OCR
RECOGNISING ACHIEVEMENT

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

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	
TOTAL	90	

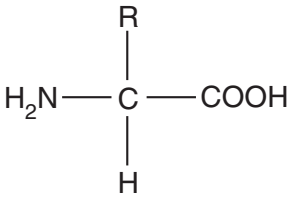
This question paper consists of 16 printed pages.

Registered Charity Number: 1066969
[Turn over

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.



arginine

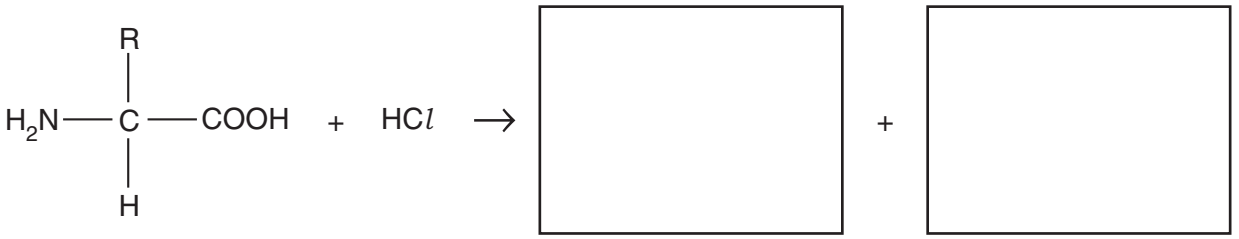
(a) What is the name for the group of compounds to which arginine belongs?

.....

[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]

(d) Arginine is one of the monomers used to make proteins.

(i) Draw the structure of an organic molecule formed when a molecule of arginine acts as a monomer and joins with a molecule of glycine, NH_2CH_2COOH, to make a dimer.

[2]

(ii) Arginine and glycine in **(i)** are joined by a *peptide link*. Draw the **full structural formula** of a peptide link.

[1]

(e) Arginine is also a muscle relaxant.

Enzymes in the body cause the breakdown of arginine to form NO, and it is the NO which affects the muscles. In the first step of this process, only one of the two enantiomers of arginine is affected by an enzyme.

(i) Describe how an enzyme can catalyse the breakdown of arginine. Using ideas of protein structure and reaction rates, explain why the enzyme

- is specific for one enantiomer of arginine
- has an optimum temperature for its activity.

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..... [5]

(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 mol dm^{-3} 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]

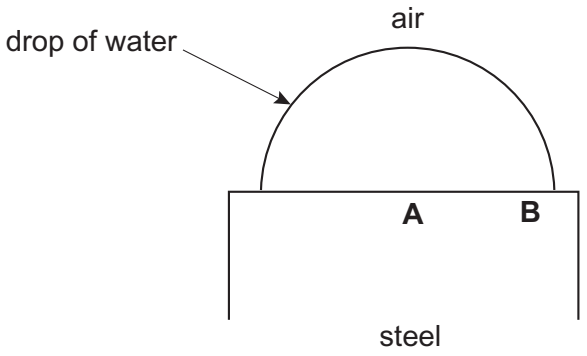
[Total: 20]

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.

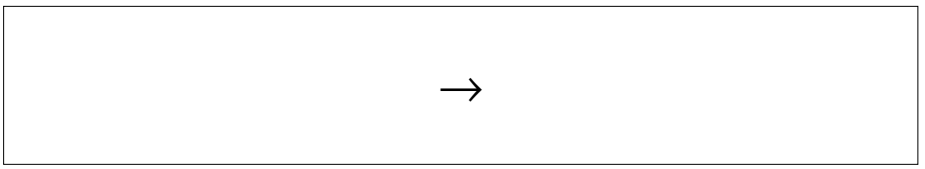
(a) Name the alloying element that is **essential** for iron to be converted into a steel.

