OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY (SALTERS) 2853

Polymers, Proteins and Steel

Wednesday **18 JUNE 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	14	
2	21	
3	21	
4	10	
5	24	
TOTAL	90	

This question paper consists of 16 printed pages.

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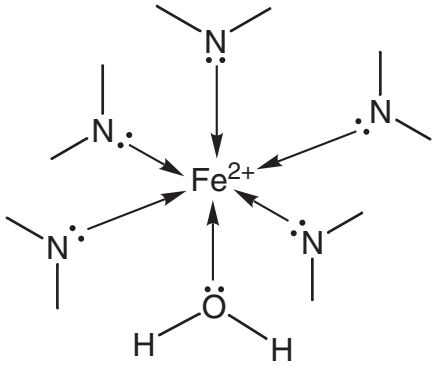
Answer **all** the questions.

1 Iron carries out a vital role in the body as part of the haemoglobin molecule.

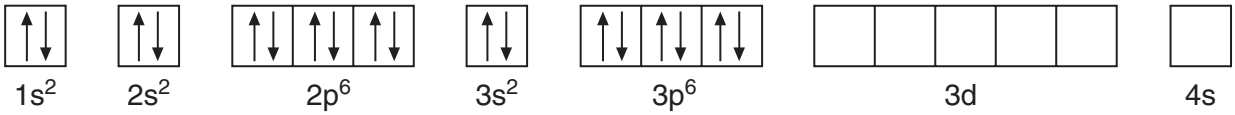
Part of the structure of haemoglobin is shown below.



Haemoglobin is a complex involving the transition metal ion Fe^{2+}.

(a) The atomic number of iron is 26.

(i) Complete the boxes below to show the electronic configuration of an Fe^{2+} **ion**.



[2]

(ii) Explain in terms of electron configuration why iron is described as a transition metal.

.....

.....

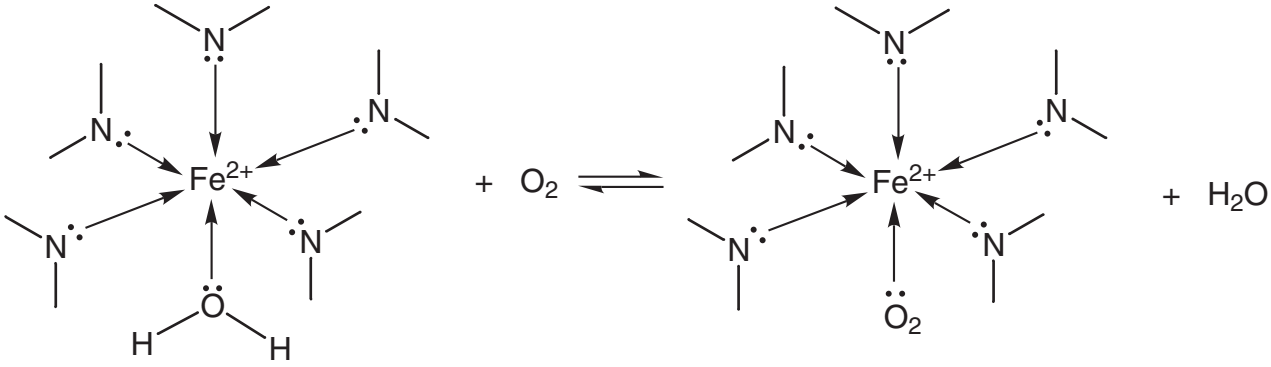
.....[2]

(iii) State **two** properties, other than ability to form complexes, shown by transition metals or their compounds.

.....

.....[2]

(b) As blood passes through the lungs, the water molecules in haemoglobin are replaced by oxygen molecules. The reverse process takes place as blood passes around the body.



What **type** of reaction takes place when the water molecule is swapped for an oxygen molecule?

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.....[2]

(c) A shortage of haemoglobin can lead to anaemia. People who suffer from anaemia can take iron tablets.

A chemist wanted to find out how much iron was present in an iron tablet. She weighed out an iron tablet, ground it into a powder and dissolved it in dilute sulphuric acid. She then titrated the contents of the flask with aqueous potassium manganate(VII) until the end point was reached.

Her results are shown below.

Mass of 1 iron tablet	= 0.780 *g*
Concentration of aqueous potassium manganate(VII)	= 0.0200 mol dm^{-3}
Volume of aqueous potassium manganate(VII)	= 17.4 cm^3

The two half-equations involved in the chemical reaction are shown below.

