OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

CHEMISTRY (SALTERS) 2853

Polymers, Proteins and Steel

Friday **24 JANUARY 2003** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry (Salters)
Scientific calculator

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	16	
2	9	
3	14	
4	15	
5	14	
6	22	
TOTAL	90	

This question paper consists of 16 printed pages.

For Examiner's Use

Answer **all** the questions.

1 Large amounts of steel are made from impure iron using the BOS process.

The first stage of the process is to remove the free sulphur, which is dissolved in the molten iron. Magnesium is added to react with the sulphur to make magnesium sulphide, MgS.

(a) (i) Write an equation to show the reaction of magnesium with sulphur.

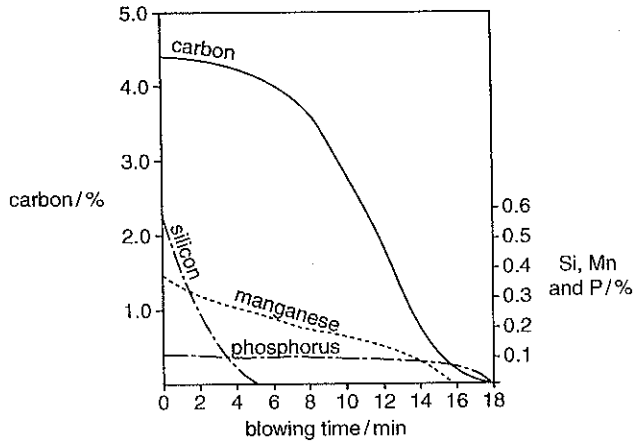
.....[1]

(ii) What **type** of reaction is this?

.....[1]

(b) Carbon and other elements are removed by direct oxidation with gaseous oxygen to form their oxides during the 'oxygen blow'.

The graph below shows the removal of four elements during steelmaking.
The % carbon is shown on the left. The % of Si, Mn and P are shown on the right.



Steel for making gas pipelines needs to have a phosphorus content of about 0.005% and a carbon content of about 0.5%.

The steel manufacturer has set the 'oxygen blow' at 15 minutes. Use the graph to suggest whether the steel produced at this time would be suitable for making gas pipelines. Give reasons for your answer.

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.....[2]

(c) **(i)** Why is it necessary to reduce the percentage of carbon in molten iron in order to make steel?

.....

.....[1]

(ii) During the 'oxygen blow', carbon monoxide is given off as a gas and is collected by a hood over the converter. Why is it necessary to prevent the gas escaping into the atmosphere?

.....[1]

(d) Acidic silicon oxide formed in the oxygen blow is removed by reaction with a base such as calcium oxide to form a slag.

Write equations to show

the reaction of silicon with oxygen

.....

the reaction of silicon oxide with calcium oxide to form a slag

.....

[2]

(e) Car bodies are made of steel. Steel rusts in the same way as iron. Car bodies are painted to protect them from rusting.
Explain how painting helps to prevent a car from rusting.

.....

.....[1]

(f) Stainless steel contains chromium. Suggest how the presence of chromium prevents the formation of rust.

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.....[2]

[Turn over

(g) A chemist determined the amount of chromium present in a piece of stainless steel by the following method.

- 1.50 g of a sample of a stainless steel were dissolved by boiling in acid.
- The resulting solution was cooled.
- Excess aqueous ammonia was added to form 250 cm^3 of a solution containing the purple complex $[Cr(NH_3)_6]^{3+}$.
- The concentration of Cr^{3+} present in the purple solution was found by colorimetry.

The concentration of Cr^{3+} was found to be 1.38×10^{-2} mol dm^{-3}.

(i) Calculate the amount in moles of Cr^{3+} in 250 cm^3 of the purple solution.

Answer ..... mol [1]

(ii) Calculate the mass of chromium present in the sample of stainless steel. [A_r : Cr, 52.0]

Answer .....[2]

(iii) Calculate the percentage of chromium present in the sample of stainless steel. Give your answer to an appropriate number of significant figures.

Answer .....[2]

[Total: 16]

2 *Pathfinder* was a lightweight solar-powered aircraft, used by NASA in the early 1990s for environmental monitoring. The plane was solar-powered during the day, but needed electrochemical cells to power it at night.

The cell used in *Pathfinder* was a zinc-silver cell.

During development, a scientist made a cell from a standard zinc half-cell and a standard silver half-cell.

