

OCR

Oxford Cambridge and RSA

Wednesday 22 June 2016 – Morning

A2 GCE CHEMISTRY B (SALTERS)

F335/01 Chemistry by Design

Candidates answer on the Question Paper.

OCR supplied materials:

- *Data Sheet for Chemistry B (Salters)* (inserted)

Other materials required:

- Scientific calculator

Duration: 2 hours




Candidate forename		Candidate surname	
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Centre number						Candidate number				
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INSTRUCTIONS TO CANDIDATES

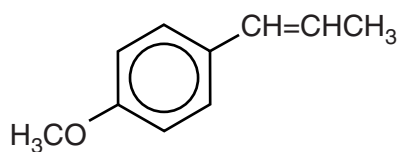
- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. 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.
-  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.
- 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 **120**.
- This document consists of **24** pages. Any blank pages are indicated.

Answer **all** the questions.

- 1 The substance anethole is present in some alcoholic drinks such as 'ouzo'. Alcoholic drinks containing anethole go cloudy when water is added.



anethole

- (a) (i) Give the molecular formula of anethole.

..... [1]

- (ii) Name the saturated functional group in anethole.

..... [1]

- (iii) Naturally occurring anethole is an *E* isomer.

Draw the structure of the *E* isomer.

[1]

- (b) The double bond in anethole reacts with bromine.

Draw the **skeletal** formula of the compound produced.

[1]

- (c) (i) Give the mechanism of the reaction of bromine with ethene, showing whole and partial charges, curly arrows, and the final product.

[3]

- (ii) Ethene is brominated using **aqueous** bromine.

Suggest why $\text{CH}_2\text{OHCH}_2\text{Br}$ is formed but $\text{CH}_2\text{OHCH}_2\text{OH}$ is **not** formed.

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..... [2]

- (d) Anethole is only slightly soluble in water.

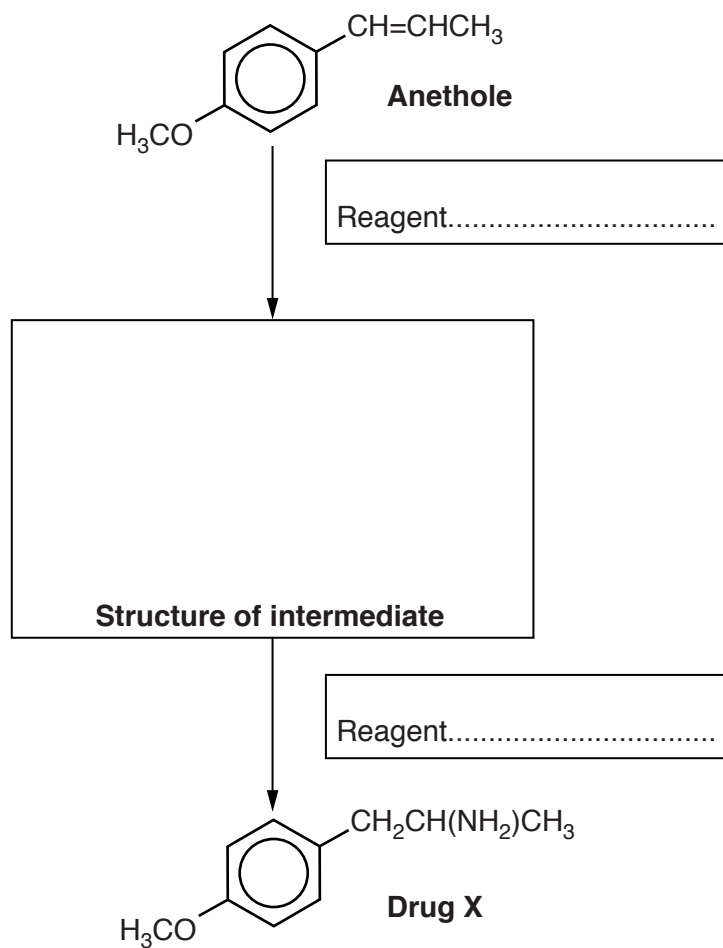
Explain this statement in terms of hydrogen bonding, indicating how these bonds are formed.

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..... [5]

(e) Anethole can be made into drug X.

