

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced GCE**

**CHEMISTRY (SALTERS)**

**2849**

Chemistry of Materials

Friday **21 JANUARY 2005** Morning 1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

*Data Sheet for Chemistry (Salters)*

Scientific calculator

Ruler

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 provided 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.

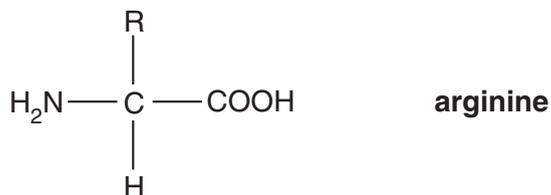
FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	20	
2	21	
3	25	
4	10	
5	14	
<b>TOTAL</b>	<b>90</b>	

**This question paper consists of 16 printed pages.**

Answer **all** the questions.

- 1 A Japanese firm has marketed a range of clothes called 'amino jeans'. The garments are impregnated with arginine. The arginine softens and moisturises the wearer's skin.

A simplified structure of arginine is shown below. R represents a carbon chain containing functional groups.



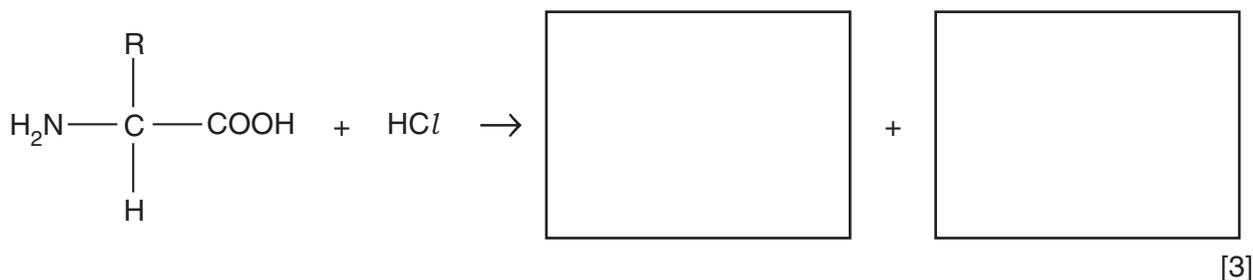
- (a) What is the name for the group of compounds to which arginine belongs?

.....

[1]

- (b) Arginine is often used as a salt made by reacting arginine with hydrochloric acid.

Complete the equation below to show the **ions** present in the salt.



[3]

- (c) Arginine exists as two enantiomers.

- (i) What structural feature causes arginine to have enantiomers?

..... [1]

- (ii) Draw the **three dimensional** structures of the two enantiomers to show how they are related.

[2]



- (ii) When arginine is at a low concentration, the enzyme catalysed reaction is first order with respect to arginine **and** first order with respect to the enzyme.

Write down the rate equation for this reaction. Give the units of the **rate constant** if the rate of the reaction is measured in  $\text{mol dm}^{-3} \text{s}^{-1}$ .

Rate equation .....

Units of rate constant ..... [3]

- (iii) At high concentrations of arginine, the order of the reaction with respect to arginine becomes zero. Explain what is meant by *zero order*.

.....

.....

..... [2]

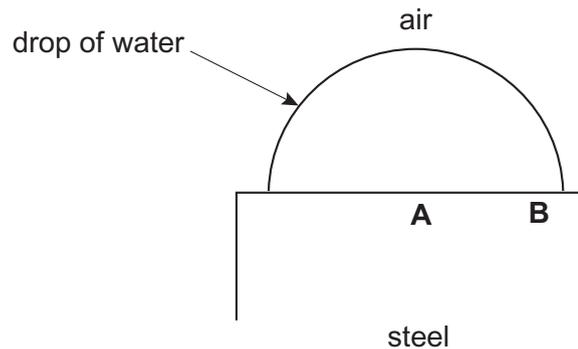
[Total: 20]

- 2 The 'Angel of the North' sculpture at Gateshead, near Newcastle, was constructed using Corten steel. This is a very strong material that oxidises naturally to produce a deep brown surface layer that protects the steel beneath. Corten steel is a mild steel that contains additional copper, chromium, nickel and silicon.