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$
$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

(i) Use the two half-equations to construct the balanced overall chemical equation for the reaction.

.....[2]

(ii) Calculate the amount in moles of manganate(VII) used in the titration.

answer.....mol [1]

(iii) Calculate the amount in moles of iron present in the iron tablet.

answer.....mol [1]

(iv) Use your answer to **(iii)** to calculate the percentage of iron present in the iron tablet.

A_r: Fe, 56.

answer.....[2]

[Total: 14]

2 Silk is an example of a fibrous protein produced by some insects and spiders. Silk is composed principally of a protein called fibroin. Part of the primary structure of fibroin is shown below.

-gly-ser-gly-ala-gly-ala-

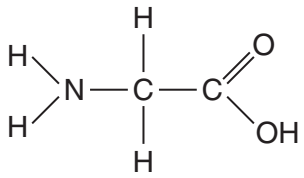
(a) What is meant by the *primary structure* of a protein?

.....

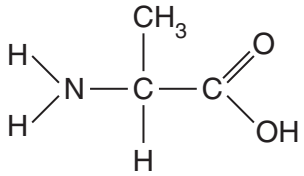
.....[2]

(b) Fibroin has peptide linkages between amino acids, for example between the amino acid molecules glycine and alanine.
The structures of glycine and alanine are shown below.

glycine



alanine



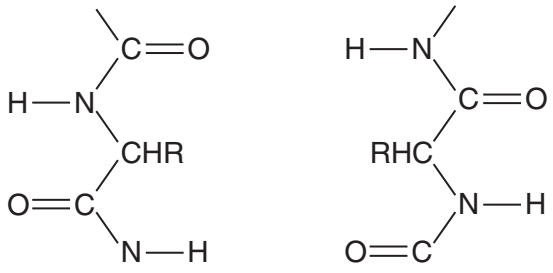
(i) Draw the structural formula of a dipeptide formed from glycine and alanine.

[2]

(ii) Draw a circle around the peptide link in your structural formula in **(i)**. [1]

(c) The protein chains in silk fibroin are folded into sheets.

Part of the structure of a sheet is shown below.



(i) What name is given to this level of protein structure?

.....[1]

(ii) State the **strongest type** of intermolecular force which holds the chains in the sheet together.

.....[1]

(iii) **On the diagram above**, show where these intermolecular forces arise. [2]

(d) A synthetic fibre related to silk was introduced to the general public at the New York World Fair in 1939. The fibre, called nylon, had similar properties to silk, but was much cheaper.

The structure of a type of nylon is shown below.

$$—HN—(CH_2)_6—NHCO—(CH_2)_4—CO—$$

A student decided to hydrolyse a sample of this nylon in the laboratory.

(i) Describe how he could do this.

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.....

.....[2]

(ii) The student obtained a dicarboxylic acid and a diamine from the hydrolysis of this nylon. Draw the **full structural formula** of each product.

dicarboxylic acid

diamine

[4]

(e) The dicarboxylic acid obtained in **d(ii)** is a white solid.

(i) Describe the steps the student would take to purify this solid by recrystallisation using water as a solvent.

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.....[4]

(ii) How could the student determine by a simple laboratory procedure whether the recrystallised sample of the solid dicarboxylic acid is pure?

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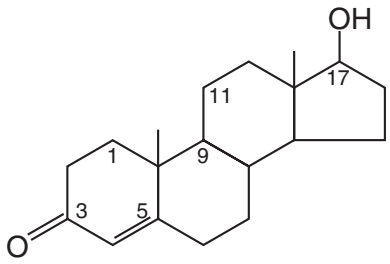
.....[2]

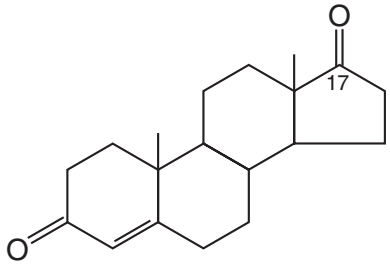
[Total: 21]

3 Testosterone was first synthesised in a pure form in 1935 by a German chemist investigating sex hormones.



testosterone

Testosterone has no effect when swallowed. This is because it is quickly oxidised in the liver to androstenedione.