(i) Complete the flowchart for this synthesis.

Write your answers in the boxes.



[3]

(ii) Drug X is reacted with $\text{HCl}(\text{aq})$.

Draw the structure of the organic product.

[1]

(iii) Drug **X** has a chiral centre but anethole does not.

Explain this statement.

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..... [3]

(iv) Draw diagrams to show the enantiomers of drug **X**.



[2]

(v) Explain how infrared spectroscopy could be used to show that all the anethole has been converted into drug **X**.

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..... [2]

[Total: 25]

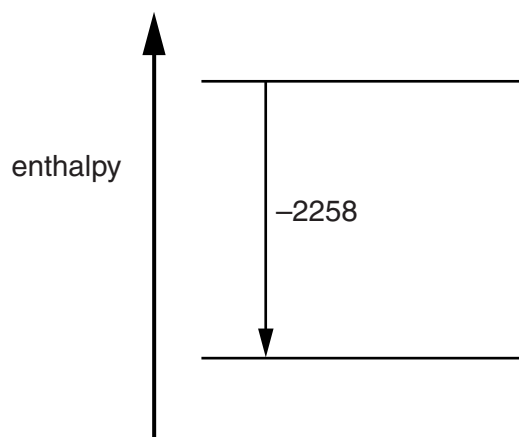
2 Calcium chloride, CaCl_2 , is used with sodium chloride to melt ice.

- (a) One reason calcium chloride helps to melt ice is that the dissolving process is exothermic. Some enthalpy changes for this process are given below.

Enthalpy change	$\Delta H/\text{kJ mol}^{-1}$
hydration of Ca^{2+}	-1650
hydration of Cl^-	-364
lattice enthalpy of CaCl_2	-2258

- (i) Part of an enthalpy level diagram for the dissolving process is shown below.

- Draw another energy level to complete the diagram.
- Label the energy levels with the relevant species, including state symbols.
- Use the diagram to calculate a value for $\Delta H_{\text{solution}}$ of CaCl_2 .



$$\Delta H_{\text{solution}} = \dots\dots\dots \text{kJ mol}^{-1} \text{ [5]}$$

- (ii) Suggest and explain why the enthalpy change of hydration for calcium ions is more exothermic than the enthalpy change of hydration for chloride ions.

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..... [2]

- (b) Draw a diagram to show a hydrated calcium ion in solution.

Show full and partial charges.

[2]

- (c) The lowering of the freezing point of water is proportional to the number of moles of **particles** dissolved.

A 1.0 mol dm^{-3} solution of NaCl freezes at -3.7°C .

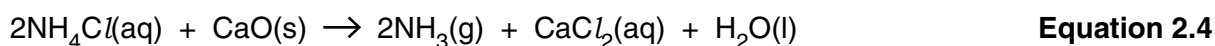
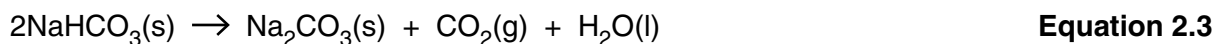
Calculate the freezing point of a solution of CaCl_2 that contains the same **mass** of solute per dm^3 as the NaCl solution.

freezing point = $^\circ\text{C}$ [3]

PLEASE DO NOT WRITE ON THIS PAGE

- (d) Calcium chloride is made by the Solvay process. This also produces another useful substance, sodium carbonate.

The Solvay process consists of the following reactions:



- (i) Write an equation in the box for the overall reaction that occurs to form just two products.

[2]

- (ii) State the atom economy of the Solvay process and explain why this is important for the environment.

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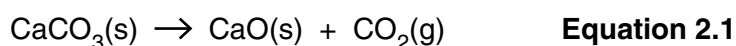
..... [1]

- (e) Give the systematic names of NaHCO_3 and NH_4Cl .

NaHCO_3

NH_4Cl [2]

- (f) The reaction in **Equation 2.1** has a positive ΔS_{sys} .



Explain the term *entropy* and give **one** reason why ΔS_{sys} is positive for this reaction.

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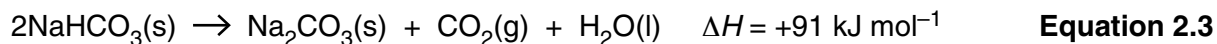
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..... [2]

(g) The standard entropies for the compounds in **Equation 2.3** are given below.



