OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

CHEMISTRY B (SALTERS)

Chemistry by Design

F335

Candidates answer on the question paper.
A calculator may be used for this paper.

OCR supplied materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)

Other materials required:
- Scientific calculator

Monday 31 January 2011
Morning

Duration: 2 hours

OCE/26187

F 3 3 5

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- 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 pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

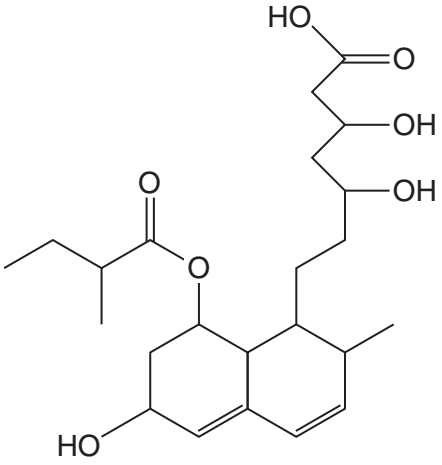
INFORMATION FOR CANDIDATES

- 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.

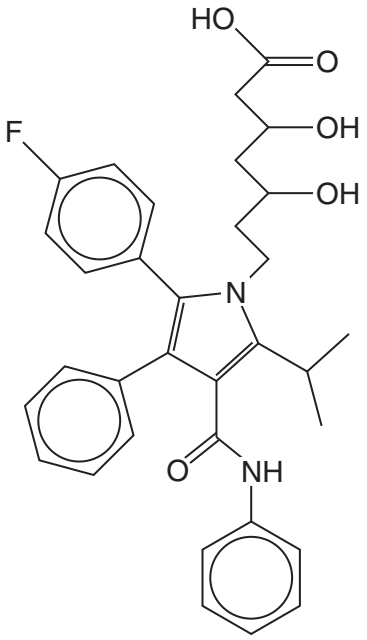
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data 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 **20** pages. Any blank pages are indicated.

Answer **all** the questions.

1 *Statins* are medicines that act in the body to lower the cholesterol level in the bloodstream. The structures of two synthetic statins are shown below.



pravastatin



atorvastatin

(a) (i) **Name** a functional group that is present in **pravastatin** but not **atorvastatin**.

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

(ii) **Name** a functional group that both statins have.

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

(b) (i) On the structure of **atorvastatin**, circle **two** chiral centres. **[1]**

(ii) Describe the structural relationship between two enantiomers, explaining why they are different compounds.

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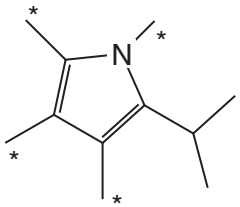
..... **[2]**

(c) Draw in the box the **full** structural formula of the part of the **atorvastatin** molecule shown below. Show the bonds marked * as unattached bonds.



[2]

(d) Both statins share the same pharmacophore.

(i) Explain the meaning of the term *pharmacophore*.

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

(ii) On the structure of **pravastatin** on page 2, draw a circle around the pharmacophore that it shares with atorvastatin. **[1]**

(iii) Statins inhibit a reaction in the body's synthesis of cholesterol. This reaction is enzyme catalysed. Suggest how the reaction is inhibited.

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

(e) Statins were discovered as a result of work on substances that can be obtained from fungi.

Suggest the sequence of events that led from one such substance to the production of a synthetic statin for medical use.

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

[Total: 16]

2 The pigment Paris Green is no longer used for painting because it is toxic.

Paris Green has the formula $Cu(C_2H_3O_2)_2 \cdot 3Cu(AsO_2)_2$.

(a) The $Cu(C_2H_3O_2)_2$ part of the formula is copper(II) ethanoate.

Draw the **full** structural formula of the ethanoate ion.

[1]

(b) (i) Give the oxidation state of arsenic in $Cu(AsO_2)_2$, assuming that copper has the +2 oxidation state.

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

(ii) Suggest the systematic name for $Cu(AsO_2)_2$.