(a) Use the data below to calculate $E^{\ominus}_{cell}$ for the zinc-silver cell.

$$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s) \qquad E^{\ominus} = -0.76\,V$$

$$Ag^{+}(aq) + e^- \longrightarrow Ag(s) \qquad E^{\ominus} = +0.80\,V$$

[1]

(b) Draw a labelled diagram to show how you would set up a simple **standard** zinc-silver cell and then measure $E^{\ominus}_{cell}$.

[5]

(c) State **with a reason** which metal would form the positive electrode of the cell.

.....

.....[1]

(d) Construct the overall equation for the cell reaction of the zinc-silver cell.

.....[2]

[Total: 9]

3 In many reactions in living cells, hydrogen peroxide is formed as a waste product.

In the body, the enzyme catalase causes hydrogen peroxide to decompose as soon as it is formed.

Hydrogen peroxide decomposes according to the following equation.

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

A student planned to investigate the rate of decomposition of hydrogen peroxide in the laboratory using liver as a source of catalase.

The student decided to measure the rate at which oxygen was produced.

(a) Draw a labelled diagram of an apparatus the student could use to do this experiment.

[3]

For Examiner's Use

(b) The student carried out several experiments with different initial concentrations of hydrogen peroxide (other conditions were kept constant). In each experiment, he found the initial rate of the reaction.

The table below shows his results.

concentration of H_2O_2 / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
0.100	0.214
0.250	0.530
0.500	1.07
1.00	2.14

(i) What is the effect on the initial rate of the reaction of

- doubling the concentration of H_2O_2?

.....[1]

- multiplying the concentration of H_2O_2 by 4?

.....[1]

(ii) What does this suggest about the order of reaction with respect to hydrogen peroxide?

.....[1]

(c) In a further set of experiments, the student found that the reaction was first order with respect to catalase.

(i) Use this information and your answer to **(b)(ii)** to construct the rate equation for the decomposition of hydrogen peroxide in the presence of catalase.

.....[3]

(ii) Use your rate equation in **(c)(i)** to work out the overall order of the reaction.

.....[1]

(d) The student also investigated the effect of increasing the temperature on the rate of the reaction. He found that the reaction was fastest at 35 °C.

Explain in terms of enzyme structure and bonding, why the rate of reaction decreases if the reaction is carried out at temperatures higher than 35 °C.

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.....

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.....

.....

.....[4]

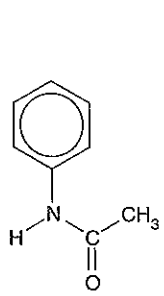
[Total: 14]

[Turn over

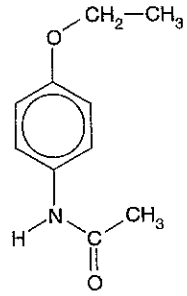
For Examiner's Use

4 Acetanilide and phenacetin have been used in medicines for the relief of pain and fever. In the late 1940s, it was discovered that both these compounds are metabolised (converted) in the body to a related compound called paracetamol. Paracetamol has since become widely used as a medicine.

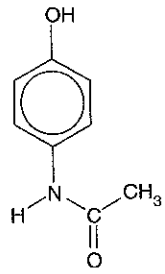
The structures of these three compounds are shown below.



acetanilide



phenacetin



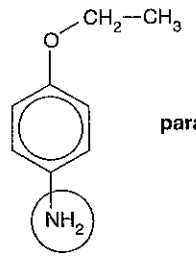
paracetamol

(a) What is the name of the functional group (other than the benzene ring) that all three structures have in common?

.....[1]

(b) Another product of the metabolism of phenacetin is para-phenetidine.

The structure of this is shown below.



para-phenetidine

(i) Name the functional group circled on para-phenetidine.

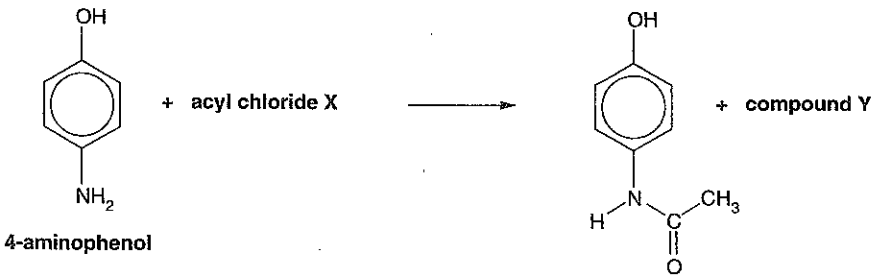
.....[1]

(ii) Choose from the list below the **type** of reaction that converts phenacetin into para-phenetidine. Circle your answer.

esterification **hydration** **condensation** **hydrolysis** **elimination** **polymerisation**

[1]

(c) Paracetamol can be prepared by reacting 4-aminophenol with an **acyl chloride X**. **Compound Y** is also formed in this reaction, as shown below.



