OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2849/01**

CHEMISTRY (SALTERS)

Chemistry of Materials

TUESDAY 22 JANUARY 2008 Morning

Time: 1 hour 30 minutes

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

CUP/T50349

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **90**.
- 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.

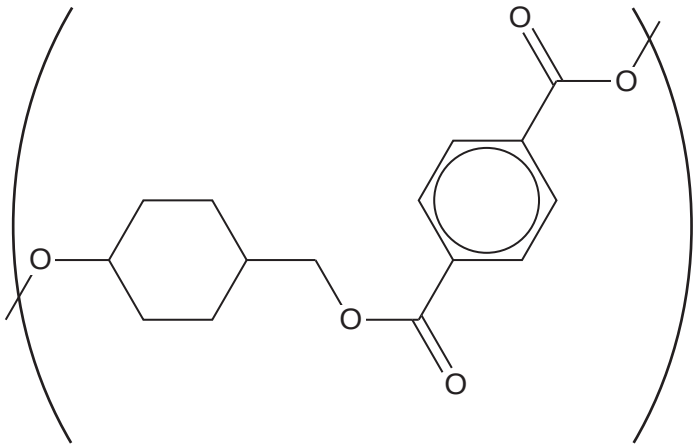
FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**19**	
2	**22**	
3	**20**	
4	**15**	
5	**14**	
TOTAL	**90**	

This document consists of **15** printed pages, **1** blank page and a *Data Sheet for Chemistry (Salters)*.

[Turn over

Answer **all** the questions.

1 Chemists have recently developed high performance polymers for use in medical devices, such as artificial parts for body organs. **PCT** is a polyester, made from two monomers, which is tough, transparent and has a high resistance to hydrolysis. The repeating unit of **PCT** is shown below.



(a) Choose **one** property of **PCT** and explain how this property makes it suitable for medical purposes.

.....

.....[1]

(b) On the above diagram draw a circle around the ester linkage which joins the two monomer units together. [1]

(c) **PCT** can be hydrolysed in the laboratory.

(i) Name the reagent and give the conditions you would use for acid hydrolysis.

.....

.....[2]

(ii) Draw the structures of the two organic products of the acid hydrolysis.

[2]

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

One of the products can be extracted from the hydrolysis mixture as a white solid.

Describe how you would purify this solid by recrystallisation from ethanol.

.....

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.....

.....

.....

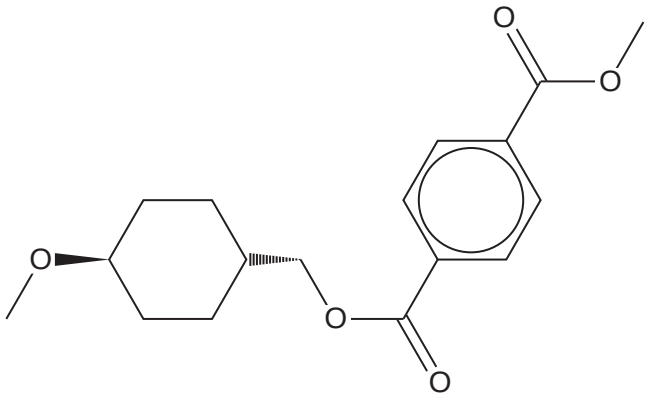
.....

.....[5]

Quality of Written Communication [1]

(d) **PCT** shows geometrical isomerism because the cyclohexane ring prevents free rotation.

The diagram below shows the *trans* form of **PCT** by using 'wedge' bonds.



Depending on polymerisation conditions, **PCT** can be made in two forms. One form contains polymer chains which are all *trans* isomers. In the other form, the polymer chains contain a mixture of *cis* and *trans* arrangements.

In terms of **crystallinity** and **melting point**, suggest how the properties of a *cis-trans* mixed chain polymer differ from the properties of an all *trans* chain polymer. Explain your answer.

.....

