OCR
RECOGNISING ACHIEVEMENT

Thursday 26 January 2012 – Afternoon

A2 GCE CHEMISTRY B (SALTERS)

F334 Chemistry of Materials

Candidates answer on the Question Paper.
A calculator may be used for this paper.

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

Other materials required:
- Scientific calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found in the centre of 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 pages 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 E300 is an antioxidant used in white wines. It prevents dissolved oxygen reacting with the ethanol to form an acid, **X**, which would produce a sour-tasting wine.

(a) In the box below draw the **full** structural formula of the acid, **X**, responsible for the wine's sour taste.

[1]

(b) A student attempted to oxidise ethanol to acid **X** in the laboratory.

(i) Give the chemical reagents and reaction conditions the student would need to use.

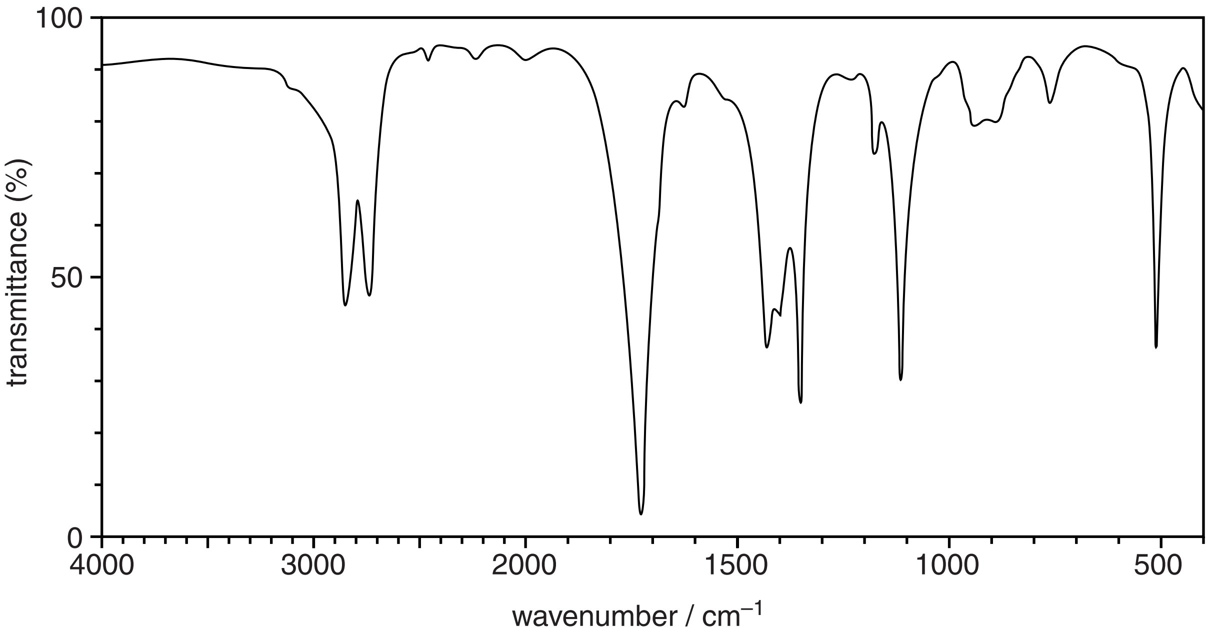
reagents ....

....

conditions ....

.... **[3]**

(ii) The infrared spectrum of the purified product the student actually obtained is shown below.



Use the *Data Sheet* together with the spectrum on page 2 to identify the product made by the student. Give your reasoning.

reasoning ....

....