Compound	$S^\ominus / \text{JK}^{-1} \text{mol}^{-1}$
$\text{NaHCO}_3(\text{s})$	+102
$\text{Na}_2\text{CO}_3(\text{s})$	+135
$\text{CO}_2(\text{g})$	+214
$\text{H}_2\text{O}(\text{l})$	+70

Calculate the minimum temperature for the reaction in **Equation 2.3** to occur.

Show all your working.

minimum temperature = K [3]

(h) $\text{NH}_3(\text{aq})$ and $\text{NH}_4\text{Cl}(\text{aq})$ can be used to make a buffer solution.

K_a for the NH_4^+ ion is $5.6 \times 10^{-10} \text{ mol dm}^{-3}$.

(i) Write the equilibrium for this K_a value.

[1]

(ii) Calculate the pH of a $0.010 \text{ mol dm}^{-3}$ solution of NH_4Cl .

pH = [2]

(iii) A small amount of acid is added to a solution that contains approximately 0.01 mol dm^{-3} of $\text{NH}_3(\text{aq})$ and $0.01 \text{ mol dm}^{-3} \text{ NH}_4^+(\text{aq})$.

Explain how the solution is buffered, by reference to your answer to **(h)(i)**.



In your answer you should indicate how the points you make link together.

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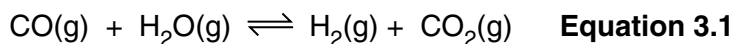
..... [4]

(iv) Calculate the pH of a buffer solution where the concentration of $\text{NH}_3(\text{aq})$ is twice the concentration of $\text{NH}_4^+(\text{aq})$.

pH = [2]

[Total: 31]

- 3 A reaction that is much used in industry is shown in **Equation 3.1**.



The reaction is first carried out at high temperature (around 800K) using one set of catalysts. Then the gases are cooled to around 500K and passed over other catalysts.

- (a) For the reaction in **equation 3.1**, K_c values are as shown in the table.

Temperature/K	K_c
500	58
800	5

- (i) Is it correct to quote K_c without units for this reaction?

Justify your answer.

.....

 [1]

- (ii) Use the data to state whether the forward reaction in **equation 3.1** is endothermic or exothermic.

Explain your reasoning.

.....

 [1]

- (iii) Suggest why the reaction is carried out at high temperature and then at low temperature.

.....

 [2]

(b) The conditions are designed to leave only a small concentration of CO in the mixture.

An initial mixture of CO and excess H₂O(g) has a CO concentration of $1.5 \times 10^{-3} \text{ mol dm}^{-3}$.

At equilibrium at 500 K, the concentration of CO is $4 \times 10^{-5} \text{ mol dm}^{-3}$.

The equilibrium concentration of hydrogen can be taken to be $1.5 \times 10^{-3} \text{ mol dm}^{-3}$.

(i) Explain why the equilibrium concentration of hydrogen can be taken to be $1.5 \times 10^{-3} \text{ mol dm}^{-3}$.

.....

 [2]

(ii) Calculate the concentration of H₂O(g) in the equilibrium mixture at 500 K.

Give your answer to an **appropriate** number of significant figures.

[H₂O(g)] = mol dm⁻³ [3]

(iii) Calculate the pressure (in atmospheres) that gives a gas a concentration of $1.5 \times 10^{-3} \text{ mol dm}^{-3}$ at 'room temperature'.

The volume of one mole of a gas at room temperature and 1 atmosphere pressure is 24 dm³.

pressure = atm [1]

- (c) Explain the term *activation enthalpy*.

Use the concept of activation enthalpy to explain why catalysts speed up reactions.

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..... [3]

- (d) Hydrogen is used in the manufacture of ammonia.

Ammonia reacts with nitric acid to form ammonium nitrate, NH_4NO_3 , a fertiliser.

- (i) Draw a 'dot-and-cross' diagram for the NO_3^- ion and give the oxidation state of nitrogen in the ion.

NO_3^- has a nitrogen atom surrounded by three oxygen atoms.

Show outer electron shells only.

oxidation state [3]

- (ii) Ammonium nitrate is potentially explosive.
When it is heated carefully, water and an oxide of nitrogen are formed.