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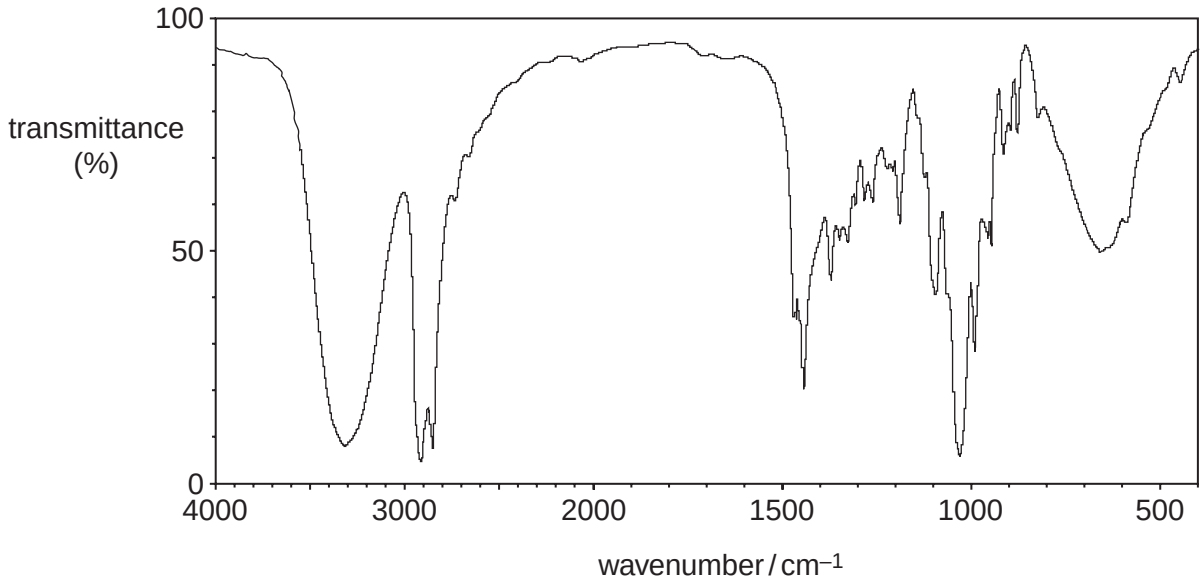
.....

.....

.....[4]

(e) The infrared spectrum of one of the monomers used to make **PCT** is shown below.



(i) Use the infrared spectrum to name the functional group present in the monomer.

.....[1]

(ii) Describe, giving the frequencies of any relevant peaks, how you used the spectrum to determine the functional group.

.....

.....

.....

.....[1]

(f) High performance polymers are made in small amounts and have specific properties for a particular use.

Name a chemical method which chemists can use to produce a polymer with slightly different properties.

.....

.....[1]

[Total: 19]

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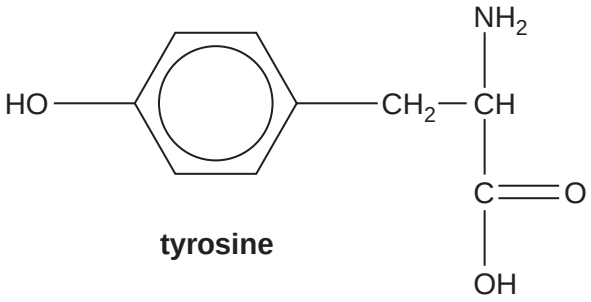
2 Tyrosine is sometimes used in helping people to lose weight and in treating depression. Its structure is shown below.



tyrosine

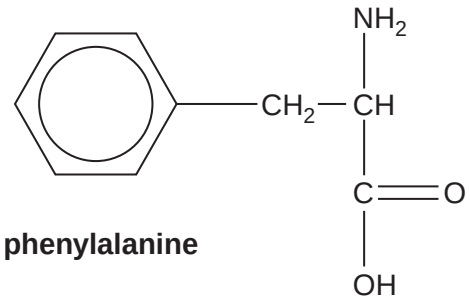
(a) Identify **three** functional groups, other than the benzene ring, present in tyrosine.

1 .....

2 .....

3 .....[3]

(b) In living cells, tyrosine can be synthesised from phenylalanine. The structure of phenylalanine is shown below.



phenylalanine

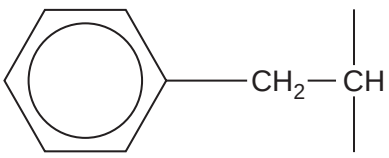
(i) Describe what colour you would **see** when neutral iron(III) chloride solution is added to samples of phenylalanine and tyrosine.

phenylalanine .....