..... [1]

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

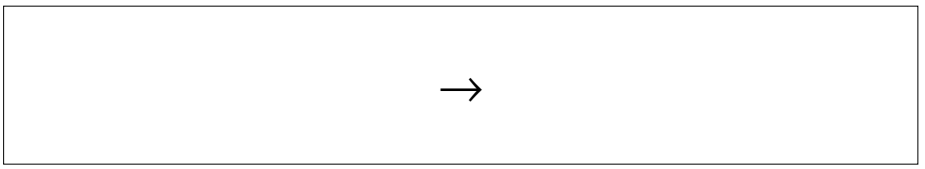


(i) Iron corrodes at **A** rather than **B**. Give the half-equation (ion-electron equation) for the reaction involving iron that occurs at **A** in the centre of the water drop.



[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]

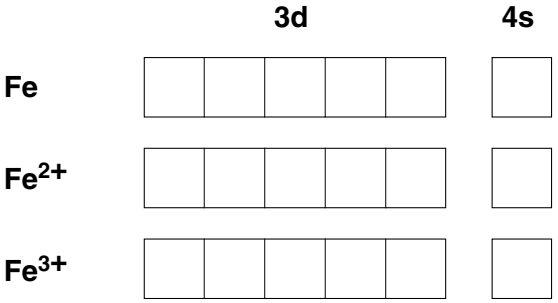
(iv) Suggest a reason why iron corrodes at **A** rather than **B**.

.....

..... [1]

(c) The formula of rust is often written as $Fe_2O_3.xH_2O$. 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, Fe^{2+}, and Fe^{3+}.

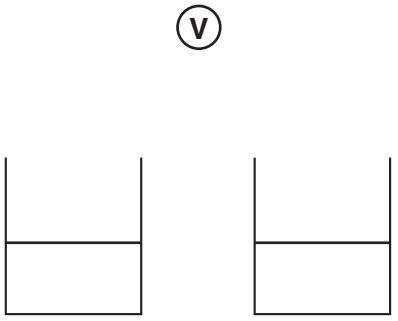


[3]

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

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

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



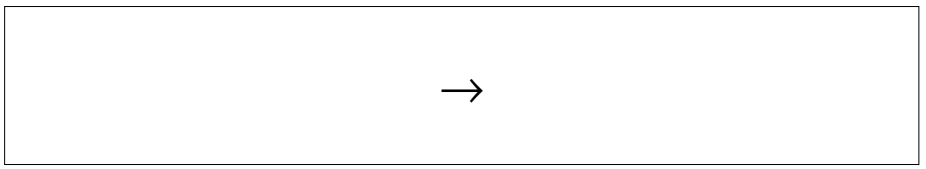
[3]

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

$E^{\ominus}_{cell}$ = ...V [1]

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

Include the appropriate state symbols.



[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.

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..... [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.

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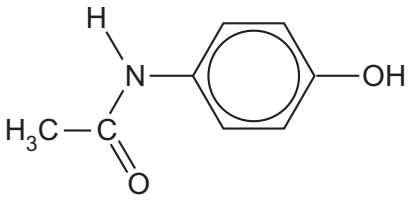
..... [1]

[Total: 21]

3 Acetaminophen is a medicine that reduces the symptoms of a fever. It is sometimes used as a substitute for aspirin for people who suffer from stomach disorders. Like aspirin, it is a solid.



acetaminophen

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

A sample of acetaminophen has been stored for some time and is found to be contaminated with impurities. It can be purified by recrystallisation, using ethanol as the solvent.

Describe how you would carry out the recrystallisation in the laboratory to obtain a pure sample of acetaminophen.

.....

.....

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..... [5]

Quality of Written Communication [1]

(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.

A graph has been removed due to third party copyright restrictions

Details: An infrared spectrum of the impurity X

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.