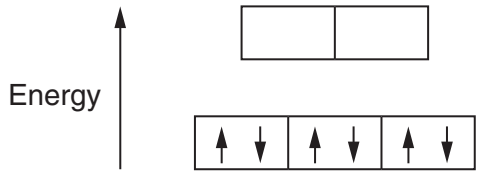
..... **[1]**

QUESTION 2 IS CONTINUED ON PAGE 6

(c) (i) Complete the electron configuration for the Cu^{2+} ion.

$1s^2 2s^2 2p^6$ **[1]**

(ii) Complete the diagram to show the arrangement of the **d-electrons** in Cu^{2+}.



[1]

(iii) Use the diagram in **(ii)** to explain:

- why copper(II) compounds are coloured.
- why different ligands cause different colours.

In your answer you should make it clear how the points you make are linked to one another.

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..... **[5]**

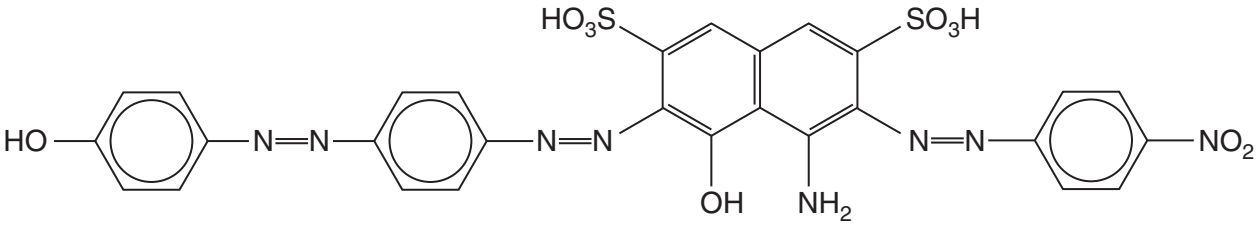
(d) Paris Green can be identified by using a technique based on atomic emission spectroscopy. Lines in the spectrum produced from the pigment correspond to the lines in the emission spectra of copper and arsenic.

Draw labelled energy-level diagrams to explain why:

- the atomic emission spectrum of copper consists of a series of lines.
- the lines in the arsenic spectrum are at different frequencies from those in the copper spectrum.

[4]

(e) The dye shown below is also green in colour.



(i) What feature of this molecule gives rise to it being coloured?

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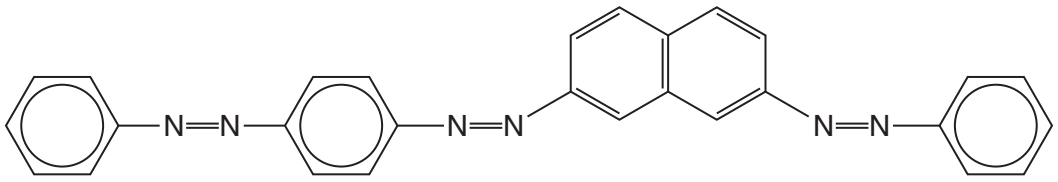
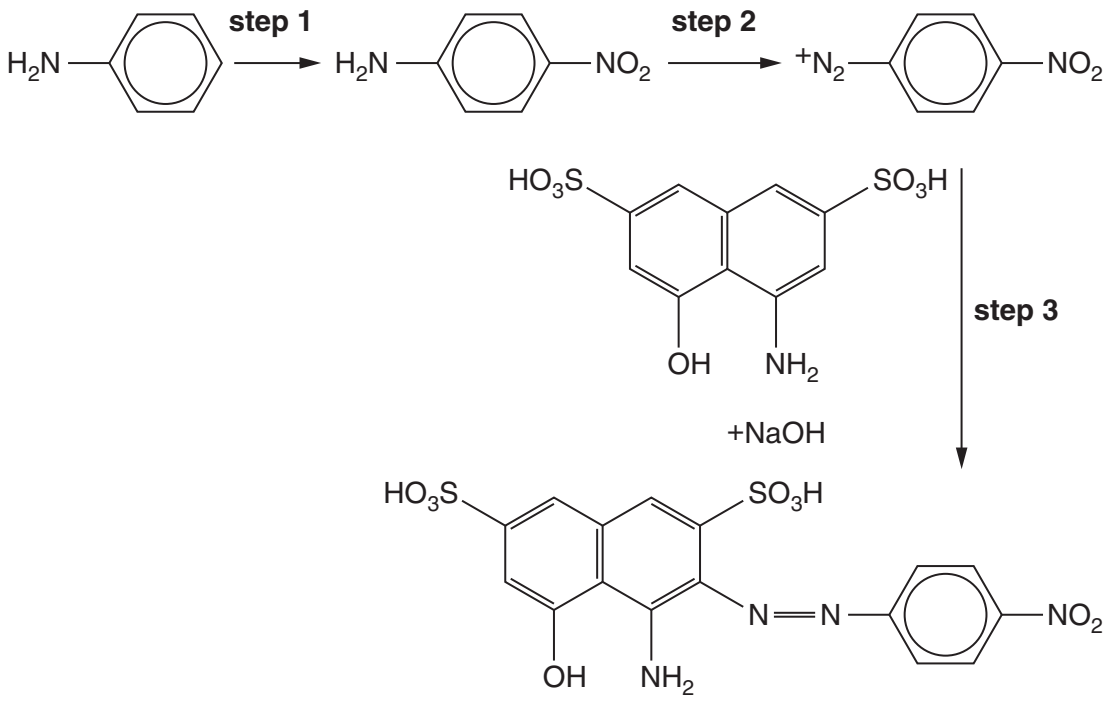
..... **[1]**