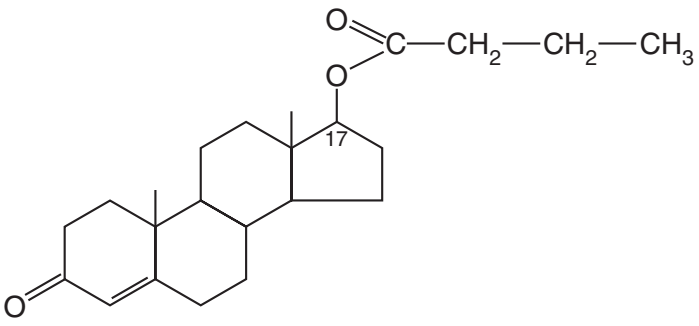
androstenedione

The only difference between testosterone and androstenedione is the functional group attached to carbon atom 17.

(a) What is the name of the functional group attached to carbon atom 17 on **testosterone**?

.....[1]

(b) Researchers found that by converting testosterone to **compound Y**, the molecule lasted longer in the body.



compound Y

(i) What **type** of functional group is attached to carbon atom 17 on **compound Y**?

.....[1]

(ii) Draw the **structural formula** of a compound that reacts with testosterone to form **compound Y** and give the name of this compound.

structural formula

name .....[2]

(iii) State the conditions you would use to carry out the reaction in **(ii)**.

.....

.....[2]

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

Enzyme catalysed reactions are specific. Enzymes in the liver are not able to catalyse the oxidation of **compound Y** and so it lasts longer in the body than testosterone.

Use your understanding of the structure of an enzyme to explain why enzymes only catalyse specific reactions.

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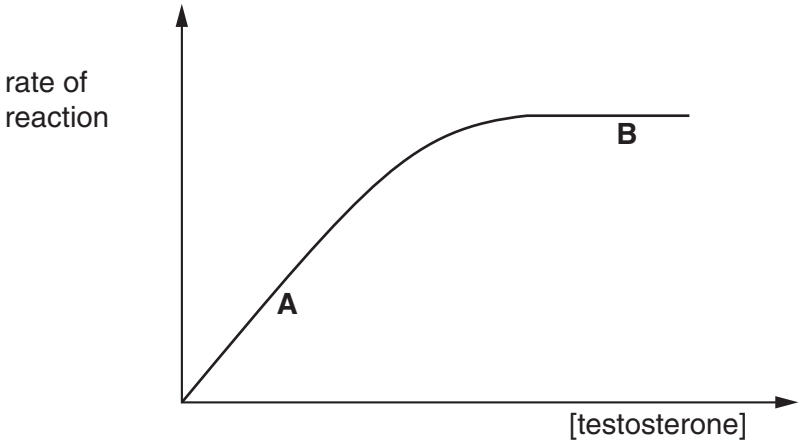
.....[5]

Quality of Written Communication [1]

(d) A series of experiments was carried out to investigate the rate of oxidation of testosterone.

The sketch graph below shows how the initial rate of oxidation of testosterone varies with initial testosterone concentration in the presence of a fixed small amount of enzyme.



(i) What is the order of reaction with respect to testosterone at point **A**?

.....[1]

(ii) At point **B**, where the concentration of testosterone is high, the reaction is zero order with respect to testosterone.

Suggest a reason for this in terms of the way enzymes work.

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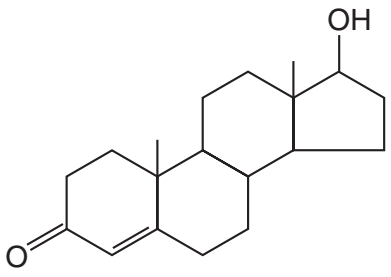
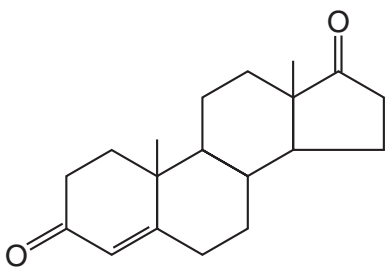
.....[3]

(e) The proton ('H) n.m.r. spectrum of testosterone contains two signals which are not present in the corresponding spectrum of androstenedione. **On the diagram of testosterone below**, label clearly the position of the hydrogen atoms responsible for these two signals.



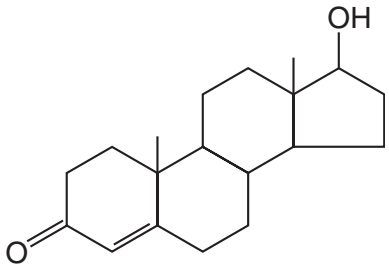
testosterone



androstenedione

[2]

(f) **(i)** Testosterone is a chiral molecule. Identify by means of asterisks (*) **two** chiral carbon atoms on the testosterone molecule.



testosterone

[2]

(ii) What feature of a carbon atom makes it chiral?

