OCR
Oxford Cambridge and RSA

Tuesday 14 June 2016 – Afternoon

A2 GCE CHEMISTRY B (SALTERS)

F334/01 Chemistry of Materials

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 30 minutes

* F 3 3 4 0 1 *

* 5 8 8 1 5 7 2 2 5 9 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  – ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  – organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an Insert with this Question Paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **90**.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Trypsin is an enzyme used by bread producers to partially hydrolyse the protein, gluten, present in wheat.

The primary structure of a protein can be described as a series of amino acid *residues*. A residue is the structure of the amino acid after it has been incorporated into a protein chain.

(a) Describe what is meant by the *secondary* and *tertiary* structures of a protein.

secondary .....

.....

.....

tertiary .....

.....

..... **[2]**

(b) Trypsin has an active site.

Describe an *active site* and give its function.

.....

.....

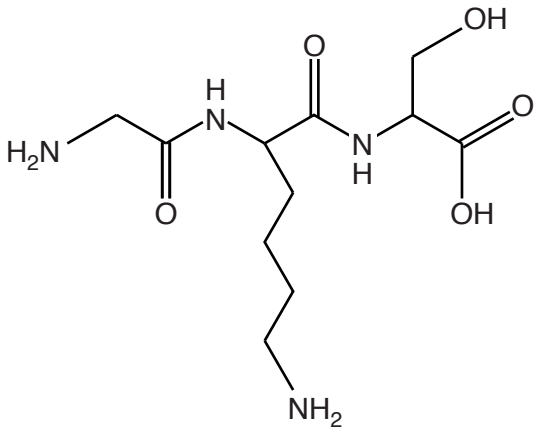
.....

.....

..... **[3]**

(c) Trypsin only catalyses the hydrolysis of amide links where the C=O is part of a lysine residue. The 'R' group in lysine is $-(CH_2)_4NH_2$.

Trypsin partially hydrolyses the tripeptide shown below.



Draw the products of this partial hydrolysis once the solution has been neutralised.

[3]

(d) In the past, bromate(V) was used to alter the structure of the protein, gluten.

Suggest **two** reasons why trypsin is now preferred.

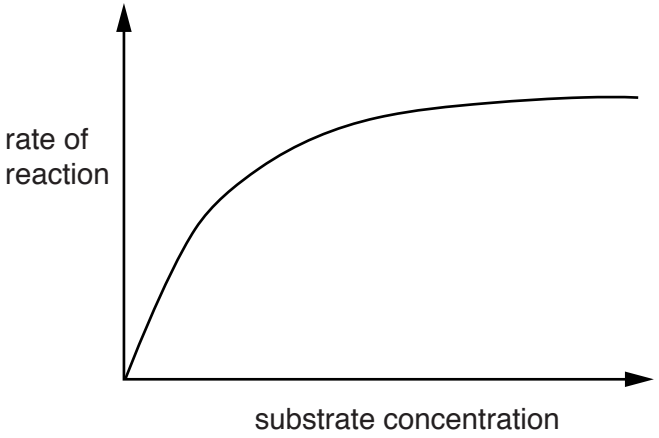
.....

.....

.....

..... **[2]**

(e) A student investigates how the rate of hydrolysis at 37 °C changes with the concentration of substrate protein. A graph of the student's results is shown below.



(i) The mechanism of the reaction can be represented by the equations:

1. $E + S \rightleftharpoons ES$
2. $ES \rightarrow E + P$

The symbols S, E and P represent the substrate, enzyme and products respectively.

Use ideas of reaction orders, rate-determining steps and active sites to explain the shape of the graph.

In your answer, you should indicate how the shape of the graph relates to the equations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[5]**

(ii) The student repeats the experiment for trypsin at 70 °C, well above the optimum temperature, which is 40 °C.

Describe the appearance of the graph of rate of reaction against substrate concentration at 70 °C.

Explain your answer.

.....

.....

.....