4-aminophenol

paracetamol

(i) Draw the full structural formula of the **acyl chloride X**. Give the systematic name of **X**.

Full structural formula of **acyl chloride X**

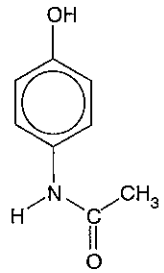
Systematic name of **X** .....[3]

(ii) Name **compound Y**.

.....[1]

(d) One method of determining the structure of a compound is to determine its proton (^{1}H) n.m.r spectrum.

(i) There are five different proton environments in the proton n.m.r spectrum of paracetamol. Use letters **a**, **b**, **c**, **d** and **e** to label each different proton environment on the diagram below.



paracetamol

[3]

(ii) Suggest the ratio of the peak intensities **a:b:c:d:e** that would be seen on the n.m.r spectrum of paracetamol.

proton environments **a : b : c : d : e**

ratio of peak intensities .....[3]

(e) When prescribing a medicine, doctors need to know how quickly it is metabolised and removed from the body. The removal of paracetamol is a first order process with a half-life of 2.5 hours.

Calculate the percentage of the original dose that would be left in the body after 7.5 hours.

Answer .....[2]

[Total: 15]

For Examiner's Use

5 Hair is made from an insoluble protein called keratin.

(a) Proteins are polypeptides. What is meant by the term *polypeptide*?

.....

.....[2]

Each polypeptide chain in keratin is coiled into an α-helix.
Part of the α-helix is shown below.

(b) Protein molecules, such as keratin, have three levels of structure.

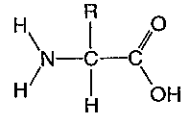
Complete the table below to show the names for the levels of structure described.

structure level	responsible for
	coiling of chain into an α-helix
	order of amino acids in chain

[2]

For Examiner's Use

(c) The general structure of an amino acid is shown below.

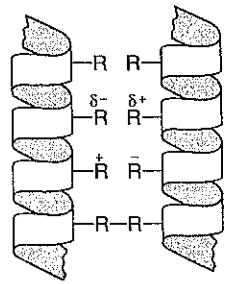


The R groups in some of the amino acids present in keratin are shown below.

R group	$-CH_2-CH_2-CH_2-CH_2-NH_2$	$-CH_3$	$-CH_2-C(=O)-OH$	$-CH_2OH$	$-CH_2SH$
amino acid	lysine	alanine	aspartic acid	serine	cysteine

Interactions between the R groups hold protein strands together as shown in the diagram.

These interactions could be
- instantaneous dipole-induced dipole forces
- ionic attractions
- hydrogen bonds
- covalent bonds



(i) Use the information above to complete the following table. This table shows the strongest interaction between the R groups on pairs of amino acids in keratin.

amino acid pairs		strongest interaction
amino acid 1	amino acid 2	
lysine	aspartic acid	ionic attraction
alanine	alanine	
aspartic acid	serine	
cysteine	cysteine	

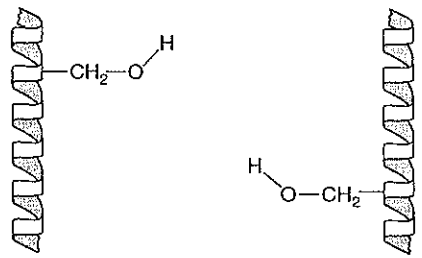
[3]

(ii) Show how an ionic attraction would form between the R groups on lysine and aspartic acid.

[2]

(d) The simplest way of creating a new hair-style is to wash the hair and dry it. When hair is washed the hydrogen bonds between helices are disrupted. The hair fibres increase in diameter because water molecules get into them forming a bridge between the helices.

(i) Complete the diagram below to show how a water molecule could make a bridge between the two helices in a hair fibre.