Write the equation for this reaction. Give the name and appearance of the oxide of nitrogen.

Equation:

Name of oxide

Appearance of oxide [2]

[Total: 18]

4 Ancient paintings have been discovered in caves. The paintings were made using *ochre*, a natural pigment. Ochre owes its colour to the presence of $\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$.

(a) (i) Give the oxidation state of Fe in $\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$ and complete the electron configuration for the iron ion in the compound.

oxidation state [1]

electron configuration:

$1s^2 2s^2$ [1]

(ii) When heated gently, 1.282 g of $\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$ loses 0.216 g of water.

Calculate the value of n in the formula of ochre, showing your working.

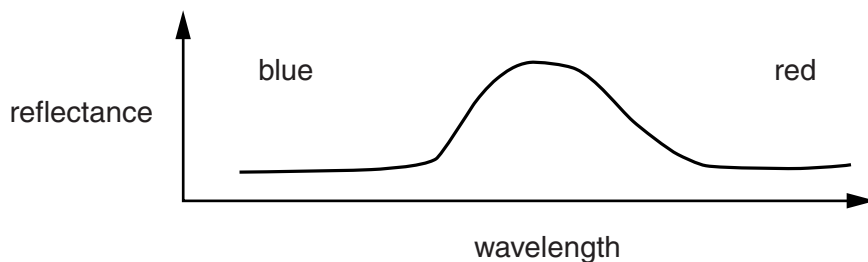
$n =$ [2]

(iii) On stronger heating, the same sample lost another 0.140 g to form Fe_3O_y .

Calculate the value of y in Fe_3O_y .

$y =$ [2]

(b) (i) The reflectance spectrum of ochre is shown below.



Suggest, with a reason, the colour of ochre.

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..... [1]

(ii) Explain why the iron compound is coloured.

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..... [4]

(c) The presence of iron can be identified from the atomic emission spectrum of ochre.

Describe the appearance of an atomic emission spectrum and explain how iron could be identified.

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..... [4]

(d) More recently, ochre has been used in oil paints. When ochre is used in oil paints it is suspended in oils such as linseed oil.

(i) Linseed oil is a triester of propane-1,2,3-triol.

Write an equation for the hydrolysis of this triester with KOH, using structural formulae for organic molecules. Represent the side chains as 'R'.

[3]

(ii) The carboxylate products from (d)(i) are converted into methyl esters.

Draw the **full** structural formula of the methyl ester formed, representing the side chain as 'R'.

[1]

(iii) Give the laboratory reagents for the production of the ester in (d)(ii) from its carboxylic acid.

reagents [1]

(e) The ester can be identified using gas-liquid chromatography.

For gas-liquid chromatography, give:

a suitable substance for the mobile phase

the nature of the stationary phase

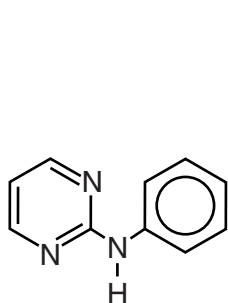
the units of the x-axis of the chromatogram [3]

[Total: 23]

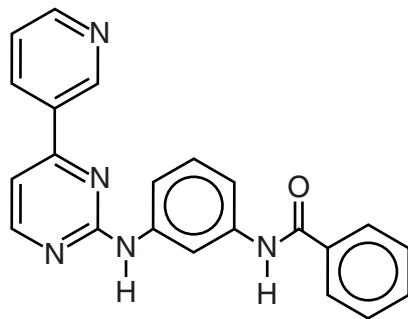
Turn over

- 5 'Imatinib' is a drug that was designed to combat leukaemia, a cancer of the blood. 'Imatinib' was developed as a result of work on three different compounds (**A**, **B** and **C**).

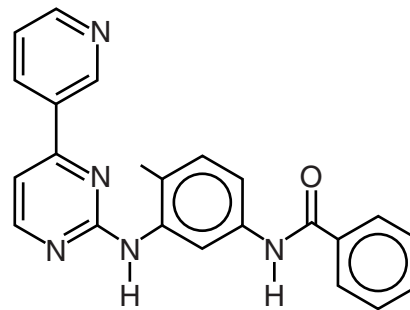
Compound **A** was found to have anti-leukaemia effects. Compound **B** was then found to be more effective and compound **C** more specific. 'Imatinib' was developed from compound **C**.