.....

.....[1]

[Total: 21]

4 Ammonia is an important raw material in the manufacture of polymers such as nylon, rayon and polyurethanes.

It is manufactured industrially by the reaction of nitrogen with hydrogen in the Haber process. Finely divided iron is used as a catalyst.

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

(a) Explain why the iron catalyst works better if it is finely divided.

.....

.....[1]

(b) Write an expression for the equilibrium constant, K_c, for the reaction in terms of the concentration of reactants and products.

[2]

(c) Scientists monitoring this equilibrium reaction at 400 atm and 1000 K found that the equilibrium concentration of nitrogen was $0.142\,mol\,dm^{-3}$ and the equilibrium concentration of hydrogen was $1.36\,mol\,dm^{-3}$.

(i) Calculate the equilibrium concentration of ammonia. Give your answer to an appropriate number of significant figures.
($K_c = 2.09\,mol^{-2}\,dm^6$ at 1000 K)

answer …….$mol\,dm^{-3}$ [3]

(ii) The pressure was reduced to 200 atmospheres. What effect would this have, if any, on the value of K_c?

.....[1]

(d) What would be the effect on K_c if the reaction was carried out at a higher temperature? Explain your answer.

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.....[3]

[Total: 10]

5 Copper contamination is widespread in copper mining areas. Copper ions are poisonous to plants and micro-organisms; at low pH they leach into ground water, where they are present as the blue complex ion $[Cu(H_2O)_6]^{2+}$.

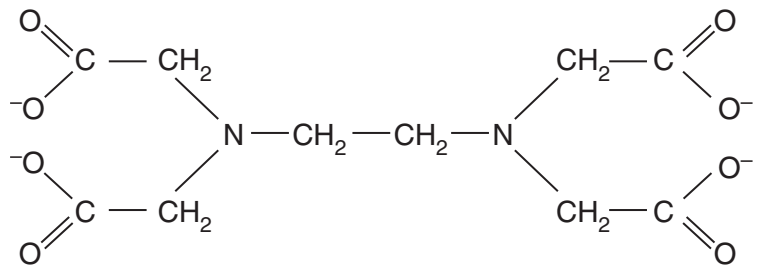
(a) (i) Draw the structure of the complex ion $[Cu(H_2O)_6]^{2+}$. Show clearly how the water molecules attach to the Cu^{2+} ion.

[2]

(ii) Give the coordination number of Cu^{2+} in the complex ion $[Cu(H_2O)_6]^{2+}$.

.....[1]

(b) Chemists can use a solution of $edta^{4-}$ ions to determine the concentration of copper ions present in ground water. The structure of $edta^{4-}$ is shown below.



Explain why $edta^{4-}$ can act as a **hexadentate** ligand.

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.....[2]

(c) Engineers investigated the possibility of reopening an old copper mine.
They noticed that as the blue groundwater ran across some old iron rails, it left a pinkish brown coating on their surface.
You are given the following half-equations.

$Fe^{2+} + 2e^- \rightarrow Fe$ $\quad E^{\ominus} = -0.44\,V$
$Cu^{2+} + 2e^- \rightarrow Cu$ $\quad E^{\ominus} = +0.34\,V$

Use these half-equations to

(i) explain the chemical reaction that took place

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.....[3]

(ii) calculate $E^{\ominus}_{cell}$ for the reaction.

answer .....V [1]

(d) A groundwater sample contains Cu^{2+} ions present as the blue complex ion $[Cu(H_2O)_6]^{2+}$. The presence of water ligands around the Cu^{2+} ion causes the five 3d orbitals to split into two groups at different energy levels. When a photon of light is absorbed, an electron is promoted from a lower energy level to a higher one.

Use this information to help you to explain why the solution of copper ions is coloured.

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.....[3]

(e) Another method of measuring the concentration of copper in ground water is to use colorimetry. Describe in outline how you could determine the concentration of copper(II) ions in ground water by this method.

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.....[5]

(f) When dilute aqueous ammonia is added dropwise to a blue solution containing $Cu^{2+}(aq)$, a blue precipitate is first formed.

(i) Write a balanced ionic equation, including state symbols, for the reaction of the copper(II) ion, $Cu^{2+}(aq)$, with hydroxide ions.

.....[3]

(ii) When excess dilute aqueous ammonia is added to the precipitate formed in **(i)** above, a further reaction takes place.

State what you would expect to see and give the formula of the complex formed.

observation .....

.....

formula of the complex formed .....[4]

[Total: 24]

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