OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY (SALTERS) 2853

Polymers, Proteins and Steel

Wednesday **21 JANUARY 2004** 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	**15**	
2	**24**	
3	**11**	
4	**28**	
5	**12**	
TOTAL	**90**	

This question paper consists of 16 printed pages.

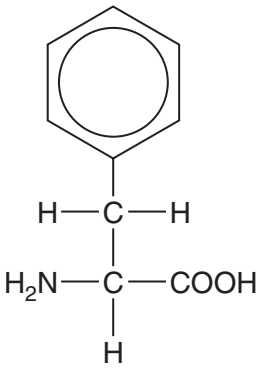
Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 People who suffer from the condition phenylketonuria are unable to metabolise the amino acid phenylalanine.

Phenylalanine is found in all protein-containing foods.

(a) The structural formula of phenylalanine is shown below.



phenylalanine

Give the names of two functional groups in phenylalanine.

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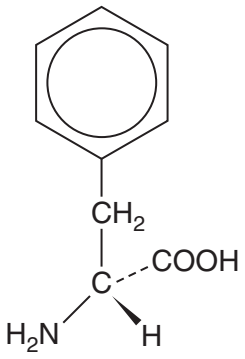
.....[2]

(b) Phenylalanine can exist in two stereoisomeric forms.
One stereoisomer of phenylalanine is shown.

(i) Draw the other stereoisomer in the space below.



isomer 1

mirror

isomer 2

[1]

(ii) What name is given to this type of stereoisomerism?

.....[1]

(iii) Why is this type of isomerism possible in phenylalanine?

.....

.....[1]

(c) Normally, an enzyme in the body converts excess phenylalanine into tyrosine. People who suffer from phenylketonuria are deficient in this enzyme and so phenylalanine builds up in the bloodstream.

(i) Different enzymes are needed to catalyse different reactions. Enzymes are proteins. Use your understanding of bonding and protein structure to explain why enzymes are specific in their action.

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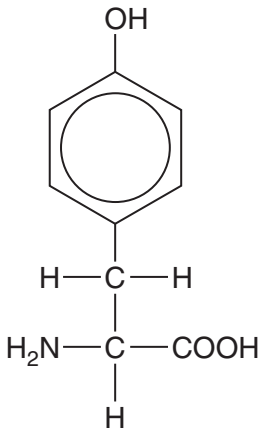
.....[5]

(ii) The structure of tyrosine is shown below.

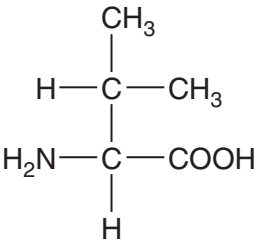


tyrosine

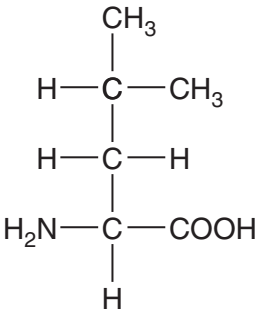
Tyrosine contains a functional group that is not found in phenylalanine. Give the name of this functional group.

.....[1]

(d) Phenylalanine cannot be made in the body. It is an essential amino acid and foods that provide it must be included as part of our diet.
Two other essential amino acids are valine and leucine. Their structures are shown below.



valine

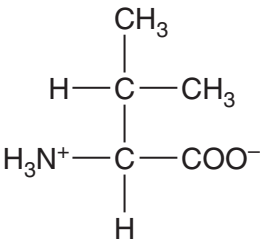


leucine

Draw the structural formula of a **dipeptide** that can be formed when valine and leucine react together.
Include the **full structural formula** of the functional group that holds two amino acids together in the dipeptide.

[2]

(e) In aqueous solution, valine exists as a zwitterion.



When a small amount of hydrochloric acid is added to this solution, the pH change is negligible.
Draw the structure of the product formed and explain why the pH change is negligible.

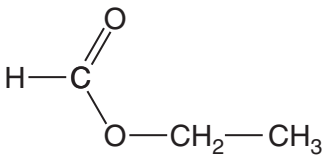
structure of product

explanation .....[2]

[Total: 15]

2 Esters are responsible for some of the smells and flavours of chemistry. They are used to give many of the fruity flavours in the manufacture of sweets.

(a) Ester **X** is used to give a raspberry flavour in sweets.



ester **X**

Give the name of ester **X**.