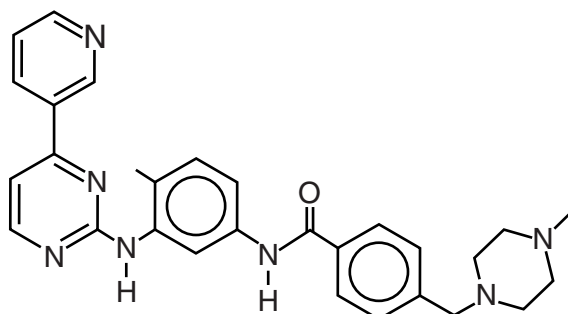
Compound A



Compound B



Compound C



'Imatinib'

- (a) An extra group is added to compound **C** to make 'Imatinib' more soluble in water.

Suggest how the extra group does this.

.....
 [1]

- (b) 'Imatinib' works by interfering with the function of an enzyme that only exists in cells affected by leukaemia. Thus the cells are unable to grow.

- (i) All the compounds above have the same pharmacophore.

Draw a ring around the pharmacophore on the structure of 'Imatinib' above.

[1]

- (ii) Suggest how this pharmacophore interferes with the function of the enzyme.

Suggest why compound **C** is more specific than compound **B**.



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

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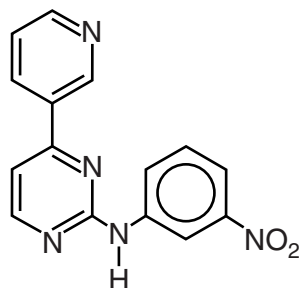
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..... [4]

- (c) Compound **A** can be converted into another compound, **D**, shown below. This uses two reactions, one of which is nitration.



Compound D

- (i) Give the reagents and conditions for the laboratory conversion of benzene to nitrobenzene.

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..... [2]

- (ii) Use the *Data Sheet* to **name** the reagents needed to convert the nitro group in compound **D** to an amine group. A new compound, **E**, is formed.

..... [1]

- (iii) Compound **E** is converted to compound **B** in a laboratory at room temperature.

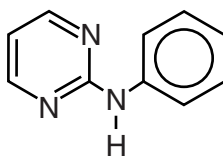
Name the functional group formed, and give the formula and name of a suitable reagent.

name of functional group formed

formula of reagent

name of reagent [3]

(d) The structure of compound **A** is shown again below.

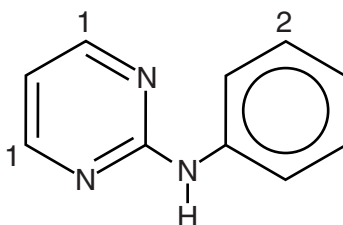


Compound A

(i) Write the molecular formula of compound **A**.

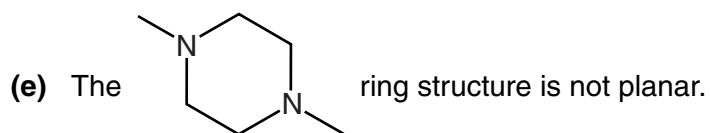
..... [1]

(ii) Indicate the number of peaks in the proton NMR of compound **A** by using numbers for each different proton environment on the structure below. Some numbers have been added already.



Compound A

[2]



State a value for the bond angle and name the shape around the nitrogen atoms in the structure. Explain how this bond angle arises.

Draw a diagram to suggest a 3D shape for the ring.



In your answer you should make it clear how the points you make are linked together.

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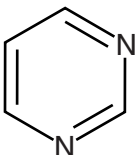
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[5]

- (f) The  ring structure is planar and has a similar electronic structure to benzene.

Suggest how the electrons are arranged in this structure.

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..... [3]

[Total: 23]

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).

A large area of lined paper for writing. It consists of a vertical solid line on the left side, creating a margin. To the right of this line, there are numerous horizontal dotted lines spaced evenly down the page, providing a guide for writing.

A large rectangular area with a vertical line on the left and horizontal dotted lines, intended for writing answers.



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