OXFORD CAMBRIDGE AND RSA EXAMINATIONS
A2 GCE

F334/01

CHEMISTRY B (SALTERS)

Chemistry of Materials

MONDAY 9 JUNE 2014: Afternoon
DURATION: 1 hour 30 minutes
plus your additional time allowance

MODIFIED ENLARGED

Candidate forename		Candidate surname	

Centre number						Candidate number				

Candidates answer on the Question Paper.

OCR SUPPLIED MATERIALS:

Data Sheet for Chemistry B (Salters) (inserted)

OTHER MATERIALS REQUIRED:

Scientific calculator

READ INSTRUCTIONS OVERLEAF

DC (CW/SW) 4074147077 97322

INSTRUCTIONS TO CANDIDATES

The Insert will be found inside this document.

Write your name, centre number and candidate number in the boxes on the first page. 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.

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.

Any blank pages are indicated.

Answer ALL the questions.

1 Steel pipelines carrying natural gas occasionally corrode leading to the formation of 'green rust', $Fe(OH)_2$.

(a) Write equations or half-equations to explain how green rust forms on steel.

In each case, name the TYPE of reaction involved.

EQUATION 1 Give a half-equation for the formation of the Fe^{2+} ions.

equation:

reaction type _____

EQUATION 2 Give a half-equation for the formation of hydroxide ions.

equation:

reaction type _____

EQUATION 3 Give an ionic equation for the formation of green rust.

equation:

reaction type _____

[6]

(b) Steel usually corrodes to form 'red–brown' rust.

(i) Give the oxidation state of Fe in red–brown rust.

_____ **[1]**

(ii) Suggest why, in some conditions, green rust rather than red–brown rust forms on buried steel pipelines.

_____ **[1]**

(c) Green rust on a steel surface can be removed by converting the rust into a soluble iron compound.

One simple method is to rub the surface with sulfuric acid.

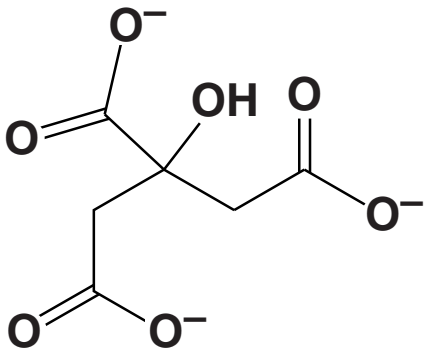
Give the systematic NAME of the soluble iron compound formed from green rust.

_____ **[1]**

(d) Another method used to remove green rust is to convert the rust into a soluble complex ion.

$Fe(OH)_2$ will form a soluble complex ion with 'citrate' ions.
Citrate ions are polydentate ligands. The structural formula of a citrate ion is shown below.

citrate ion ($C_6H_5O_7^{3-}$)



(i) Explain the meaning of the terms 'complex', 'ligand' and 'polydentate'.

complex _____

_____

_____

ligand _____

_____

_____

polydentate _____

_____

_____

[4]

(ii) The ratio of iron ion to citrate ion in the complex ion is 1:1.
The iron has a coordination number of 3.

Give the formula and charge of the complex ion formed.

[2]

(e) After some time, green rust can change into 'black rust'. The equation for this reaction is given below.

black rust

$$3Fe(OH)_2 \rightarrow (Fe^{2+})(Fe^{3+})_2O_4 + H_2 + 2H_2O$$

(i) Use OXIDATION STATES to determine what has been oxidised and reduced.

_____ is oxidised because _____

_____

and _____ is reduced because _____

_____ [4]

(ii) Calculate the volume of hydrogen gas produced when 100 g of green rust changes into black rust.

Assume that 1.0 mole of gas occupies 24 dm^3 at room temperature and pressure.

volume of hydrogen = _____ dm^3 [2]

(f) If seawater is present, the green rust is often oxidised to $[FeCl_4]^-$ ions.

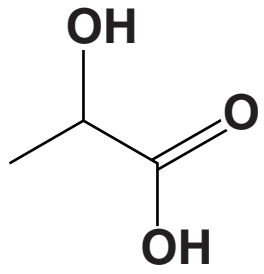
Draw diagrams to show TWO possible shapes for $[FeCl_4]^-$.

[2]

[TOTAL: 23]

2 ‘Oust’ is a common descaling treatment for kettles. Its main ingredient is the acid A, $C_3H_6O_3$.

acid A



(a) Give the systematic name for acid A.

_____ **[2]**

(b) A sachet of 'Oust' contains 25.0 g of a liquid. The information on the packet indicates that the only acid present is acid A and that its content is 30–50% by mass.

Some students decide to investigate the percentage of acid A in 'Oust'. They dilute the liquid from one sachet to 100 cm^3 with water. 25.0 cm^3 of this solution reacts exactly with 33.6 cm^3 of 1.00 mol dm^{-3} sodium hydroxide solution.

Calculate the actual percentage by mass of acid A in 'Oust'.

Give your answer to an APPROPRIATE number of significant figures.

percentage of acid A in 'Oust' = _____ % [5]

(c) The students use indicator B to determine the end point of their titration in (b).
They find that the indicator used for the titration is pink in very dilute alkali, but that the colour slowly fades in more concentrated alkali.