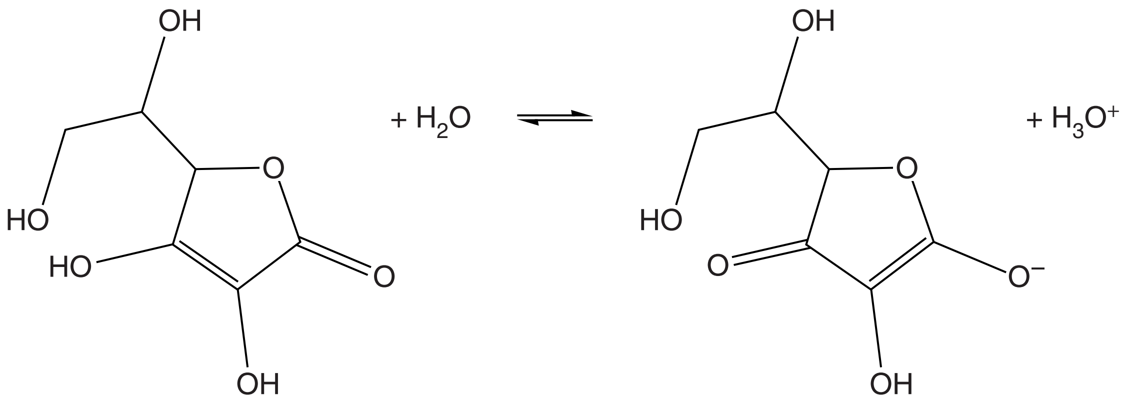
....

....

....

name or formula of product .... **[3]**

(c) When E300 is added to water, an acid–base equilibrium is set up, as shown below.



E300

(i) Explain what is meant by the term *base* in the Brønsted–Lowry theory.

.... **[1]**

(ii) Circle **two** species in the equation above that are acting as bases. **[1]**

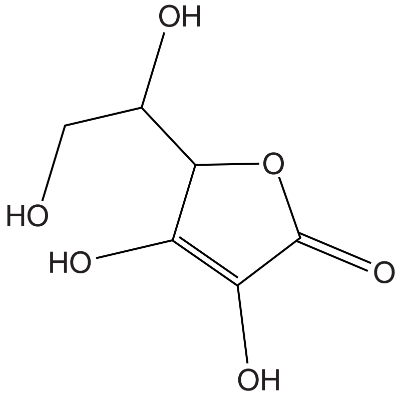
(iii) When a solution of E300 reacts with calcium carbonate, fizzing occurs and a solid product can be extracted from the resulting mixture.

Identify the gas produced and suggest a formula for the solid product.

gas ....

formula of solid product:

[2]



E300

(iv) Both E300 and phenol, C_6H_5OH, are acidic in solution.

Describe the relative acidities of E300 and phenol. Give your reasoning.

....

....

....

....

.... **[2]**

(d) The maximum allowed concentration of E300 in drinks is 150 mg dm^{-3}.

A student performed the following redox titration procedure to find out if a 250.0 cm^3 sample of a drink containing E300 was within this limit.

The sample was acidified followed by the addition of 25.0 cm^3 of 0.00500 mol dm^{-3} KIO_3(aq). Excess KI(aq) was then added to form I_2 in solution.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

(i) Calculate the amount, in moles, of iodine, I_2, formed in this reaction.

amount of I_2 = ... mol **[2]**

(ii) Some of the I_2 formed reacted with the E300 in the 250.0 cm^3 sample of the drink.

$$\underset{\textbf{E300}}{C_6H_8O_6} + I_2 \rightarrow C_6H_6O_6 + 2H^+ + 2I^-$$

The amount of unreacted I_2 was found by titrating with sodium thiosulfate, $Na_2S_2O_3(aq)$, using starch indicator. At the end point, 20.4 cm^3 of 0.00500 $mol\,dm^{-3}$ $Na_2S_2O_3(aq)$ had been added.

The following reaction occurred:

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

Calculate the amount, in moles, of iodine, I_2, remaining after the E300 had reacted.

amount of I_2 remaining = ... mol **[2]**

(iii) Determine the concentration of the E300 in the 250.0 cm^3 sample of the drink and hence whether the drink is within the limit allowed.

M_r (E300) = 176

concentration = ... units ....

Is the drink within the allowed limit for E300? .... **[3]**

(iv) In the titration, the student went past the end point and added too much sodium thiosulfate.

What effect would this have on their answer for the concentration of the E300 in the drink?

Give your reasoning.

....

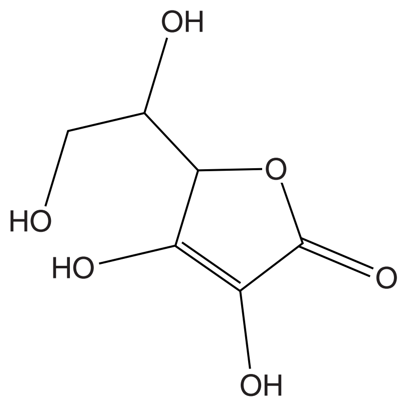
....

