



ADVANCED GCE
CHEMISTRY (SALTERS)
 Chemistry by Design

2854/01

Candidates answer on the Question Paper

OCR Supplied Materials:

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

Other Materials Required:

- Scientific calculator

Monday 28 June 2010
Morning

Duration: 2 hours



Candidate
Forename

Candidate
Surname

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **120**.
- 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.
- This document consists of **20** pages. Any blank pages are indicated.

Examiner's Use Only:

1			
2			
3			
4			
5			
Total			



Answer **all** the questions.

- 1 High concentrations of NO_x (NO and NO_2) in the atmosphere give rise to acid rain. One mechanism for the oxidation of NO to NO_2 in polluted air is shown below.



- (a) Write the overall equation for the oxidation of NO to NO_2 by this route.

[1]

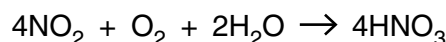
- (b) Suggest a source of atmospheric NO .

[1]

- (c) Give the oxidation states of nitrogen in

NO N_2O_2 NO_2 [3]

- (d) NO_2 reacts with water and oxygen to form nitric acid, HNO_3 .



- (i) Calculate the mass of nitric acid which could be made from 1.0 kg of nitrogen dioxide.

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

A_r : H, 1.0; N, 14; O, 16

mass =kg [3]

- (ii) Suggest **one** advantage and **one** disadvantage of nitric acid being present in the soil.

advantage

.....

disadvantage

..... [2]

- (e) Nitric acid in the soil reacts with calcium hydroxide to form calcium nitrate, an ionic solid.

Describe and explain **two** physical properties of ionic solids.

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..... [4]

- (f) (i) Suggest, with a reason, the sign of ΔS_{sys} for the forward reaction in **equation 1.1**.



.....

..... [1]

- (ii) The forward reaction in **equation 1.1** is **exothermic**. Use your understanding of entropy to explain why you would expect this forward reaction to be **more** likely to occur at lower temperatures.

$$\Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} \quad \Delta S_{\text{surr}} = -\frac{\Delta H}{T}$$

.....

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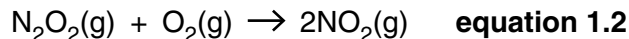
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..... [3]

- (g) The equilibrium in **equation 1.1** is established rapidly, so the overall rate of the reactions in **equations 1.1** and **1.2** depends only on the rate of the reaction in **equation 1.2**.

This is summarised below.



The rate expression for the reaction in **equation 1.2** is

$$\text{rate} = k[\text{N}_2\text{O}_2][\text{O}_2]$$

- (i) What is the effect of raising the temperature on the rate constant k ?

..... [1]

- (ii) The rate of the overall reaction in the two equations is found to **decrease** when the temperature is raised.

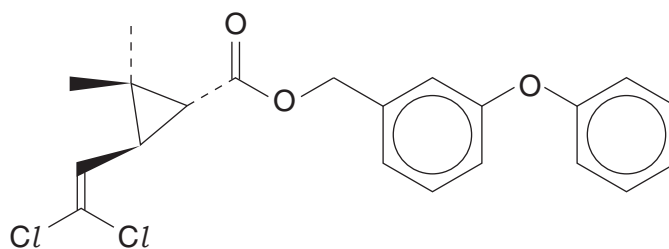
Suggest an explanation for this, bearing in mind that the concentration of N_2O_2 is governed by the equilibrium in **equation 1.1**.

.....

 [3]

[Total: 22]

- 2 Biopermethrin is one of the pyrethroid insecticides that are very effective against insects but are usually harmless to mammals.



biopermethrin

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

..... [2]

- (ii) Biopermethrin has an ester group and aromatic rings. Name **two** other functional groups in the structure.

..... [2]

- (iii) On the structure above, put a circle round the **two** *chiral centres*. [2]

- (iv) Explain why the C=C bond in biopermethrin does **not** give rise to geometric isomers.