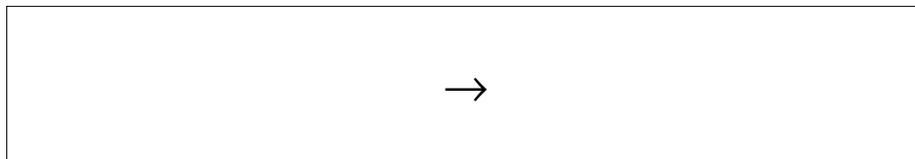
(a) Name the alloying element that is **essential** for iron to be converted into a steel.

..... [1]

(b) The diagram below is part of an explanation of how steel rusts when in contact with moist air.

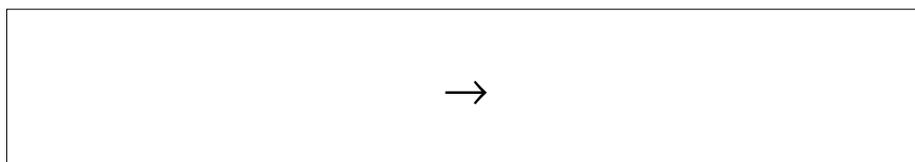


(i) Iron corrodes at **A** rather than **B**. Give the half-equation (ion-electron equation) for the reaction involving iron that occurs at **A** in the centre of the water drop.



[2]

(ii) Give the half-equation (ion-electron equation) for the reaction occurring at the position labelled **B** at the edge of the water drop.



[2]

(iii) Draw an arrow on the diagram in (b) above to show the direction of the electron flow. [2]

(iv) Suggest a reason why iron corrodes at **A** rather than **B**.

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

- (c) The formula of rust is often written as  $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ . Iron(III) ions are responsible for the brown colouring of rust.

By drawing arrows in the appropriate boxes, complete the outer electron structures for Fe,  $\text{Fe}^{2+}$ , and  $\text{Fe}^{3+}$ .

	3d	4s
<b>Fe</b>	<input type="text"/>	<input type="text"/>
<b><math>\text{Fe}^{2+}</math></b>	<input type="text"/>	<input type="text"/>
<b><math>\text{Fe}^{3+}</math></b>	<input type="text"/>	<input type="text"/>

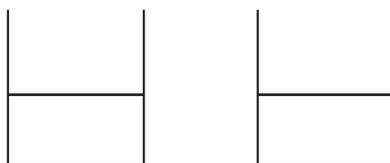
[3]

- (d) When copper is in contact with iron, a cell is set up. The half-reactions for this cell are given below.

half-reaction	$E^\ominus/\text{V}$
$\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$	-0.44
$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$	+0.34

- (i) Complete and label the diagram below to show how you would set up an iron-copper cell in the laboratory.

Ⓟ



[3]

- (ii) Calculate  $E^\ominus_{\text{cell}}$  for this iron-copper cell.

$$E^\ominus_{\text{cell}} = \dots\dots\dots\text{V} \quad [1]$$

(iii) Give the equation for the overall cell reaction in (i).

Include the appropriate state symbols.

$\rightarrow$

[2]

(iv) The first stage in rusting involves the oxidation of iron to iron(II). Use the electrode potentials given above to explain how the presence of copper causes rusting to become more severe.