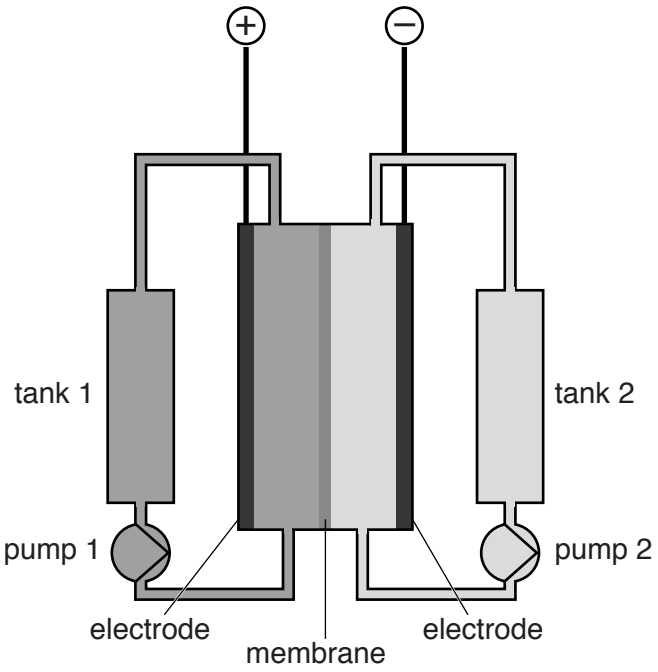
..... **[2]**

[Total: 17]

2 Large flow electrochemical cells are used to power agricultural machinery in California.

The flow cell contains two solutions. **Solution A** contains Cr^{2+} and Cr^{3+} and **Solution B** contains Fe^{2+} and Fe^{3+}.

The cell has a membrane between two half-cells and each half-cell has a different solution pumped through it.



(a) (i) Use the data in the table below to determine which solution is in tank 1 and which solution is in tank 2.

Give your reasoning.

Half-reaction	$E^{\ominus}$/V
$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$	–0.41
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77

.....

.....

.....

..... **[2]**

(ii) Write an ionic equation for the reaction taking place in the cell when it is producing electrical energy. State symbols are not required.

$\rightarrow$

[1]

(iii) The two tanks and cell are made from steel that has a protective coating.

Give **two** reasons for coating the steel and suggest a suitable substance for the coating.

Reasons

.....

.....

.....

Coating substance .....

[3]

(iv) Suggest **one** function of the membrane shown in the diagram on page 6.

.....

..... **[1]**

(v) Name a suitable material to use for the electrodes.

..... **[1]**

(b) A student decided to investigate whether a solution of V^{2+} and V^{3+} ions could be used instead of a solution of Cr^{2+} and Cr^{3+} ions (**solution A**).

The student found that the $E^{\ominus}_{cell}$ was 1.03V and the Fe^{3+}/Fe^{2+} electrode had the same sign as in the cell opposite.

Calculate $E^{\ominus}$ for the V^{3+}/V^{2+} half-cell.

$E^{\ominus}$ for half-cell = ... V **[1]**

(c) A solution containing only $Fe^{3+}(aq)$ and $Fe^{2+}(aq)$ cations is left open to the atmosphere for a few hours. On addition of aqueous hydroxide ions, only a red-brown precipitate forms.

Explain why only a red-brown precipitate forms.

In your answer, suggest equations for the reactions taking place. Include state symbols.

.....

.....

.....

.....

.....

..... **[5]**

[Total: 14]

3 One way of measuring the amount of an alkene in a sample is by titrating it with standard bromine solution. This method enables a value for the bromine number of the sample to be calculated.

The bromine number is the mass (in g) of bromine, Br_2, absorbed by 100 g of a sample.

(a) Calculate the bromine number of a pure sample of hexa-2,4-diene (C_6H_{10}).
Give your answer to the nearest whole number.

bromine number = ... **[2]**

(b) A student decides to determine the bromine number of a solution of hexa-2,4-diene in cyclohexane.

