to the chiral carbon atom on the structure of *Benzedrine*. [1]

A more potent form of the drug is its mirror image *Dexedrine*.

- (b) Draw the 3-dimensional structures of *Benzedrine* and its mirror image *Dexedrine*. (You do not need to label which is which).

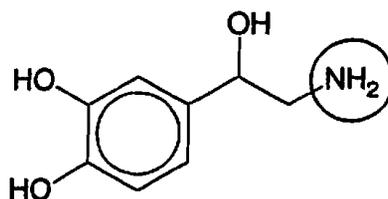
mirror



[2]

The structures of amphetamines resemble that of noradrenaline. Noradrenaline is a molecule made in our bodies that affects blood pressure.

The structure of noradrenaline is shown below.

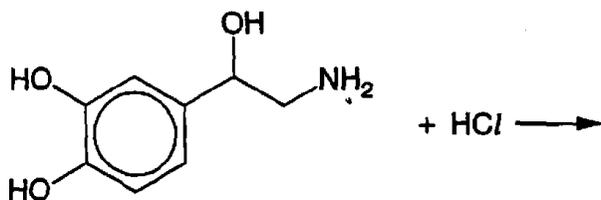


noradrenaline

- (c) (i) Name the functional group circled on noradrenaline.

.....[1]

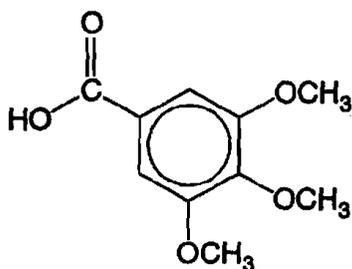
- (ii) Complete the equation below to show the product formed from the reaction of noradrenaline with dilute hydrochloric acid.



[2]

People who suffer from high blood pressure can be given a drug called reserpine which lowers the amount of noradrenaline in the nerve endings. This lowers blood pressure.

When reserpine is hydrolysed one of the products formed is Compound R.



Compound R

The proton nmr spectrum of Compound R contains three signals.

- (d) Use the data sheet which accompanies this paper to complete the table below.

chemical shift in the region	type of proton	relative number of protons
3.7		
11.0		1
7.5		

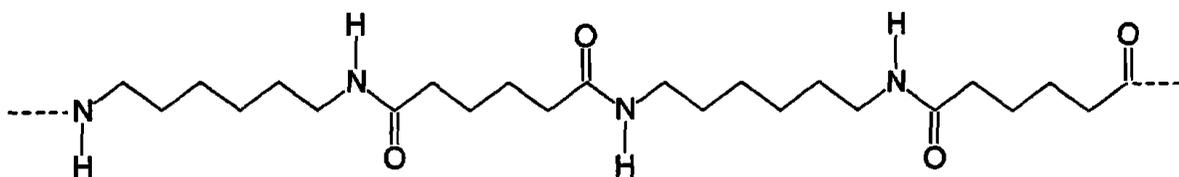
[4]

[Total : 10]

- 6 Some of the properties of nylon were discovered accidentally by chemists working on polyesters. They decided to see how far a strand of polyester could be stretched around the laboratory. They realised that as they stretched the strands they were orienting the molecules and observed that the strands took on a silky appearance.

They found that a similar thing happened with nylon. The nylon had a greater tensile strength and a higher melting temperature than the polyesters and so was better for producing fibres.

Part of a polymer chain of nylon-6,6 is shown below.



- (a) The process of pulling the polymer into strands is called cold drawing. Explain why cold drawing increases the tensile strength of a polymer.

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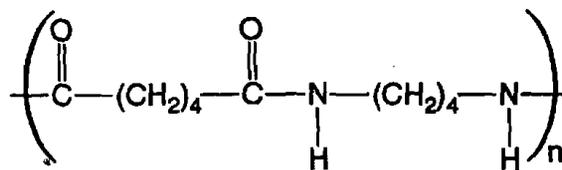
.....[3]

Nylon-6,6 and nylon-6 have dominated the polyamide market for many years. Another competitor has now been developed, a polyamide sold under the trade name *Stanyl*. *Stanyl* is made from two monomers, hexanedioic acid and 1,4-diaminobutane.

- (b) Draw the full structural formula of 1,4-diaminobutane in the space below.

[2]

The repeating unit of *Stanyl* is shown below.



Initially *Stanyl* was rejected because its molecular mass was considered to be too low. However, *Stanyl* has recently been produced with a molecular mass in the region of 30 000. *Stanyl* has a greater tensile strength and melts at a higher temperature than nylon-6,6.

- (c) (i) *Stanyl* melts at a higher temperature than nylon-6,6. Explain why this is so. (You may assume that the polymer chains have a similar M_r .)

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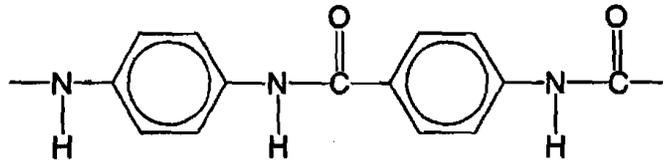
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.....[4]

- (ii) How many repeating units would you expect to be present in a polymer chain of *Stanyl* of M_r 32 000?
[A_r: C,12; H,1; N,14; O,16]

Answer[2]

Kevlar is a fire resistant material, which is also much stronger than nylon. The strength of *Kevlar* is one property which makes it suitable for the replacement of steel cord in tyres. *Kevlar* belongs to a family of polyamides called aramids.



Kevlar

(d) Suggest three other useful properties of *Kevlar* which arise from its structure.

.....

.....

.....

.....

.....[3]

Spiders produce a special type of silk to support their webs. Scientists have discovered that this silk is, weight for weight, stronger than *Kevlar*.