(ii) The addition of alkali changes the colour. Complete the structure below to show the effect of excess alkali on the molecule.



[3]

(f) A possible initial stage in the synthesis of the dye is shown below.



(i) Suggest a reagent for **step 1**.

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

(ii) Name the **type** of electrophilic substitution reaction that is occurring in **step 3**.

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

(g) The presence of the $-SO_3H$ groups on the dye structure makes it more soluble in water because the $-SO_3H$ groups ionise in solution.

(i) Name the $-SO_3H$ group.

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

(ii) Explain why many ionic substances are soluble in water, naming the bonds which are made and broken.

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

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

(h) Paris Green was once used in oil paint, dissolved in an unsaturated triester of propane-1,2,3-triol.

(i) Draw the **full structural** formula of a triester of propane-1,2,3-triol. Represent the hydrocarbon chains of the carboxylic acids by 'R'.

[2]

(ii) Explain what is meant by the term *unsaturated* in terms of your structure in **(i)**.

.....

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

[Total: 28]

3 In 1828, a German chemist Friedrich Wöhler amazed scientists by using the inorganic compound ammonium cyanate, NH_4OCN, to synthesise urea, H_2NCONH_2. Urea is an organic substance found in the urine of many animals.
Previously it had been thought that organic substances could be synthesised only from living things.

(a) (i) Draw the **full** structural formula of urea, H_2NCONH_2.

Indicate the bond angles around the carbon and one nitrogen atom.

[3]

(ii) Draw the full structural formula for the ammonium ion, NH_4^+, indicating a dative covalent bond.

[1]

(iii) The cyanate ion is often written as $[N{\equiv}C{-}O]^-$

Suggest a '*dot-and-cross*' diagram for this ion.

[2]

(b) Why are modern chemists not surprised that organic compounds can be made from inorganic compounds?

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

(c) Urea can be used as a fertiliser.

Calculate the percentage by mass of nitrogen in urea.

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

percentage by mass = ... % **[2]**

(d) Ammonia is the starting material for many inorganic fertilisers and is made from nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92\,kJ\,mol^{-1} \qquad \textbf{equation 3.1}$$

(i) Use the data in the table below to calculate ΔS_{sys} for the forward reaction in **equation 3.1**.

substance	S / J K^{-1} mol^{-1}
N_2	+192
H_2	+130
NH_3	+192

ΔS_{sys} = ... J K^{-1} mol^{-1} **[2]**

(ii) Explain the sign of your answer to **(i)** by reference to **equation 3.1**.