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

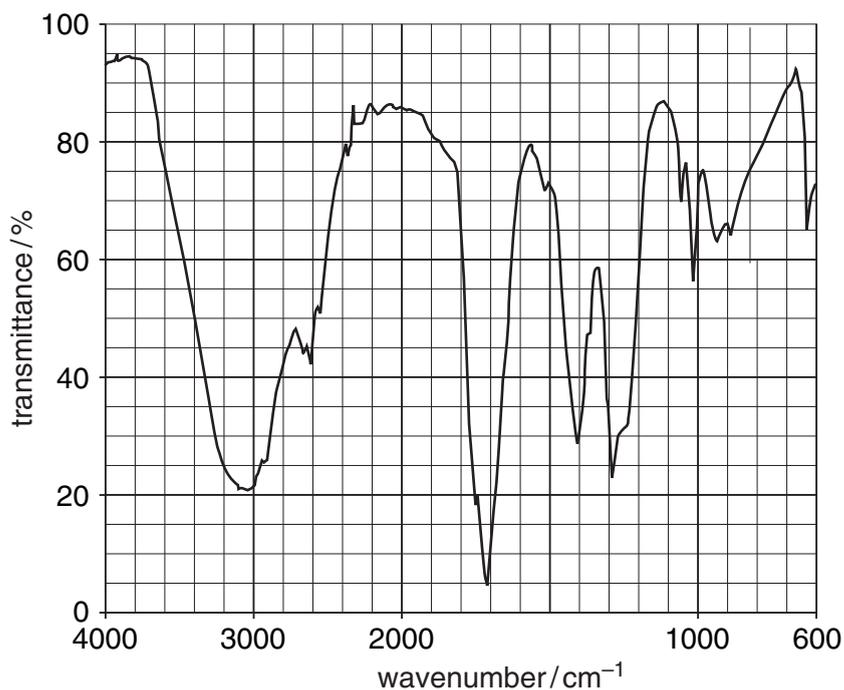
(e) The addition of copper and other elements to mild steel modifies the structure of the rust layer. This enables Corten steel to acquire a protective coating. Suggest **one** way in which the physical properties of rust have been modified.

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

[Total: 21]



- (ii) The stored sample of acetaminophen is damp and some hydrolysis has taken place to give the impurities. The infrared spectrum of **one** of the impurities, **X**, is shown below.



Use the *Data Sheet*, together with the information above, to identify the functional group in **X**. Give your reasoning by identifying the key peaks in the spectrum and the bond to which each corresponds.

reasoning: .....

.....

.....

functional group: ..... [3]

- (iii) The  $M_r$  of **X** is 60. Draw the **full structural formula** of **X**.

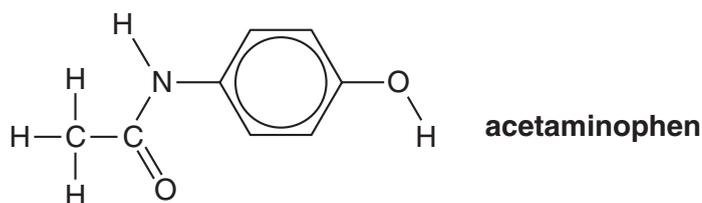
[2]

- (iv) 2.00 g of **impure** acetaminophen contains 0.010 mol acetaminophen. Calculate the percentage by mass of acetaminophen in the impure sample.

$A_r$ : H,1.00; C,12.0; N,14.0; O,16.0

percentage purity = ..... % [3]

- (b) Acetaminophen dissolves readily (without hydrolysis) in cold dilute aqueous sodium hydroxide.



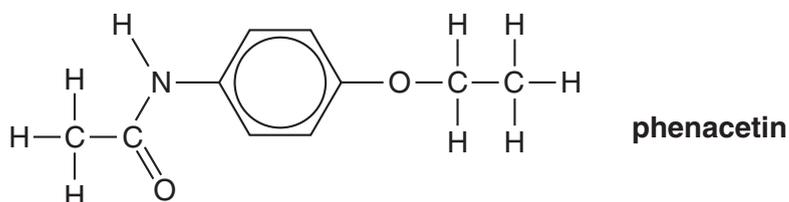
- (i) **Name** the functional group present in acetaminophen responsible for its solubility in sodium hydroxide solution.

..... [1]

- (ii) Draw the structure of the organic species formed in the sodium hydroxide solution.