....

....

.... **[2]**

(e) E300 has a C=C bond with two different groups on each carbon. It does not, however, show *E/Z* isomerism whereas 1,2-dichloroethene does.



E300

Explain why 1,2-dichloroethene shows *E/Z* isomerism **and** suggest a reason why E300 does not.

....

....

....

....

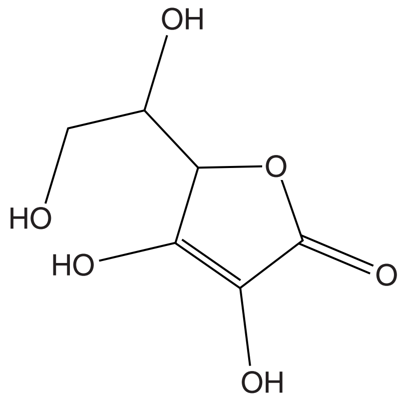
....

....

.... **[3]**

(f) A primary alcohol group in E300 reacts with $C_{17}H_{35}COOH$ to form another antioxidant.

(i) Circle a primary alcohol group on the structure of E300 below.



E300

[1]

(ii) Draw the structural formula of the new functional group formed in this reaction.

[1]

(iii) What else must be added to a mixture of E300 and $C_{17}H_{35}COOH$, to make the new antioxidant?

.... **[1]**

(iv) In addition to the antioxidant, another product is formed in this reaction.

Name this product.

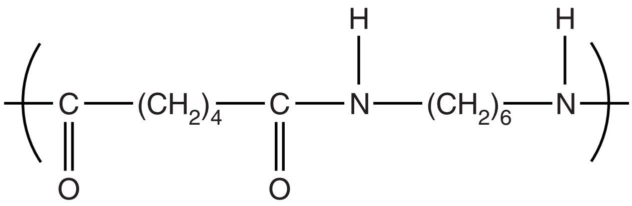
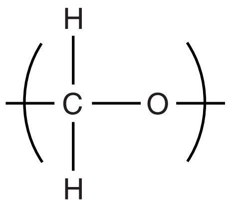
.... **[1]**

[Total: 29]

Turn over

2 Some nylons can be used to make moulded mechanical parts such as gear wheels. However for high performance engineering components, polyoxymethylene, POM, is often used instead.

(a) (i) Complete the table below by drawing the correct formulae in the appropriate boxes.

polymer	nylon-6,6 (condensation polymer)	POM (addition polymer)
repeating unit		
formula(e) of monomer(s)		

[3]

(ii) Name the functional group in POM.

.... **[1]**

(iii) Both polymers can be hydrolysed by *heating under reflux* with a suitable reagent. The monomers can then be obtained by *distillation*.

Describe and explain **one** difference between *heating under reflux* and *distillation*.

....

....

....

....

.... **[2]**

(b) The table below compares the differences in three properties of nylon-6,6 and POM.

property	**POM**
water absorption	much less than nylon-6,6
T_m	lower than nylon-6,6
flexibility	much more rigid than nylon-6,6

Explain each of these differences in properties. Use ideas of intermolecular bonding between polymer chains in your answer.

In your answer, you should clearly link the property of ***water absorption*** *to the type of intermolecular bonding.*

....

....

....

....

....

....

....

....

....

....

....

....

....

.... **[6]**

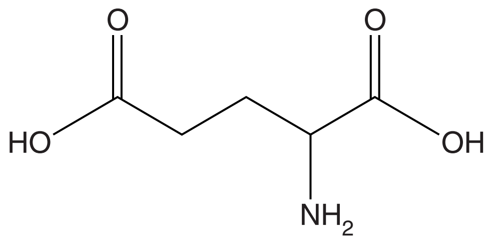
(c) What **type** of additive could be mixed with the POM to make it more flexible?

.... **[1]**

[Total: 13]

Turn over

3 Glutamic acid is a naturally occurring amino acid. Derivatives of glutamic acid are used as flavour enhancers in many foods.



glutamic acid

(a) Give the systematic name for glutamic acid.