.....

..... [1]

- (b) The *partition coefficient* for a pesticide is defined as shown below.

$$K_{ow} = \frac{\text{concentration of compound in octan-1-ol}}{\text{concentration of compound in water}}$$

For biopermethrin $K_{ow} = 1 \times 10^5$

- (i) Write a structural formula for octan-1-ol.

[1]

- (ii) Explain the significance of a high value of K_{ow} on the effectiveness of a pesticide.

.....

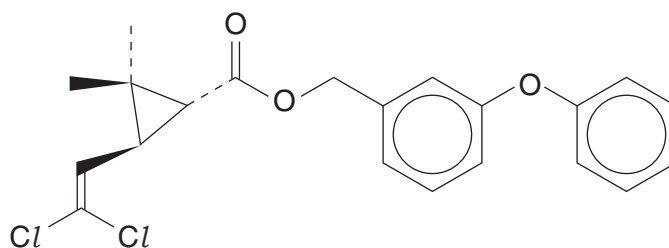
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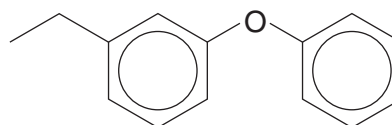
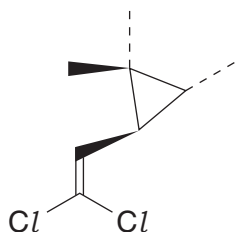
..... [4]



biopermethrin

- (c) Biopermethrin is broken down in mammals by hydrolysis of the ester link. The K_{ow} values for the hydrolysis products are too low to make these products harmful.

Complete the structures below to show the products of hydrolysis of biopermethrin.



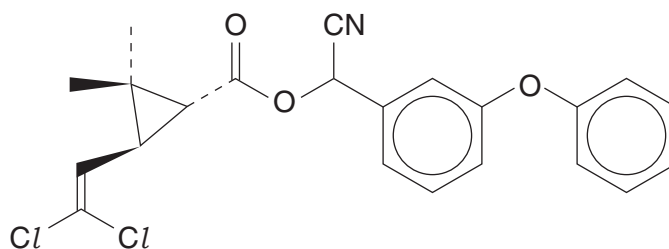
[2]

- (d) Having synthesised *biopermethrin*, chemists set out to prepare even better pesticides. Suggest **two** properties of these new pesticides that could make them more environmentally acceptable.

.....

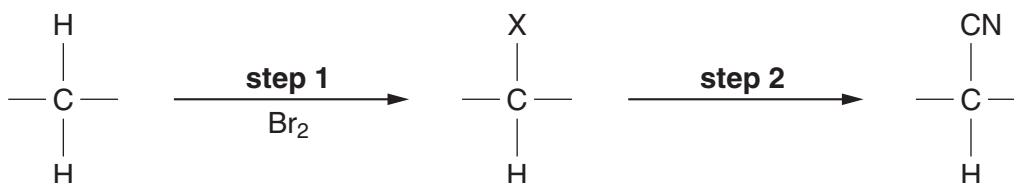
 [2]

- (e) The substance *biocypermethrin* was found to be a more efficient pesticide than *biopermethrin*.



biocypermethrin

A nitrile ($-\text{CN}$) group can be substituted for a hydrogen atom in a carbon chain by using the following reaction sequence.



- (i) Classify the **type** of mechanism for the substitution reaction in **step 1** and give an important condition.

.....
 [2]

- (ii) Identify **X** in the middle compound.

..... [1]

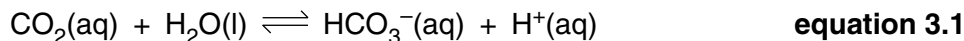
- (iii) Use your *Data Sheet* to write down the reagent for **step 2**.

..... [1]

[Total: 20]

- 3** The oceans are maintained at a pH of around 8 by buffering reactions that involve carbon dioxide.

The main reaction is given below.