.....[2]

(b) A chemist hydrolysed ester **X** and obtained two products, **Y** and **Z**.

$$\underset{\text{ester } \mathbf{X}}{HCOOCH_2CH_3} + H_2O \longrightarrow \text{product } \mathbf{Y} + \text{product } \mathbf{Z}$$

(i) The n.m.r. spectrum of product **Y** showed **three** regions of absorption. Use the data sheet provided and your understanding of the hydrolysis reaction to complete the table below.

chemical shift	type of proton	relative intensity
1.2		3
3.6		2
4.5		1

[3]

(ii) Use the table to work out the **full structural formula** and **name** of product **Y**.

full structural formula of product **Y**

name ..... [2]

(iii) Now give the **full structural formula** and **name** of product **Z**.

full structural formula of product **Z**

name ..... [2]

[Turn over

(c) The chemist investigated the rate of hydrolysis of ester **X**, $HCOOC_2H_5$.

He weighed out 8.87 g of ester **X**, added 2.00 cm^3 of concentrated sulphuric acid and made the solution up to 500 cm^3 with water. The reaction mixture was placed in a water bath at 40 °C.

Work out the amount in moles of ester **X** used in the experiment and hence show that the initial concentration of ester **X** is 0.240 mol dm^{-3}.

Show and explain your working.

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

[3]

(d) The reaction was followed by measuring the concentration of ester at different times. The reaction started at time t = 0 s.

(i) Use the following data to plot a graph of concentration of ester against time. [3]

time / 1 x 10^4 s	concentration of ester **X** / mol dm^{-3}
0	0.240
0.36	0.156
0.72	0.104
1.08	0.068
1.44	0.045

(ii) Draw **two** half-lives on your graph and label these with their values. [2]

(iii) How does the graph show that the reaction is first order with respect to the concentration of ester **X**?

.....[1]

(iv) Describe how you would use your graph to find the initial rate of the reaction.

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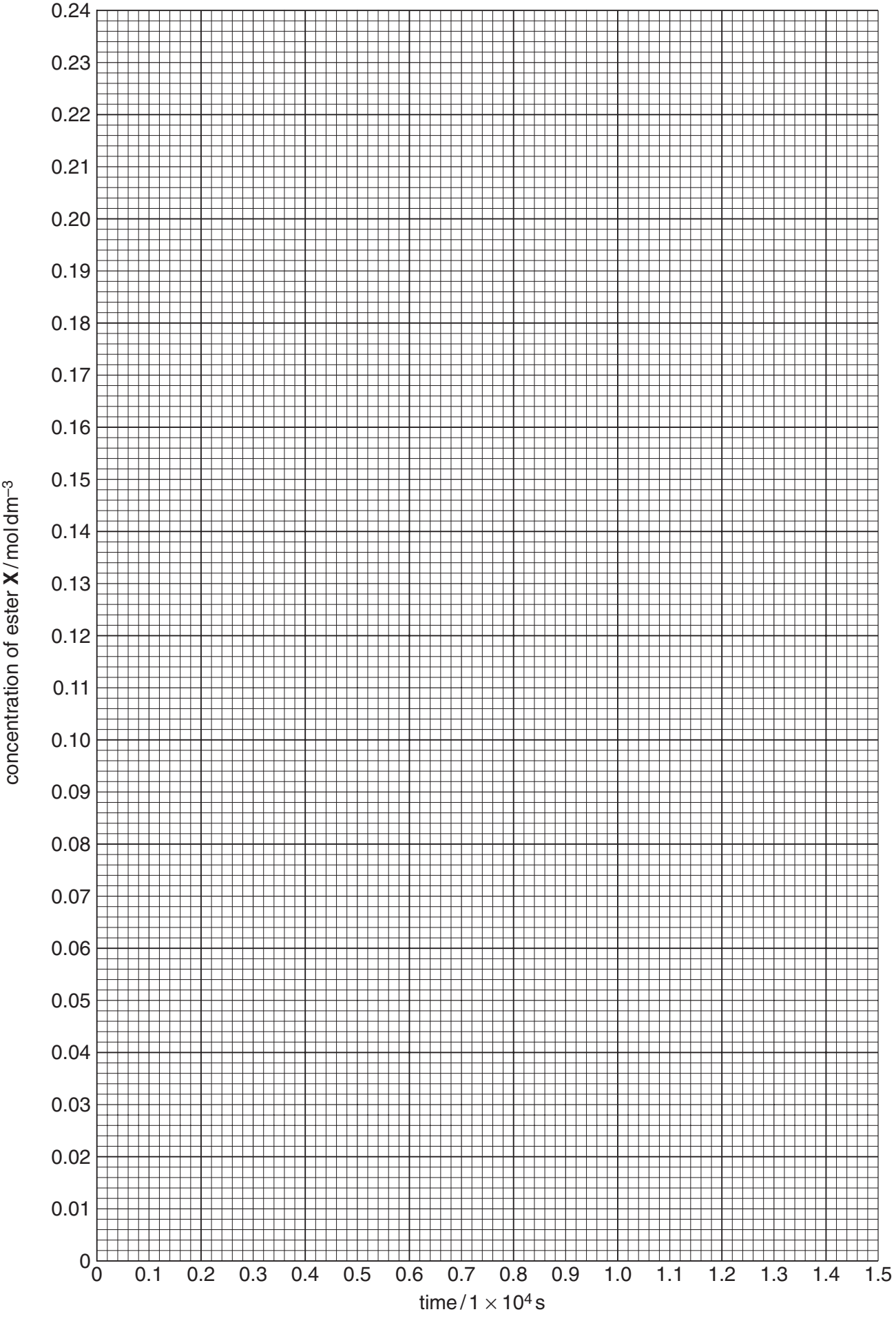
.....[3]