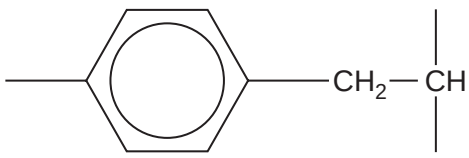
tyrosine .....[2]

(ii) Excess aqueous sodium hydroxide is added to samples of phenylalanine and tyrosine.

Complete the structure of the product formed in each case.



product from phenylalanine



product from tyrosine

[2]

(iii) Both phenylalanine and tyrosine are very soluble in water. This is because both compounds are present as zwitterions.

Explain how they form zwitterions.

.....

.....

.....[2]

(c) Draw the structure of the dipeptide formed when **two** tyrosine molecules join together.

Circle the peptide (secondary amide) link.

[2]

(d) Tyrosine can exist as two optical isomers.

(i) What structural feature of the molecule is responsible for this property?

Explain why there are two isomers.

.....

.....

.....

.....[2]

(ii) In living cells, only one of these isomers can act as a substrate for enzymes.

Explain why.

.....

.....

.....

.....[2]

(iii) Explain why it is important for the pH to be controlled in an enzyme-catalysed reaction.

.....

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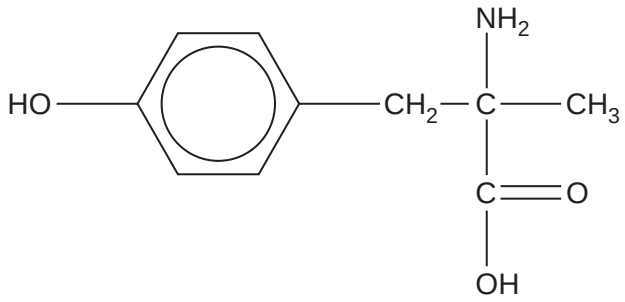
.....

.....[2]

(iv) An enzyme whose substrate is tyrosine can be inhibited by the drug Metyrosine, shown below.



Describe how Metyrosine can inhibit the enzyme-catalysed reaction.

.....

.....

.....

.....[2]

(e) The enzyme-catalysed reaction of tyrosine in **(d)(iv)**, under certain conditions, is first order with respect to both tyrosine and the enzyme.

(i) Write the rate equation for the enzyme-catalysed reaction.

rate =

[2]

(ii) Give the units for the rate constant of the reaction.

.....[1]

[Total: 22]

3 The earliest evidence for the use of electrochemical cells comes from archaeological digs in Iraq. Over 2000 years ago, cells made by inserting iron rods into clay pots lined with copper were used for electroplating jewellery. It is thought that vinegar, a dilute solution of ethanoic acid, was used as the electrolyte.

(a) Using the data below, calculate the $E^{\ominus}_{cell}$ value for a standard copper–iron cell.

half-reaction	$E^{\ominus}$/V
$Fe^{2+} + 2e^- \longrightarrow Fe$	–0.44
$2H^+ + 2e^- \longrightarrow H_2$	0.00
$Cu^{2+} + 2e^- \longrightarrow Cu$	+0.34

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

(b) Suggest and explain **one** reason why you would expect the voltage of the ancient cell to be different from the value calculated in **(a)**.

.....

.....

.....

.....[2]

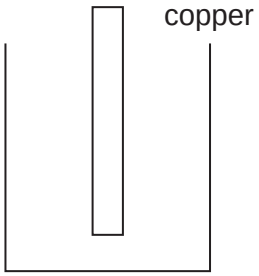
(c) Indicate, by ticking the appropriate box, whether the following statements about a copper–iron cell, when it is producing a current, are **true** or **false**.

statement	true	false
Copper is the negative electrode.		
Copper atoms are oxidised in the reaction.		
Electrons move through the wire from the copper electrode.		
Electrons do not move through the solution.		

[2]

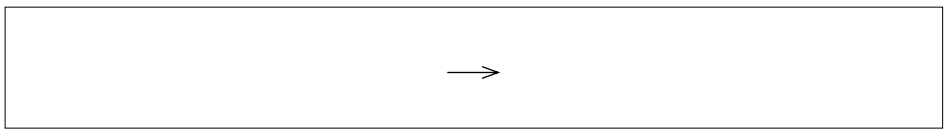
half-reaction	$E^{\ominus}$/V
$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$	–0.44
$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$	+0.34
$2H^+(aq) + 2e^- \longrightarrow H_2(g)$	0.00
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.77

(d) Complete and label the diagram below to show how the **standard** electrode potential of a copper half-cell is measured, using a hydrogen electrode.