- (a) (i)** Give the hydrogen ion concentration in a solution of pH 8 with the appropriate units.

$[\text{H}^+] = \dots\dots\dots$ **[2]**

- (ii)** Calculate the hydroxide ion concentration in a solution of pH 8.

$$K_w = 1 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$$

$[\text{OH}^-] = \dots\dots\dots$ **[2]**

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

Carbon dioxide is only slightly soluble in water. Sodium hydrogencarbonate (containing HCO_3^-) is very soluble in water.

Use ideas of intermolecular forces to explain why.

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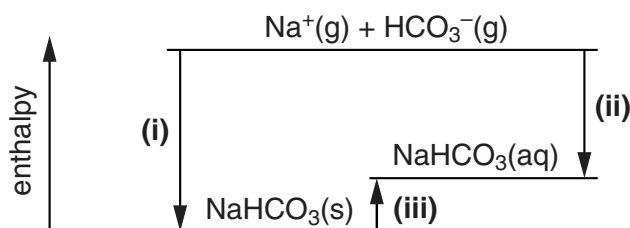
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..... **[5]**

Quality of Written Communication **[1]**

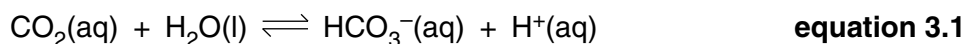
- (c) An enthalpy level diagram for the dissolving of sodium hydrogencarbonate is shown below. Give appropriate labels for the arrows at (i), (ii) and (iii).



- (i)
- (ii)
- (iii)

[3]

- (d) The oceans are kept at pH 8 by the equilibrium in **equation 3.1**.



- (i) The acidity constant, K_a , for the equilibrium in **equation 3.1** is $4.5 \times 10^{-7} \text{ mol dm}^{-3}$.

Write down the expression for K_a in terms of $[\text{CO}_2]$, $[\text{H}^+]$ and $[\text{HCO}_3^-]$.

Do **not** include the concentration of water.

[1]

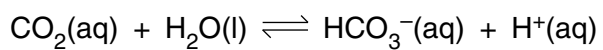
- (ii) Calculate the ratio $\frac{[\text{HCO}_3^-]}{[\text{CO}_2]}$ when $[\text{H}^+] = 1 \times 10^{-8} \text{ mol dm}^{-3}$.

$$\frac{[\text{HCO}_3^-]}{[\text{CO}_2]} = \dots\dots\dots [3]$$

- (iii) The solubility of carbon dioxide is $3.3 \times 10^{-2} \text{ mol dm}^{-3}$ at 298 K. Calculate the mass of NaHCO_3 which must be dissolved in 1.0 dm^3 of a saturated solution of carbon dioxide, so that $\frac{[\text{HCO}_3^-]}{[\text{CO}_2]} = 1.0$.

A_r : Na, 23; C, 12; O, 16; H, 1.0

mass of $\text{NaHCO}_3 = \dots\dots\dots \text{ g} [3]$

**equation 3.1**

- (iv) Sea-water acts as a buffer solution when a very small amount of acid is added.

Use the equilibrium in **equation 3.1** to explain how sea-water acts as a buffer solution.

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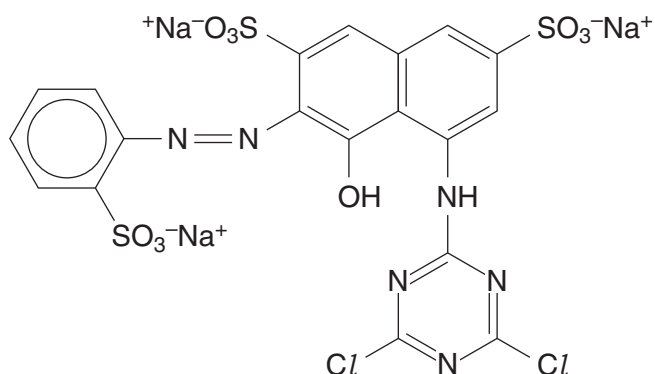
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..... [3]

[Total: 23]

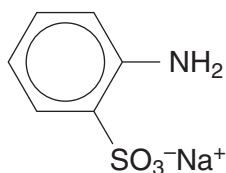
- 4 One of the first 'fibre reactive dyes' was Procion Brilliant Red 2BS.