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

(iii) Calculate the value of ΔS_{tot} for the forward reaction in **equation 3.1** at 298 K.

ΔS_{tot} = ... J K^{-1} mol^{-1} **[2]**

(iv) Use your calculations in **(iii)** to explain the effect of **raising** the temperature on the forward reaction.

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

(e) Ammonium nitrate is an inorganic fertiliser that is manufactured from NH_3 and HNO_3.

(i) Give the oxidation states of nitrogen in:

NH_3 ..... HNO_3 ..... **[2]**

(ii) Write an ionic half-equation for the conversion of NH_3 to HNO_3 in the presence of H_2O, given that the number of electrons involved is the same as the oxidation state change.

[2]

(iii) Write an equation for the reaction of NH_3 with HNO_3 to form ammonium nitrate. Give the atom economy of this reaction.

Equation:

atom economy = ... % **[2]**

(iv) Suggest **one** hazard of carrying out the reaction in **(iii)**.

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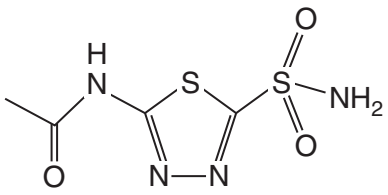
..... **[1]**

[Total: 24]

4 Acetazolamide is used to combat altitude sickness. It works by inhibiting an enzyme called carbonic anhydrase.

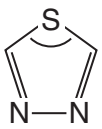


acetazolamide

(a) When acetazolamide is hydrolysed, the only bond that breaks is the N–C bond in the amide. Give the formula of the smaller molecule that would be formed in this hydrolysis reaction, under acid conditions.

[1]

(b) Suggest the value for the –S– bond angle in the part of the acetazolamide structure shown below. Explain your answer.



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

(c) Carbonic anhydrase is a catalyst for the reaction shown below.

$$CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$$ **equation 4.1**

(i) Give the systematic name of the ion HCO_3^-.

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

(ii) Describe and explain the effect that carbonic anhydrase will have on the position of the equilibrium shown in **equation 4.1**.

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

$$CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$$ **equation 4.1**

(iii) Draw a labelled energy-level diagram to show how carbonic anhydrase acts as a catalyst for the forward **and** reverse reactions shown in **equation 4.1**.

[4]

(d) At high altitudes, there is less carbon dioxide in the air as the pressure is lower. This in turn lowers the amount of dissolved carbon dioxide in blood. This affects the position of equilibrium in **equation 4.1**, which changes the blood pH. This contributes to 'altitude sickness'.

(i) Describe and explain how a lower amount of dissolved CO_2 affects the pH of the blood.

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

(ii) Explain how the inhibition of carbonic anhydrase by acetazolamide affects the change in **(i)** and so combats altitude sickness.

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

$$CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$$ **equation 4.1**

(e) The equilibrium in **equation 4.1** is important for maintaining the pH of the blood by buffering. For this equilibrium $K_a = [HCO_3^-][H^+]/[CO_2] = 4.5 \times 10^{-7}\,mol\,dm^{-3}$.

Calculate the concentration of carbon dioxide in a sample of blood where the pH = 7.4 and $[HCO_3^-] = 2.5 \times 10^{-2}\,mol\,dm^{-3}$.

$[CO_2]$ = ... $mol\,dm^{-3}$ **[2]**

(f) Explain what is meant by a *buffer solution* and how a buffer solution works by referring to the equilibrium in **equation 4.1**.

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

(g) There is considerable concern over rising levels of carbon dioxide in the atmosphere.

Give **two** methods for removing carbon dioxide from the atmosphere.

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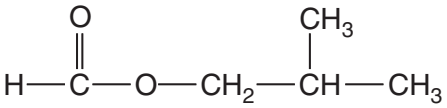
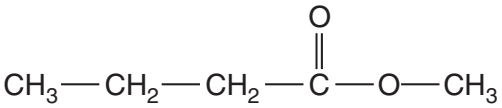
..... **[2]**

[Total: 25]

5 Two esters used in the food industry are shown below.



ester A (raspberry flavour)



ester B (apple flavour)

(a) Give the systematic name for ester **B**.