.... **[2]**

(b) Glutamic acid is a crystalline solid with a melting point of 199 °C. It reacts with both acids and alkalis in solution.

(i) Explain why glutamic acid can react with both acids and alkalis in solution.

....

....

....

.... **[2]**

(ii) Explain in terms of structure and bonding why glutamic acid has such a high melting point.

....

....

....

....

....

.... **[3]**

(c) One mole of glutamic acid reacts with two moles of sodium hydroxide to form one organic product.

In the box below draw a structure for the organic product of this reaction, showing any relevant charges.

[2]

(d) Glutamic acid exists as two isomers.

(i) State the type of isomerism shown by glutamic acid and explain why glutamic acid can form two isomers.

type of isomerism ....

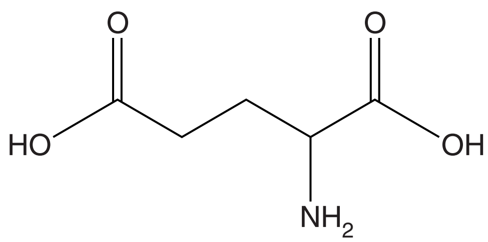
explanation ....

....

....

.... **[3]**

(ii) Identify the structural feature present in glutamic acid that is responsible for this type of isomerism by drawing a circle around it on the diagram below.



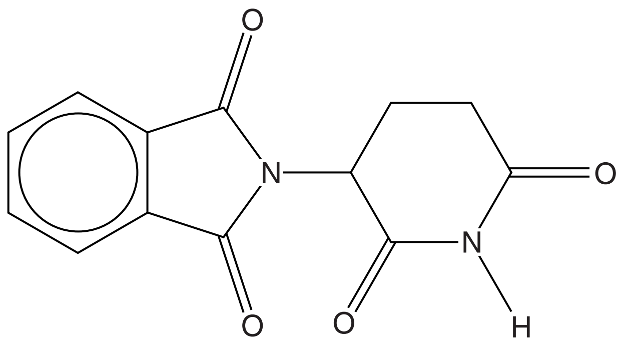
glutamic acid

[1]

(e) Glutamic acid was used as the starting material to make the drug thalidomide. Thalidomide began to be prescribed as a sedative and painkiller for pregnant women around 1958. The drug was withdrawn from use in 1961 because it was linked to severe birth defects. Testing procedures for new drugs then became much stricter.

(i) Thalidomide contains secondary amide links, similar to the peptide links found in proteins.

Circle, on the structure of thalidomide below, a secondary amide link.



thalidomide

[1]

(ii) Suggest **two** possible reasons why thalidomide may have been used as a sedative in place of drugs that existed at that time.

....

....

.... **[2]**

(iii) Suggest **one** way that the testing of drugs today ensures that the thalidomide tragedy is unlikely to happen again.

....

.... **[1]**

[Total: 17]

4 A bromate of potassium, $KBrO_3$, was widely used for many years to improve the properties of bread dough. However, after baking, the small amounts of $KBrO_3$ remaining in the bread were found to be a health risk.

The problem has been solved by adding the $KBrO_3$ in an aqueous solution with iron(II) sulfate and ascorbic acid. This makes sure that any unwanted $KBrO_3$ is removed on baking.

(a) The bromate ion, BrO_3^-, acts as an oxidising agent in acidic solution. It reacts with iron(II) ions when the dough is baked.

(i) The half-equation for the reaction of BrO_3^- is:

$$BrO_3^-(aq) + 6H^+(aq) + 6e^- \rightarrow Br^-(aq) + 3H_2O(l)$$

Give the oxidation states of Br in this reaction and use them to explain why BrO_3^- is acting as an oxidising agent.

....

....

....

.... **[2]**

(ii) Give a balanced equation for the redox reaction between BrO_3^- and iron(II) ions in acid solution to produce iron(III) ions. State symbols are **not** required.

$\rightarrow$

[2]

(iii) Suggest a reason why ascorbic acid is added to the bread dough.

....

.... **[1]**

(b) BrO_3^- ions can also react with bromide ions, Br^-, in acidic solution to form bromine. The equation for the reaction is:

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(l)$$

A student carried out a series of experiments using a colorimeter to find out the rate equation for this reaction.

(i) Explain why colorimetry can be used to follow this reaction.

....

....

....