For Examiner's Use



[Turn over

(e) The chemist found that the rate equation for the hydrolysis of ester **X** is as follows.

rate = k [ester **X**]

He found that the initial rate of the reaction was 4.60×10^{-5} mol dm^{-3} s^{-1} when the initial concentration of ester **X** was 0.240 mol dm^{-3}.

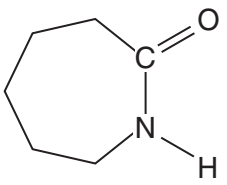
Use this information to calculate a value for the rate constant k.
Include the units for k in your answer.

rate constant k ..... units ..... [3]

[Total: 24]

3 Nylon-6 and nylon-6,6 were first produced in the 1930s but are still the most widely used polyamides. They are used to make fibres and plastic materials.

(a) Nylon-6 is made from a single monomer called caprolactam.



caprolactam

When heated with water at 500 K, the caprolactam ring opens and polymerisation takes place to form nylon-6, a linear polyamide.

(i) Draw the structure of the linear compound produced when caprolactam is hydrolysed by water.

[2]

(ii) Draw the structure of the nylon-6 polymer. Show **two** repeating units.

[2]

(b) Nylon-6,6 is made in the laboratory from 1,6-diaminohexane and compound **A**.

$ClOC\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}COCl$
compound **A**

(i) Name the functional group present in compound **A**.

.....[1]

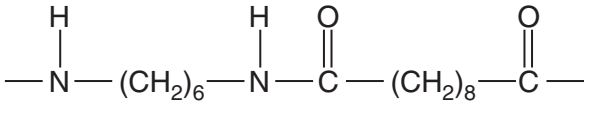
(ii) Name the **type** of polymerisation that takes place when nylon-6,6 is formed from 1,6-diaminohexane and compound **A**. Explain your answer.

.....

.....[2]

[Turn over

(c) A more recent type of nylon is nylon-6,10, which is used to make engineering plastics.



nylon-6,10

The monomers used for making nylon-6,6 and nylon 6,10 are shown in the table below.

type of nylon	monomer 1	monomer 2
nylon-6, 6	$H_2N\text{-}(CH_2)_6\text{-}NH_2$	$ClOC\text{-}(CH_2)_4\text{-}COCl$
nylon-6,10	$H_2N\text{-}(CH_2)_6\text{-}NH_2$	$ClOC\text{-}(CH_2)_8\text{-}COCl$

Nylon-6,6 melts at a higher temperature than nylon-6,10.
Explain why this is so.
Assume that the polymer chains have the same **overall** length.

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.....

.....

.....[4]

[Total: 11]

4 Gardeners use 'lawnsand' to kill moss and improve the appearance of their lawns. Lawnsand contains a mixture of iron(II) sulphate and sand.

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

A group of students analysed the percentage of iron(II) sulphate $FeSO_4$ in a sample of lawnsand.

They found that adding water to lawnsand dissolved the iron(II) sulphate.

They decided to use a redox titration with aqueous potassium manganate(VII) to find the concentration of Fe^{2+} ions in the solution.

Outline the procedure the students could use for this analysis, starting with a weighed sample of lawnsand and a standard solution of aqueous potassium manganate(VII).

Assume that the lawnsand contains only iron(II) sulphate and sand.

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.....[6]

Quality of Written Communication [1]

(b) Use the following half-equations to construct a balanced equation for the chemical reaction that takes place during the titration.

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

.....[2]

(c) The students found that 0.70 moles of Fe^{2+} were present in a 1.0 kg packet of lawnsand. Calculate the percentage of **iron(II) sulphate $FeSO_4$** in this packet of lawnsand.