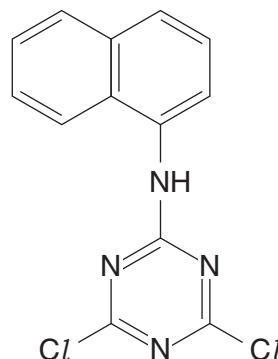
Procion Brilliant Red 2BS

- (a) Draw a circle round the phenol group on the dye structure. [1]
- (b) Which functional group on the dye molecule makes it soluble in water? [1]

- (c) This dye can be made by diazotising **compound A** and coupling it with **compound B**. [2]
- (i) Complete the structure of **compound B**.



compound A

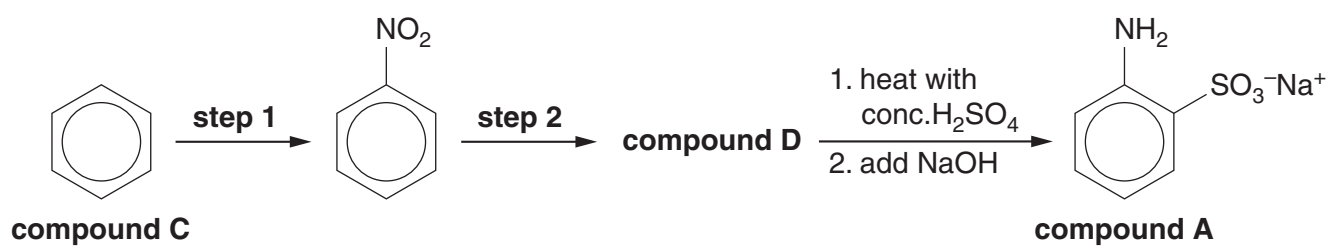


compound B (incomplete)

- (ii) State the reagents and conditions needed for the **coupling** reaction.

..... [2]

(d) **Compound C** can be converted to **compound A** by the reactions shown below.



(i) Name **compound C**.

..... [1]

(ii) Give the reagents and conditions needed for the reaction in **step 1**.

.....

.....

..... [3]

(iii) Use the reactions in the *Data Sheet* to answer this part.

Give the structure of **compound D** and then state the reagents and conditions for **step 2**.

structure of **compound D**

reagents and conditions for **step 2**

..... [2]

(e) The organic compounds in (d) contain rings of six carbon atoms with delocalised electrons.

(i) What general name is given to such compounds?

..... [1]

(ii) What do we mean when we say that the electrons are *delocalised*?

.....
 [1]

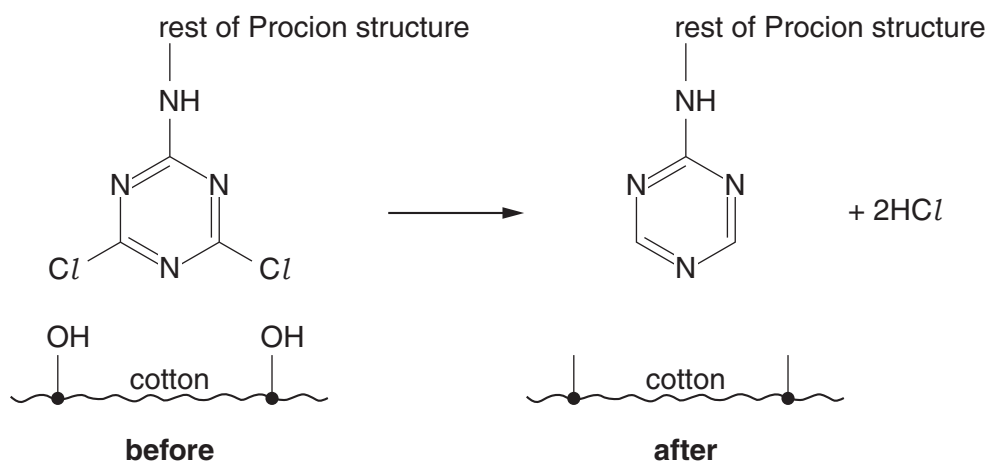
(f) Procion Brilliant Red 2BS is used to dye cotton. The OH groups on the cotton displace the Cl atoms from the dye molecule.