The student makes a bromine solution as follows. 100 cm^3 of an acidified solution of 0.167 mol dm^{-3} KBr is reacted with 100 cm^3 of 0.0500 mol dm^{-3} $KBrO_3$. The total volume is 200 cm^3.

The equation for the reaction is given below.

$$5Br^- + BrO_3^- + 6H^+ \longrightarrow 3Br_2 + 3H_2O$$

(i) Show that the $KBrO_3$ is in excess.

[2]

(ii) 10.0 g of the hexa-2,4-diene solution required 82.0 cm^3 of the bromine solution to produce the first permanent yellow tinge to the mixture.

Calculate the bromine number of the hexa-2,4-diene solution.
Give your answer to the nearest whole number.

bromine number = ... **[5]**

(c) Hexa-2,4-diene, $CH_3CH=CHCH=CHCH_3$, can form several *E/Z* isomers.

(i) Give **two** reasons why *E/Z* isomers exist.

.....

.....

..... **[2]**

(ii) Draw structural diagrams to represent all the *E/Z* isomers.
Label the appropriate parts of each formula with **E** or **Z**.

[4]

(d) To ensure that the alkene is fully brominated in the reaction, a mercury catalyst is sometimes used.

Explain how transition metals can act as heterogeneous catalysts.

.....

.....

.....

.....

..... **[3]**

(e) A student investigates the reaction rate at room temperature of Br^- with BrO_3^- in excess acid to form bromine and water.

$$5Br^- + BrO_3^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$$

(i) Suggest an appropriate method for following the progress of this reaction in a student laboratory at room temperature.

Measure the concentration of .....

by (method) .....

The reason for choosing method is

.....

.....

[3]

(ii) The student then carries out an initial rate study on the reaction. The results are shown below.

Experiment	$[BrO_3^-]$ / mol dm^{-3}	$[Br^-]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	Relative rate of reaction
1	6.95×10^{-4}	1.39×10^{-3}	6.95×10^{-4}	4
2	6.95×10^{-4}	6.95×10^{-4}	6.95×10^{-4}	2
3	1.39×10^{-3}	1.39×10^{-3}	3.48×10^{-4}	2
4	6.95×10^{-4}	1.39×10^{-3}	3.48×10^{-4}	1

Determine the rate equation for the reaction.

rate = ... **[3]**

(iii) The student repeats the experiment on a very hot day. The student is concerned that the high temperature will make volatile substances escape from the solution.

Discuss how this would affect the measured rate of reaction.
Give reasons for your answer.

.....

.....

.....

.....

.....

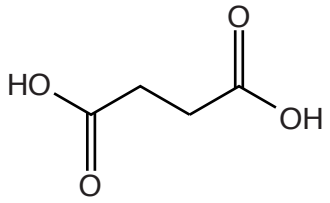
..... **[3]**

[Total: 27]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

4 Polymers made using succinic acid and ethane-1,2-diol were first synthesised in 1863. In the 1930s, these polymers were further investigated by Wallace Carothers as possible alternatives to silk. He later abandoned the project in favour of researching polyamides, which he thought would be stronger.



Succinic acid

(a) (i) Draw the structural formula of the repeating unit of the polymer produced using succinic acid and ethane-1,2-diol.

[1]

(ii) Give the name of this type of condensation polymer.

..... **[1]**

(iii) Circle in your repeating unit the group of atoms responsible for this type of polymer. **[1]**

(b) (i) Suggest why Carothers thought that polyamides would form stronger fibres than the polymer in **(a)(i)**.

In your answer, refer to **all** the types of intermolecular bonds present in the two types of polymer.

.....

.....

.....

.....

.....

.....

..... **[4]**

(ii) The strength of polyamide fibres is improved by the process of cold drawing.

Describe the process of cold drawing and explain how this makes the fibres stronger.

.....