[2]

- (c) Phenacetin is a related compound with similar medicinal properties to acetaminophen.



- (i) A student was asked to devise a chemical test to distinguish between phenacetin and acetaminophen. He added a little of each compound to a fresh sample of aqueous iron(III) chloride.

Give the colour of aqueous iron(III) chloride and describe the results of the tests on each substance by completing the table below.

	colour of solution
aqueous iron(III) chloride	
with phenacetin	
with acetaminophen	

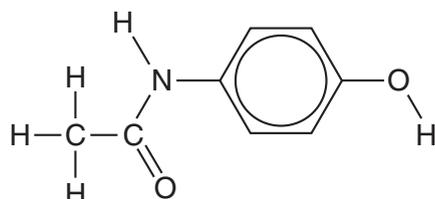
[3]

- (ii) Another way of distinguishing between the two medicines is to compare their n.m.r. spectra.

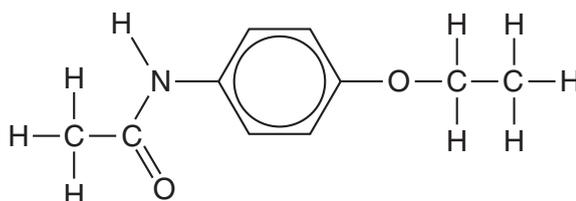
Use the *Data Sheet* to deduce how the two n.m.r. spectra differ.

In the tables below, give the chemical shifts of the peaks that **differ** in the two spectra, indicating the relative intensity of the peaks **where appropriate**.

working space:



**acetaminophen**



**phenacetin**

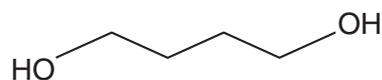
chemical shifts for <b>acetaminophen</b> only	type of proton	relative intensity

chemical shifts for <b>phenacetin</b> only	type of proton	relative intensity

[5]

[Total: 25]

- 4 Polyesters have become the major group of condensation polymers manufactured at present. There is an increasing demand for PBT, a polymer used in making mouldings for cars. PBT is made using the two monomers shown below.



- (a) (i) Explain why the formation of PBT is an example of *condensation polymerisation*.

condensation .....

.....

polymerisation .....

..... [2]

- (ii) Complete the diagram below to show the structural formula of the repeating unit for the polyester, PBT.



[2]

- (iii) The monomers in (ii) are joined by *ester links*. Draw the **full structural formula** of an ester link.

[1]

(b) At very low temperatures, mouldings made from PBT become brittle. Explain why thermoplastic (thermosoftening) polymers become brittle when their temperature is lowered.

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

(c) Describe **two** ways that chemists can modify a polymer, such as PBT to make it more flexible.

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

[Total: 10]



- (ii) Equilibrium constants for ligand exchange reactions are usually called stability constants,  $K_{\text{stab}}$ . The value of  $K_{\text{stab}}$  for the above reaction is  $2.00 \times 10^{19} \text{ mol}^{-1} \text{ dm}^3$  at  $25^\circ\text{C}$ .

What does this tell you about the position of equilibrium at  $25^\circ\text{C}$ ? Explain your reasoning.

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

- (iii) The forward reaction in the above equilibrium is slightly exothermic. At temperatures higher than  $25^\circ\text{C}$ ,  $\text{edta}^{4-}$  ions sequester nickel(II) ions less effectively. Explain why this is so.

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

- (e) The amount of nickel(II) ion in a solution can be found by titrating with a solution of  $\text{edta}^{4-}$  of known concentration using a suitable indicator.

$25.0 \text{ cm}^3$  of a solution containing nickel(II) ions reacted with exactly  $22.0 \text{ cm}^3$  of a  $0.100 \text{ mol dm}^{-3}$  solution of  $\text{edta}^{4-}$  ions.

Calculate the concentration of nickel(II) ions in the solution.

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

concentration = .....  $\text{mol dm}^{-3}$  [4]

[Total: 14]

**END OF QUESTION PAPER**