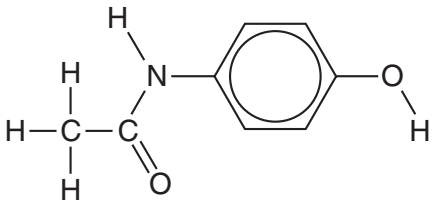
[2]

(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.



acetaminophen

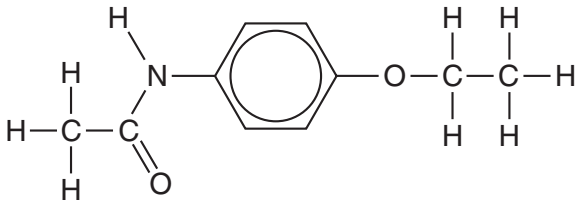
(i) **Name** the functional group present in acetaminophen responsible for its solubility in sodium hydroxide solution.

..... [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.



phenacetin

(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	

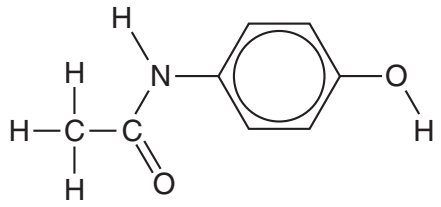
[3]

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

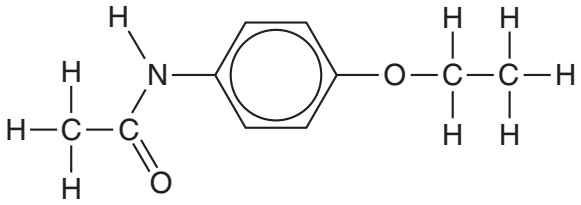
Use the *Data Sheet* to deduce how the two n.m.r. spectra differ.

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

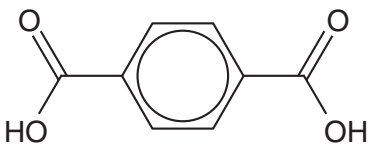
chemical shifts for **acetaminophen** only	type of proton	relative intensity

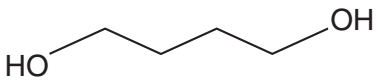
chemical shifts for **phenacetin** only	type of proton	relative intensity

[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.

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..... [3]

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

.....

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..... [2]

[Total: 10]

5 Unwanted metals can find their way into food, either from the soil or from machinery during harvesting and processing. Ions of metals such as copper, iron and nickel catalyse the breakdown of fats in food.

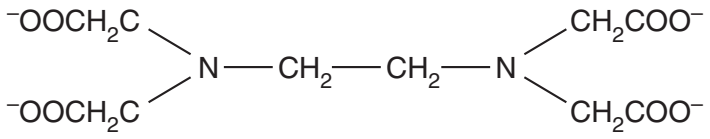
(a) Copper, iron and nickel are transition metals. What property of transition metals allows them to behave as catalysts?

..... [1]

(b) A class of food additives known as sequestrants can be used to remove these metal ions.

Typical sequestrants are the calcium and sodium salts of H_4 edta.

The structure of the $edta^{4-}$ ion is shown below.



The $edta^{4-}$ ion acts as a hexadentate ligand. On the structure above, label with an asterisk (*) the six sites that form bonds to the metal ion. [2]

(c) Underline the term below that describes the shape of the complex formed between a nickel(II) ion and an $edta^{4-}$ ion.

linear **octahedral** **square planar** **tetrahedral** [1]

(d) The reaction of $edta^{4-}$ ions with nickel(II) ions can be represented by the following equation.

$$[Ni(H_2O)_6]^{2+}(aq) + edta^{4-}(aq) \rightleftharpoons [Ni(edta)]^{2-}(aq) + 6H_2O(l)$$

(i) Write an expression for the equilibrium constant, *K*, for the reaction. Omit the concentration of water.

$K =$

[2]

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

What does this tell you about the position of equilibrium at 25 °C? Explain your reasoning.

.....

.....

..... [2]

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

.....

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..... [2]

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

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

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

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

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

[Total: 14]

END OF QUESTION PAPER