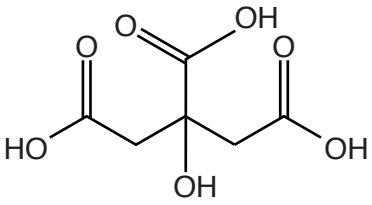
.....

.....

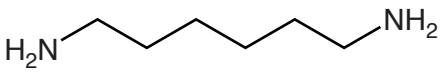
.....

..... **[3]**

(c) Recently, polymers containing citric acid and **compound C** have been developed.



Citric acid



Compound C

(i) Give the systematic name for **compound C**.

..... **[1]**

(ii) Draw the structure of part of the chain formed from **two** molecules of compound **C** and **one** molecule of citric acid.

[2]

(iii) These polymers are water-soluble.

Suggest why they are water-soluble.

.....

..... **[1]**

(iv) The polymers can protect human cells from damage at freezing temperatures.

Give **two** questions that clinical trials would have to answer before the polymers could be used as medicines.

1. .....

2. ..... **[1]**

(v) **Compound C** can act as a base.

Explain how **compound C** acts as a base.

.....

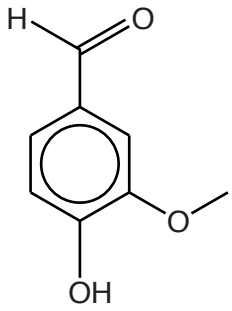
.....

..... **[2]**

[Total: 17]

5 Vanillin is the main component of natural vanilla extract used to flavour foods.

Artificial vanilla flavouring is often just a solution of synthetic vanillin.



Vanillin

(a) (i) Name the functional groups, other than the benzene ring, present in vanillin.

.....

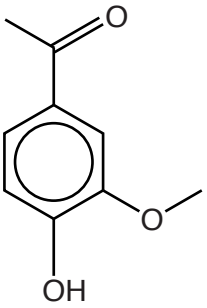
..... **[2]**

(ii) In plants, vanillin is sometimes oxidised to vanillinic acid.

Give the **name(s)** of the reagent(s) that can be used for such an oxidation in the laboratory.

..... **[1]**

(b) Other compounds are sometimes added to artificial vanilla flavouring. One such compound is apocynin.



Apocynin

(i) An unlabelled substance is thought to be either vanillin or apocynin.
An infrared spectrum is used to identify the substance.

The unlabelled substance has peaks at 3310 cm^{-1} (broad), 3010 cm^{-1} (medium-strong), 2930 cm^{-1} (medium-strong), and 1705 cm^{-1} (strong).

Identify the bonds responsible for these peaks and identify the substance.

.....

.....

.....

.....

.....

..... **[3]**

(ii) Suggest **one** way in which mass spectrometry could be used to distinguish between vanillin and apocynin. Assign *m*/*z* values to any peaks you describe.

.....

.....

.....

..... **[2]**

(iii) Apocynin is a solid that is insoluble in cold water but soluble in hot water.

Describe how a sample of solid apocynin containing water-soluble impurities can be purified in the laboratory.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

.....

.....

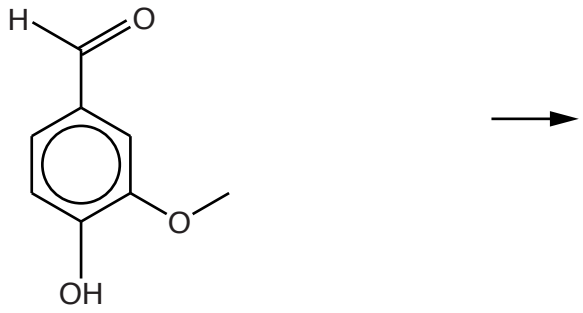
.....

.....

..... **[3]**

(c) Vanillin reacts with cyanide ions and dilute acid.

Complete the diagram below to show the mechanism of this reaction, including the structure of the final product. Use curly arrows, electron pairs, bond polarities and charges as appropriate.



[4]

[Total: 15]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).