(i) In this reaction, the dye forms covalent bonds with the cotton and HCl is formed.

What **type** of reaction is this?

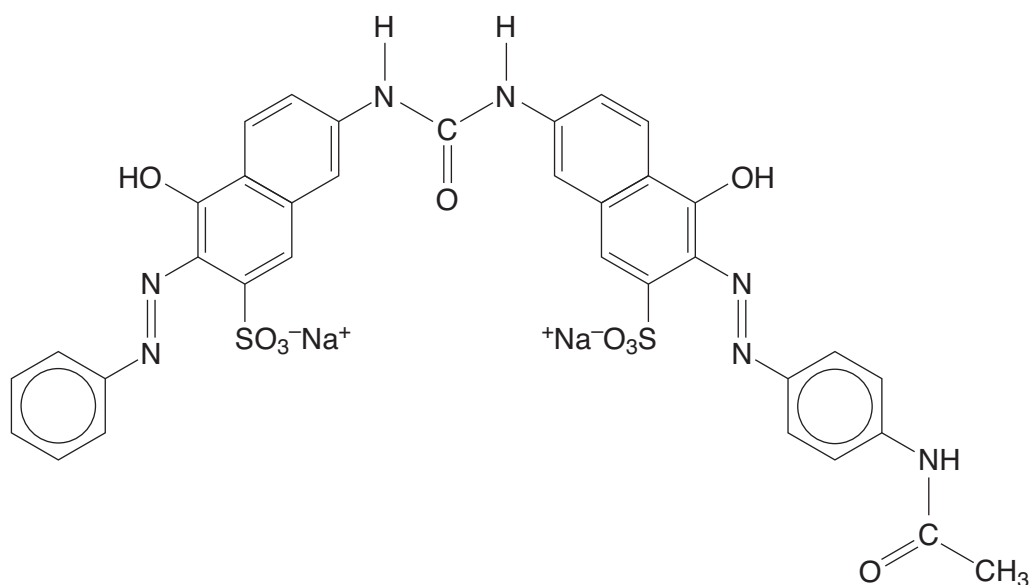
..... [1]

(ii) Illustrate the reaction by completing the 'after' diagram below.



[2]

(g) The dye Direct Red 23 is also used to dye cotton.



Direct Red 23

This dye binds to cotton with intermolecular forces that are much weaker than covalent bonds.

- (i) Suggest which is the strongest type of intermolecular force involved in binding this dye to cotton, giving a reason for your answer.

.....

 [3]

- (ii) A student has two pieces of cotton fabric, one dyed with the Procion dye and the other with the Direct Red dye. She places each one in a separate beaker containing the same volume of water and boils them for ten minutes.

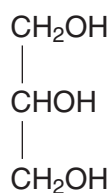
What difference would she expect to see in the contents of the two beakers?

Explain your answer.

.....

 [3]

[Total: 23]



(a) In this question, two marks are available for the quality of use and organisation of scientific terms.

Infrared spectroscopy can be used to show that glycerol is an alcohol. Glycerol can be distinguished from other alcohols by its proton n.m.r. spectrum.

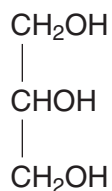
Describe and explain **two** features of its infrared spectrum which glycerol has in common with other alcohols.