[4]

(e) Write an equation for the reaction taking place in the cell you have drawn in **(d)**, when it is producing a current. Include state symbols.



[3]

(f) Using the data at the top of the page predict and explain whether copper metal might react with Fe^{3+} ions in aqueous solution.

.....

.....

.....[2]

(g) Vinegar was often made in the ancient world by allowing wine, a dilute solution of ethanol, to oxidise in the air.

(i) Give the **full structural** formulae for ethanol and ethanoic acid.

ethanol	**ethanoic acid**

[2]

(ii) Explain why ethanoic acid is weakly acidic but ethanol is neutral.

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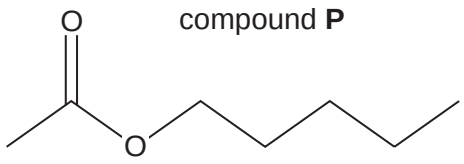
.....[4]

[Total: 20]

4 Pear oil is an artificial flavouring containing esters including compound **P**. The structure of **P** is shown below.



compound **P**

(a) Name compound **P**.

.....[2]

(b) Compound **P** can be synthesised by reacting a carboxylic acid with an alcohol. The equation for the reaction is shown below.

$$\text{acid} + \text{alcohol} \rightleftharpoons \text{compound } \mathbf{P} + \text{water}$$

In an experiment, the acid and alcohol are refluxed together to form an equilibrium mixture. The equilibrium concentration of both the acid and the alcohol is 1.06 mol dm^{-3}. The equilibrium constant for the reaction, K_c, is 4.15 at the temperature at which the concentrations are measured.

(i) Calculate the concentration of compound **P** present at equilibrium. Give your answer to an **appropriate** number of significant figures.

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

(ii) A student repeated the experiment using the same initial quantities. During the experiment she noticed that the water in the condenser had stopped flowing. There was a smell of pears coming from the top of the condenser.

What effect, if any, will this problem have on:

- the concentrations of the reactants in the flask?
- the equilibrium constant?

Explain your answers.

.....

.....

.....

.....

.....[4]

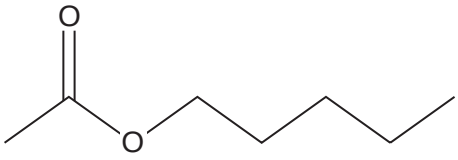
(iii) The acid and alcohol react together very slowly.

Name a reagent that is added to the mixture so that equilibrium is reached faster.

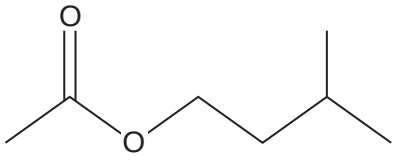
.....[1]

(c) An oil can be extracted from pears which contains a mixture of many esters but only one of the compounds **P** and **Q**.

compound **P**



compound **Q**



The proton (^{1}H) n.m.r. data given in the table below was obtained from a pure sample known to be either **P** or **Q**.

The data below corresponds to two of the peaks in the spectrum. Use the data to identify which of **P** or **Q** is present in the pure sample. Show your reasoning.

chemical shift	relative intensity
0.9	6
1.5	1

.....

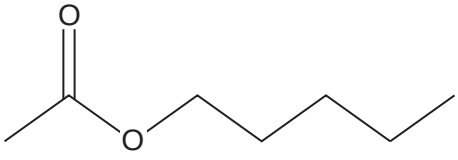
.....

.....[2]

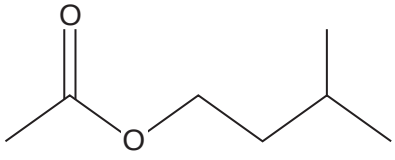
(d) Suggest **two** groups of protons which occur in both **P** and **Q** that will give similar chemical shifts.