Give your answer to an appropriate number of significant figures.

A_r: Fe, 56; S, 32; O, 16

percentage = ... [4]

(d) A solution of iron(II) sulphate contains Fe^{2+} present as the complex ion $[Fe(H_2O)_6]^{2+}$.

(i) Draw a diagram to show the shape of the complex ion. Show clearly how the water molecules bond to the Fe^{2+} ion.

[2]

(ii) In the complex ion, the water molecules behave as ligands. What feature of the water molecule allows it to behave as a ligand?

.....[1]

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

.....[1]

(e) Lawnsand is not active on very alkaline soils because the Fe^{2+} ions become unavailable to kill moss.

(i) The students investigated the reaction of $Fe^{2+}(aq)$ with aqueous hydroxide ions.

They added an aqueous solution of sodium hydroxide to a freshly prepared solution of iron(II) sulphate in a test tube. Describe what they observed.

.....

.....[2]

(ii) Write a balanced **ionic** equation, including state symbols, for the reaction in **(e)(i)**.

.....[2]

(iii) The students left the test tube open to the air overnight.
When they returned the next morning, a chemical reaction had taken place in the test tube.
Describe what they observed and explain the reaction that had taken place.

.....

.....[3]

(f) Iron is often given to plants as *chelated iron*, in which the iron is present as the complex ion $[Fe(edta)]^{2-}$. This is a more stable form of iron(II) from which Fe^{2+} ions can be released as required.

The edta forms six bonds to Fe^{2+}.

What name is given to a ligand such as $edta^{4-}$ that can form **six bonds** to the central metal ion?

.....[1]

(g) Chelated iron can be made by adding a solution of $edta^{4-}$ to a solution of iron(II) sulphate to produce a yellow solution.

The equation is shown below.

$$Fe(H_2O)_6^{2+} + edta^{4-} \rightleftharpoons Fe(edta)^{2-} + 6H_2O$$

(i) In this equilibrium reaction, the water ligands are replaced by $edta^{4-}$. What is the name given to this **type** of reaction?

.....[1]

(ii) Write an expression for the stability constant K_{stab} of $Fe(edta)^{2-}$.

K_{stab} =

[2]

[Total: 28]

5 Mobile phones sometimes use NICAD batteries that contain nickel and cadmium electrodes.

(a) When the battery is being used, a simplified equation for the cell reaction that takes place is

$$2Ni^{3+} + Cd \longrightarrow 2Ni^{2+} + Cd^{2+}$$

(i) Write an ionic half-equation to show what happens to cadmium in this cell.

.....[1]

(ii) The cadmium electrode is the negative electrode. What does this imply about the electrode potential of the cadmium electrode compared with the nickel electrode?

.....

.....[1]

(b) Care must be taken when disposing of these batteries. Cadmium is an environmental poison. Its presence in river water is monitored using a cadmium electrode.

The standard electrode potential of a $Cd^{2+}(aq)/Cd(s)$ half-cell is –0.4 V.

Draw a labelled diagram of an apparatus a chemist could set up to measure the standard electrode potential of this half-cell.

[5]

(c) A chemist measured some $E^{\ominus}_{cell}$ values made by connecting together different half-cells. Some of the results are shown below.

	positive electrode	negative electrode	$E^{\ominus}_{cell}$ / V
first cell	$Fe^{3+}(aq) / Fe^{2+}(aq)$	$Cd^{2+}(aq) / Cd(s)$	1.17
second cell	$Cd^{2+}(aq) / Cd(s)$	$Zn^{2+}(aq) / Zn(s)$	0.36

(i) The standard electrode potential for the $Cd^{2+}(aq) / Cd(s)$ half-cell is –0.40 V. Use this information and the information in the table to calculate values of the standard electrode potential, $E^{\ominus}$ for

- $Fe^{3+} + e^- \longrightarrow Fe^{2+}$

$E^{\ominus}$ = ...V

- $Zn^{2+} + 2e^- \longrightarrow Zn$

$E^{\ominus}$ = ...V [3]

(ii) Use your values from **(c)(i)** to calculate a value for $E^{\ominus}_{cell}$ for the cell made by connecting the $Fe^{3+}(aq) / Fe^{2+}(aq)$ and $Zn^{2+}(aq) / Zn(s)$ half-cells.

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

(iii) Give the direction of the electron flow in the external circuit of the cell in **(ii)**. Explain why.

from ..... half-cell to ..... half-cell

explanation .....

.....

.....[1]

[Total: 12]