Scientists have isolated the gene responsible for making this silk. They inserted this gene into *E.coli* bacteria. The bacteria then produced the silk.

(e) Outline the stages in the genetic engineering technique that allowed scientists to transfer the gene and so use *E.coli* bacteria as an 'artificial spider'.

.....

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.....[4]

[Total : 18]

Copyright Acknowledgements:

Question 3 Photograph of an Anglian helmet discovered in the Jorvik Viking Centre Site, © York Archaeological Trust.

7 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.

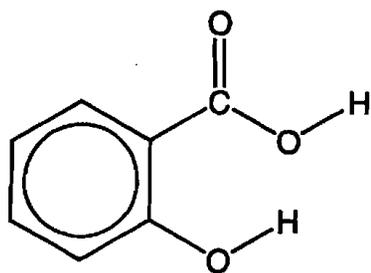
- (a) Suggest **two** reasons why chemists might want to modify the structure of a molecule which already has a medicinal effect.

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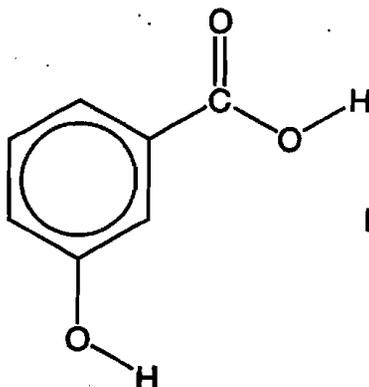
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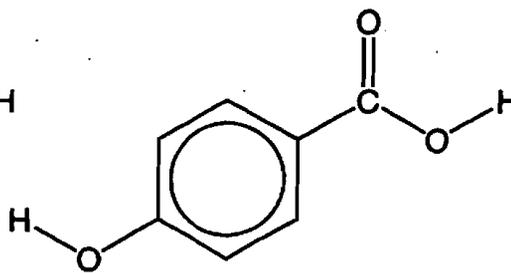
- (b) Before chemists can prepare a natural product such as salicylic acid in the laboratory, they must first work out its structure. Chemical tests and infrared spectroscopy show that salicylic acid has one of the structures shown below.



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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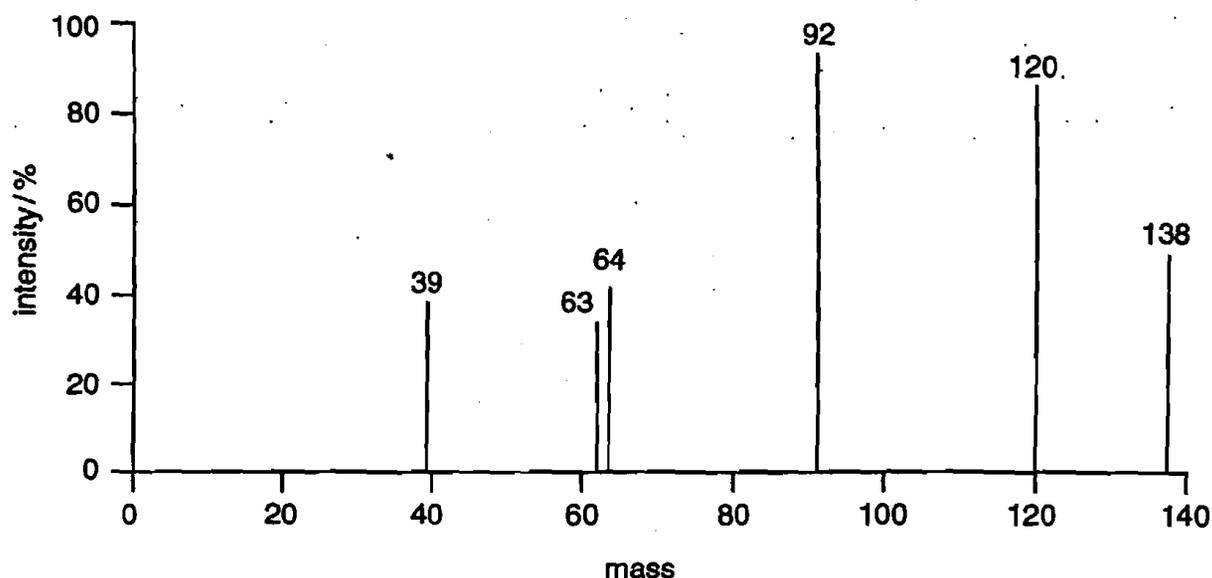
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..... [3]

(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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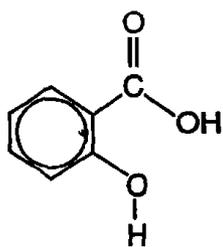
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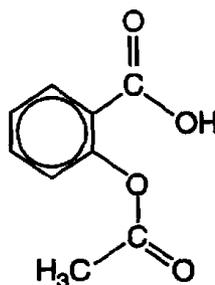
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..... [3]

- (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.

.....

..... [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.



[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 cm³ solution with distilled water. The student took a 25.0 cm³ 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?

.....

 [2]

- (iii) The student found that 27.5 cm³ of 0.025 mol dm⁻³ aqueous sodium hydroxide exactly neutralised the 25.0 cm³ 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 cm³ sample?

Answer moles [1]

(v) What is the number of moles of aspirin in the 250 cm³ of solution?

Answer moles [1]

(vi) The molecular formula of aspirin is C₉H₈O₄. 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 cm³ of solution.

Answer g [1]

(viii) The mass of the aspirin tablet used by the student to make the 250 cm³ solution was 1.450 g. Calculate the percentage purity of the aspirin tablet.

Answer % [1]

[Total : 32]