Describe and explain how the proton n.m.r. spectrum of glycerol would be distinctive.

[6]

Quality of Written Communication [2]

16



glycerol

(b) Glycerol forms oils when it combines with long-chain carboxylic acids.

(i) Which elements make up these *long-chains*?

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

(ii) Draw the structure of the triglyceride (triester) formed between glycerol and the acid R-COOH.

[2]

(iii) Name the strongest type of intermolecular force that exists between molecules of the triglyceride.

..... [2]

(iv) The reaction of glycerol with a carboxylic acid can be carried out in the laboratory.

Give the conditions and the name of the other chemical required.

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

(c) Oil-based paints contain certain triglyceride oils in which the pigments are suspended.

(i) What structural feature of these oils makes them useful as the basis for paints?

..... [1]

(ii) Describe the process by which such oils harden.

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

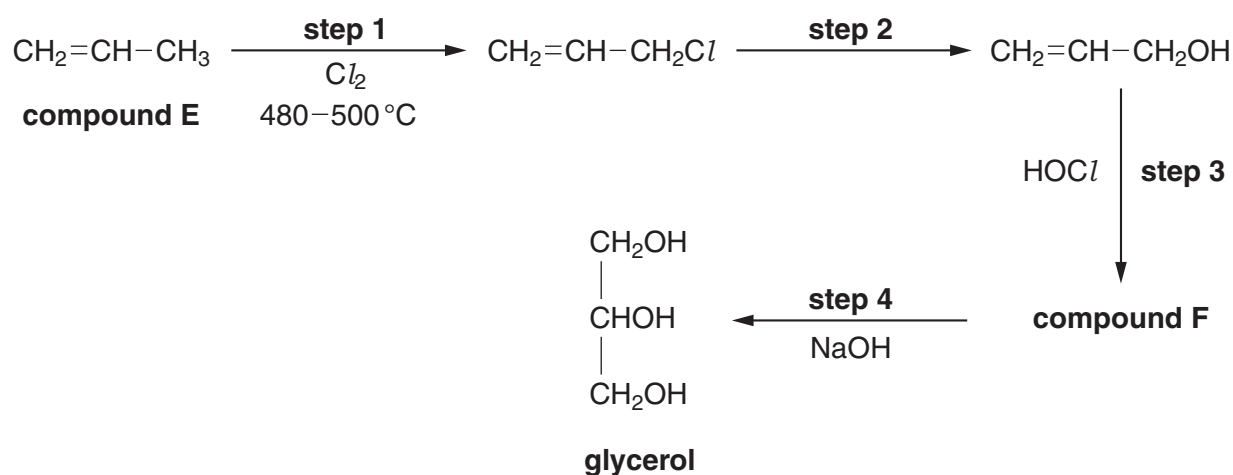
(d) Glycerol itself is used as a water-soluble lubricant with a relatively high boiling point. These properties can be explained by hydrogen bonding between O–H groups.

Explain how hydrogen bonding accounts for the water-solubility and the relatively high boiling point of glycerol.

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..... [4]

PLEASE TURN OVER FOR QUESTION 5(e)

(e) The following synthetic route can be used to make glycerol.



(i) Name **compound E**.

..... [1]

(ii) Suggest a raw material from which **compound E** is produced in industry.

..... [1]

(iii) Classify the reaction in **step 1** by circling one word.

addition **condensation** **elimination** **substitution**

[1]

(iv) Suggest a reagent for **step 2**.

..... [1]

(v) In **step 3**, the compound $\text{HOC}l$ adds across the double bond.

Suggest a structure for **compound F**.

[2]

- (vi) In a small-scale trial, 4.0 g of glycerol were made from 40 g of **compound E**. Calculate the percentage yield of the process.

A_r : C, 12; O, 16; H, 1.0

yield = % [3]

[Total: 32]

END OF QUESTION PAPER

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