[2]

(ii) Use the information and your diagram in **(d)(i)** to suggest why it is possible to change your hairstyle when it is washed and dried with hot air from a hair drier.

.....

.....

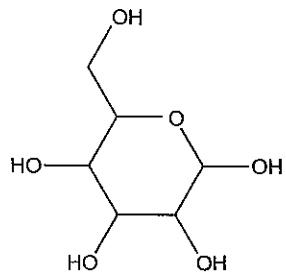
.....

.....[3]

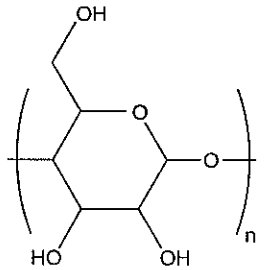
[Total: 14]

6 Synthetic fibres have taken the place of natural fibres for many applications.
The early development of synthetic fibres involved modifying natural polymers such as cellulose.

Cellulose is the main constituent of cell walls in plants. It is made by linking together many glucose molecules.



glucose
molecular formula $C_6H_{12}O_6$



cellulose
molecular formula $(C_6H_{10}O_5)_n$

(a) **(i)** Refer to the molecular formulae of glucose and cellulose. Name the small molecule that is eliminated when glucose polymerises to form cellulose.

.....[1]

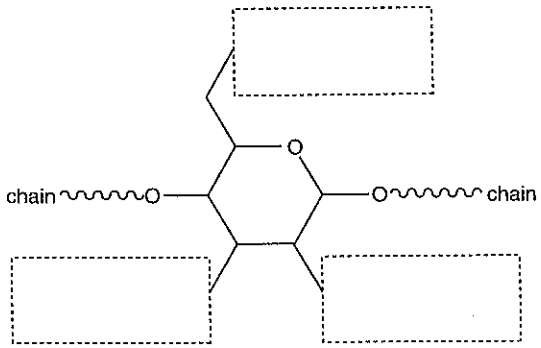
(ii) What is the name of this **type** of polymerisation?

.....[1]

For Examiner's Use

(b) The synthetic fibre *Tricel*, (cellulose triethanoate), is made by esterifying the –OH groups on cellulose with an excess of ethanoic acid, CH_3COOH, and concentrated sulphuric acid.

The diagram below is an incomplete structure of cellulose triethanoate
Complete the structure by drawing the ester groups in the boxes. Show the full structural formula of the ester group.



cellulose triethanoate

[2]

(c) In this question, one mark is available for the quality of written communication.

Cotton is a natural material consisting of cellulose.

In a cotton fibre, many cellulose chains are arranged in bundles, aligned more or less along the length of the fibre. Cotton fibres have a high degree of crystallinity and are stiff. They also have a high water absorbency. The fibres of *Tricel* are much less stiff than those of cotton and they have a low water absorbency.

Suggest and explain, in terms of intermolecular forces, reasons for the differences in the properties of these fibres.

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.....

.....[5]

Quality of Written Communication [1]

[Turn over

For Examiner's Use

(d) Plastic made from cellulose triethanoate was once used to make children's dolls. Museums now collect these dolls. Sometimes the dolls suffer from 'doll disease'; the dolls begin to lose their shape and sticky brown liquid oozes from their joints.

When this type of plastic is made, traces of sulphuric acid remain in the plastic.

The dolls contain steel spikes, and the iron in the steel reacts with sulphuric acid to form iron(II) sulphate and hydrogen.

Write an equation, including state symbols, for the reaction of the iron with sulphuric acid.

[2]

(e) The iron(II) sulphate reacts with air to form iron(III) sulphate. The Fe^{3+} ions formed in this reaction are thought to catalyse the breakdown of the cellulose triethanoate.

What property of transition metal ions such as Fe^{3+} allows them to behave as catalysts?

.....

.....[1]

(f) A sample of the brown liquid which oozed from the dolls' joints was thought to contain the complex ion $[Fe(H_2O)_6]^{3+}$.

(i) What is the coordination number of the complex ion $[Fe(H_2O)_6]^{3+}$?

.....[1]

(ii) Name the shape of this complex ion.

.....[1]

(iii) The water molecules act as ligands in the complex ion. Explain how the water molecules can act as ligands.

.....

.....

.....[2]

(iv) State what you would expect to see when dilute sodium hydroxide is added to a solution containing Fe^{3+}. Write an equation to show this reaction. Include state symbols in your equation.

observation .....

equation

[5]

[Total: 22]