.... **[2]**

(ii) The student's processed results are given in the table below.

$[BrO_3^-(aq)]$ / mol dm^{-3}	$[Br^-(aq)]$ / mol dm^{-3}	$[H^+(aq)]$ / mol dm^{-3}	relative initial rate
0.01	0.02	0.001	1
0.01	0.02	0.004	4
0.02	0.02	0.004	8
0.01	0.04	0.004	16

Use the data in the table to work out the rate equation for the reaction.

Write your answer in the box below.

Rate = *k*

[3]

(c) Recently, chemists found that at very low pH values the rate equation for the reaction of BrO_3^- with Br^- is different from that determined by the student. The rate equation is given below.

$$\text{Rate} = k\,[BrO_3^-(aq)] \times [Br^-(aq)] \times [H^+(aq)]^2$$

(i) The chemists used the following initial concentrations:

$[BrO_3^-(aq)] = 7.00 \times 10^{-4}\,mol\,dm^{-3}$

$[Br^-(aq)] = 5.00 \times 10^{-2}\,mol\,dm^{-3}$

$[H^+(aq)] = 2.00 \times 10^{-1}\,mol\,dm^{-3}$

The rate of reaction was found to be $4.5 \times 10^{-6}\,mol\,dm^{-3}\,s^{-1}$.

Calculate the numerical value of the rate constant for the reaction. Give your answer to an **appropriate** number of significant figures.

rate constant = ... **[2]**

(ii) Give the units of the rate constant.

units = ... **[1]**

(iii) What other variable should the chemists control and report to enable their experiments to be reproduced by other chemists?

.... **[1]**

(iv) The chemists suggested that the slow, rate-determining, step of the reaction involved the interaction of an intermediate, $H_2BrO_3^+$, with Br^-.

$$\text{Rate} = k\,[BrO_3^-(aq)] \times [Br^-(aq)] \times [H^+(aq)]^2$$

Explain how the orders of reaction support the chemists' suggested rate-determining step.

....

....

....

....

....

.... **[3]**

[Total: 17]

5 Vanadium forms a range of coloured compounds. Some of these can be used for dyeing and printing fabrics. **Table 5.1** gives the colours of some vanadium ions in aqueous solution.

vanadium ion	**colour of solution**
V^{2+}	lilac
V^{3+}	green
VO^{2+}	blue
VO_2^{+}	yellow

Table 5.1

(a) Explain, in terms of frequencies of light, why some transition metal ions in solution are coloured.

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

....

....

.... **[2]**

(b) A student made up a solution of VCl_2 and left it in an open beaker. After a while it had turned blue because of oxidation by the air.

Use the data in **Table 5.1** and **Table 5.2** to explain the student's observations. In your answer, show how you have used the data **and** explain why the final solution was blue, rather than green or yellow.

half-reaction	$\boldsymbol{E^{\ominus}/V}$
$V^{3+} + e^- \rightarrow V^{2+}$	–0.26
$VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$	+0.34
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	+0.40
$VO_2^{+} + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$	+1.00

Table 5.2

....

....

....

....

....

....

....

.... **[4]**

(c) In aqueous solution, V^{2+} forms complex ions with the formula $[V(H_2O)_6]^{2+}$.

(i) Complete the table below for the complex ion $[V(H_2O)_6]^{2+}$.

coordination number	
shape of ion	
name of ligand	
type of bonding between vanadium and ligand	

[4]

(ii) $[V(H_2O)_6]^{2+}$ can react with ammonia to form a new complex ion.

Name the **type** of reaction occurring.

.... **[1]**

(d) Complete the electronic configuration for vanadium in the V^{2+} ion.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

[1]

(e) Vanadium and its compounds are used as catalysts both in solution and as solids.

Indicate, by placing ticks in the appropriate boxes, whether the following statements about catalysis by vanadium and its compounds are true or false.

	true	**false**
Vanadium compounds can act as homogeneous catalysts because vanadium can exist in several oxidation states		
In heterogeneous catalysis vanadium can only use s electrons to form weak bonds on the catalyst surface		
Homogeneous catalysts provide a route of lower activation enthalpy for the reaction		

[2]

[Total: 14]

END OF QUESTION PAPER

ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

ADDITIONAL PAGE

ADDITIONAL PAGE