Draw the appropriate hydrogen atoms on the formulae below and state the chemical shifts where the appropriate peaks will occur.

compound **P**



compound **Q**



[2]

[Total: 15]

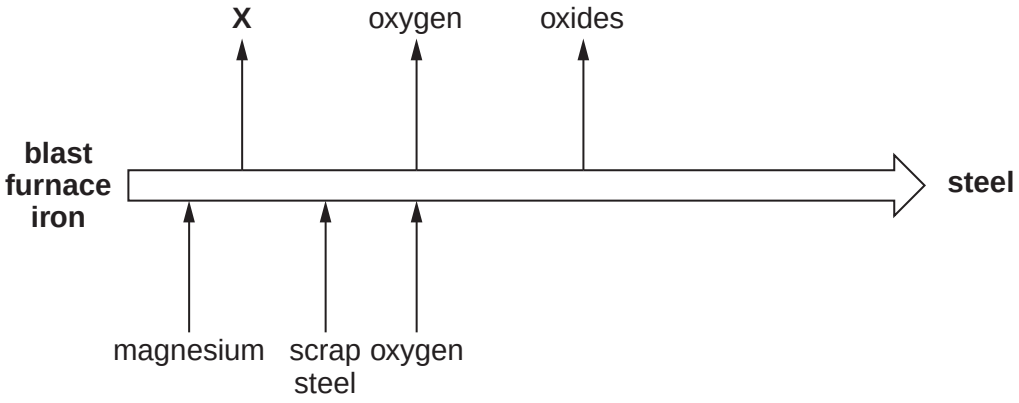
5 Steels containing large amounts of chromium and nickel were first developed in the early part of the 20th century. In the 1920s they were used widely by artists and architects in producing sculptures and for cladding buildings. These artefacts and buildings are as shiny today as they were when they were first constructed.

(a) Describe **one** property that steels have as a result of containing chromium and nickel.

.....

.....[1]

(b) The flow diagram below shows some of the processes involved in making steel.



(i) Identify **X**.

.....[1]

(ii) Other than recycling materials, what important role does adding scrap steel serve?

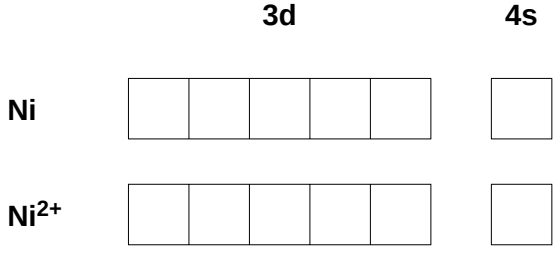
.....[1]

(iii) Name **two** elements which are removed by direct oxidation with gaseous oxygen.

.....[1]

(c) The amount of nickel in steel can be analysed by using a colorimeter. The nickel is converted to nickel(II) ions by oxidation with nitric acid.

(i) By drawing arrows in the appropriate boxes complete the outer electron structures for Ni and Ni^{2+}.

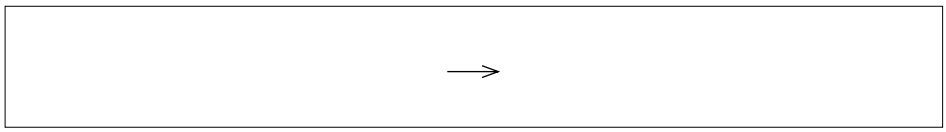


[2]

(ii) Use the two half-equations below to construct an overall equation for the reaction of nickel with nitric acid.

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

$$NO_3^- + 4H^+ + 3e^- \longrightarrow NO + 2H_2O$$



[2]

(d) In aqueous solution, nickel(II) ions have the formula $[Ni(H_2O)_6]^{2+}$.

Dilute solutions of the complex are very pale green in colour and are hard to see.

Dimethylglyoxime, a **bidentate** ligand, can be added to dilute nickel(II) solutions to produce an intensely red coloured complex.

(i) Use ideas of energy levels and ligands to explain why the colour changes.

.....

.....

.....

.....[2]

(ii) The red complex can be represented by $[Ni(dimethylglyoxime)_2]^{2+}$.

State the coordination number for the following ions.

$[Ni(H_2O)_6]^{2+}$..... $[Ni(dimethylglyoxime)_2]^{2+}$.....

[2]

(iii) Suggest the shape of each complex ion.

$[Ni(H_2O)_6]^{2+}$..... $[Ni(dimethylglyoxime)_2]^{2+}$.....

[2]

[Total: 14]

END OF QUESTION PAPER