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

(b) Ester **A** is hydrolysed under **acid** conditions.

Draw structural formulae for the products and give their systematic names.

[4]

(c) Mass spectrometry, infrared spectroscopy and proton NMR spectroscopy can be used to determine organic structures.

- What information about organic structures can be obtained from each technique?
- Explain which piece(s) of information could be used to distinguish between the two esters **A** and **B**.

In your answer, you should indicate how the information links to the distinguishing of the esters.

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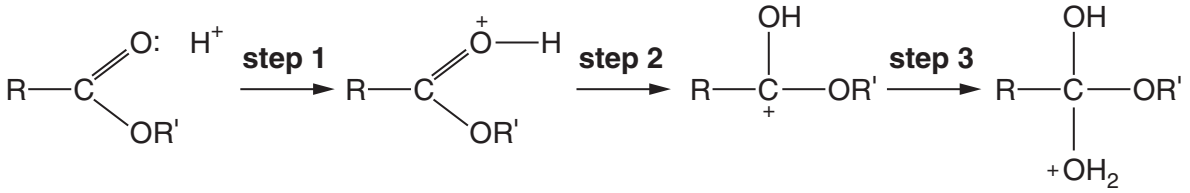
..... **[6]**

(d) The first steps in the mechanism of acid catalysed ester hydrolysis are shown below.



intermediate X

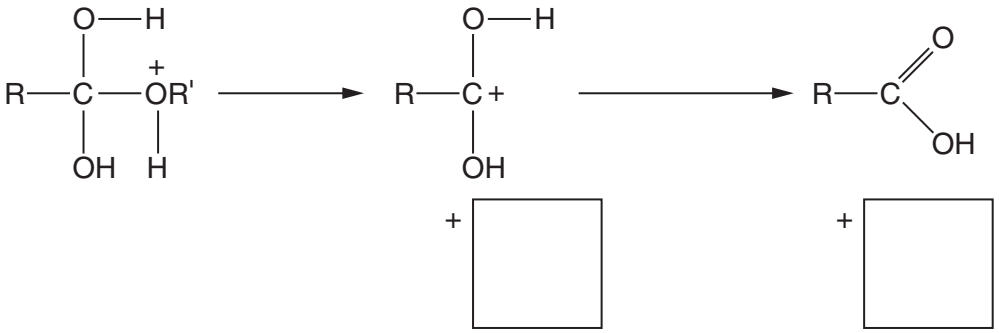
(i) Complete **steps 1 and 2** by drawing curly arrows. **[2]**

(ii) Give the name of the species that attacks the carbocation in **step 3**.

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

Intermediate X rearranges to form **intermediate Y**. The reaction then proceeds as shown.

intermediate Y **intermediate Z**



(iii) Complete the mechanism by drawing curly arrows on **intermediate Y** and **intermediate Z**. Give the formulae of the other products in the boxes shown. **[4]**

(e) Organic acids are weak acids in aqueous solution.

(i) Write the equation for the ionisation of ethanoic acid.

[1]

(ii) A solution made by dissolving ethanoic acid in pure water has a pH of 3.2. Calculate the concentration of ethanoate ions in this solution.

answer = ... mol dm^{-3} **[2]**

QUESTION 5 CONTINUES ON PAGE 18

(f) Esters can be made by heating acids and alcohols under reflux with a catalyst.

$$ROH + RCOOH \rightleftharpoons RCOOR + H_2O$$

In one experiment, 1.10 mol of an organic acid and 1.10 mol of an alcohol are heated under reflux. When equilibrium is reached, 0.40 mol of acid remain.

(i) Suggest how the initial and equilibrium amounts of acid could be measured.

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

(ii) Use the equation for the reaction to calculate the amount, in moles, of ester that forms.

amount of ester = ... mol **[1]**

(iii) Calculate a value for the equilibrium constant at the temperature of the reaction.

K_c = ... **[3]**

[Total: 27]

END OF QUESTION PAPER

ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

ADDITIONAL PAGE