The slow reaction of indicator B in alkali can be represented as:

$$B(aq) + OH^-(aq) \rightarrow BOH^-(aq)$$

The students decide to follow this reaction by measuring the absorbance in a colorimeter.

They are provided with:
three aqueous solutions of sodium hydroxide with different concentrations

a suitable pink solution of indicator B.

They carry out experiments with the three sodium hydroxide solutions.

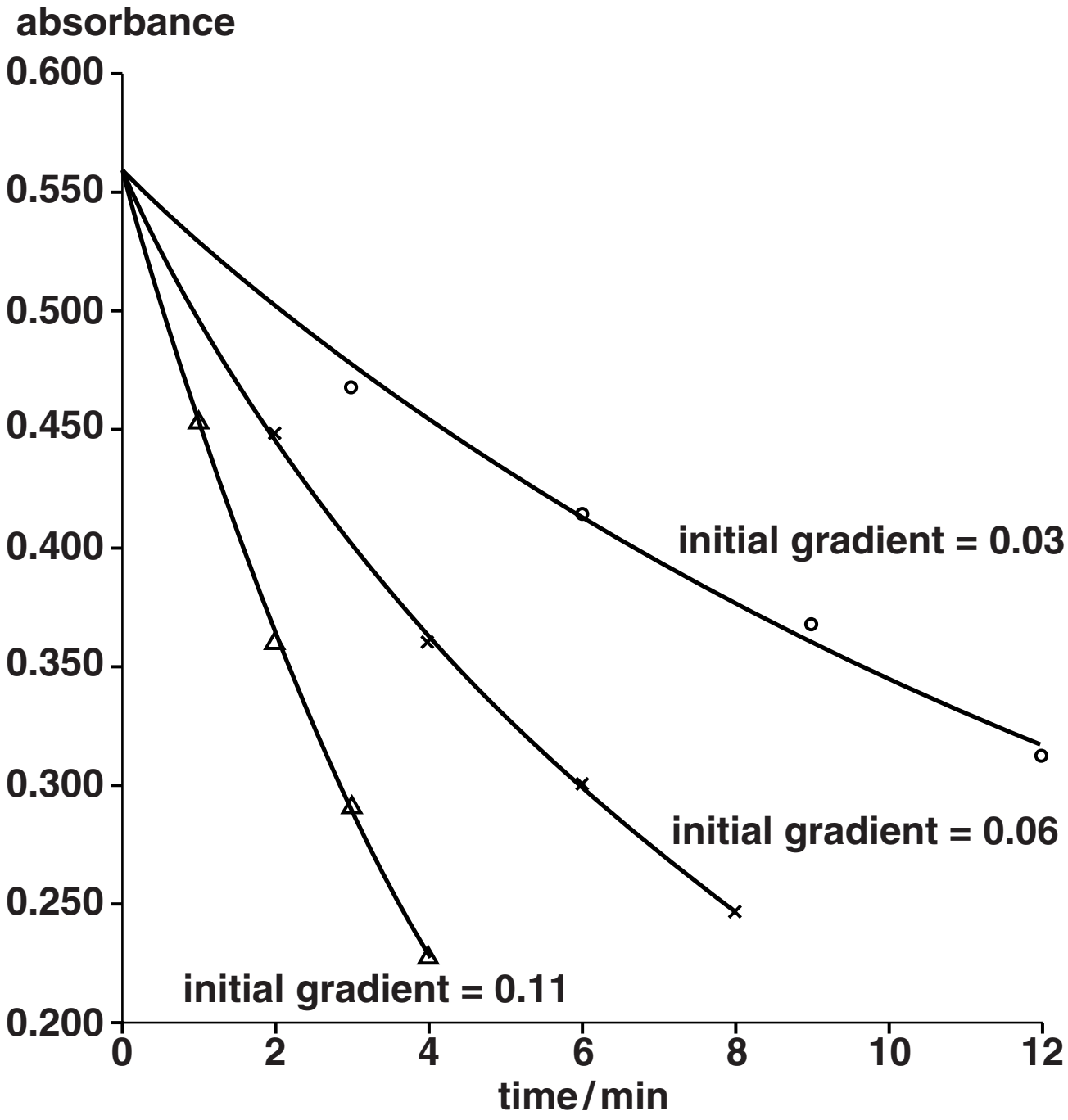
The results are shown on the graph on the next page and the magnitude of each initial gradient is given.

Concentration of sodium hydroxide:

△ = 0.20 mol dm^{-3}

× = 0.10 mol dm^{-3}

○ = 0.05 mol dm^{-3}



Describe how the students could have carried out the experiments to obtain these results.

_____

_____

_____

_____

_____

_____ **[4]**

(d) The absorbance is proportional to the concentration of B.

(i) How would the students confirm that the absorbance was proportional to the concentration of B?

_____

_____

_____ **[3]**

(ii) Use the data on the graph to determine the order of reaction with respect to hydroxide ion.

Order is _____ because _____

_____

_____ **[2]**

(iii) The students then set out to determine the order with respect to B.

How would the students do this?

_____

_____

_____ **[2]**

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TURN OVER FOR QUESTION 2(e)

(e) Indicator B is an organic compound which gives a purple colour with neutral iron(III) chloride solution.

The infrared spectrum of indicator B is shown opposite.

(i) Use the spectrum to identify TWO functional groups present in indicator B.

Give your reasoning.

_____

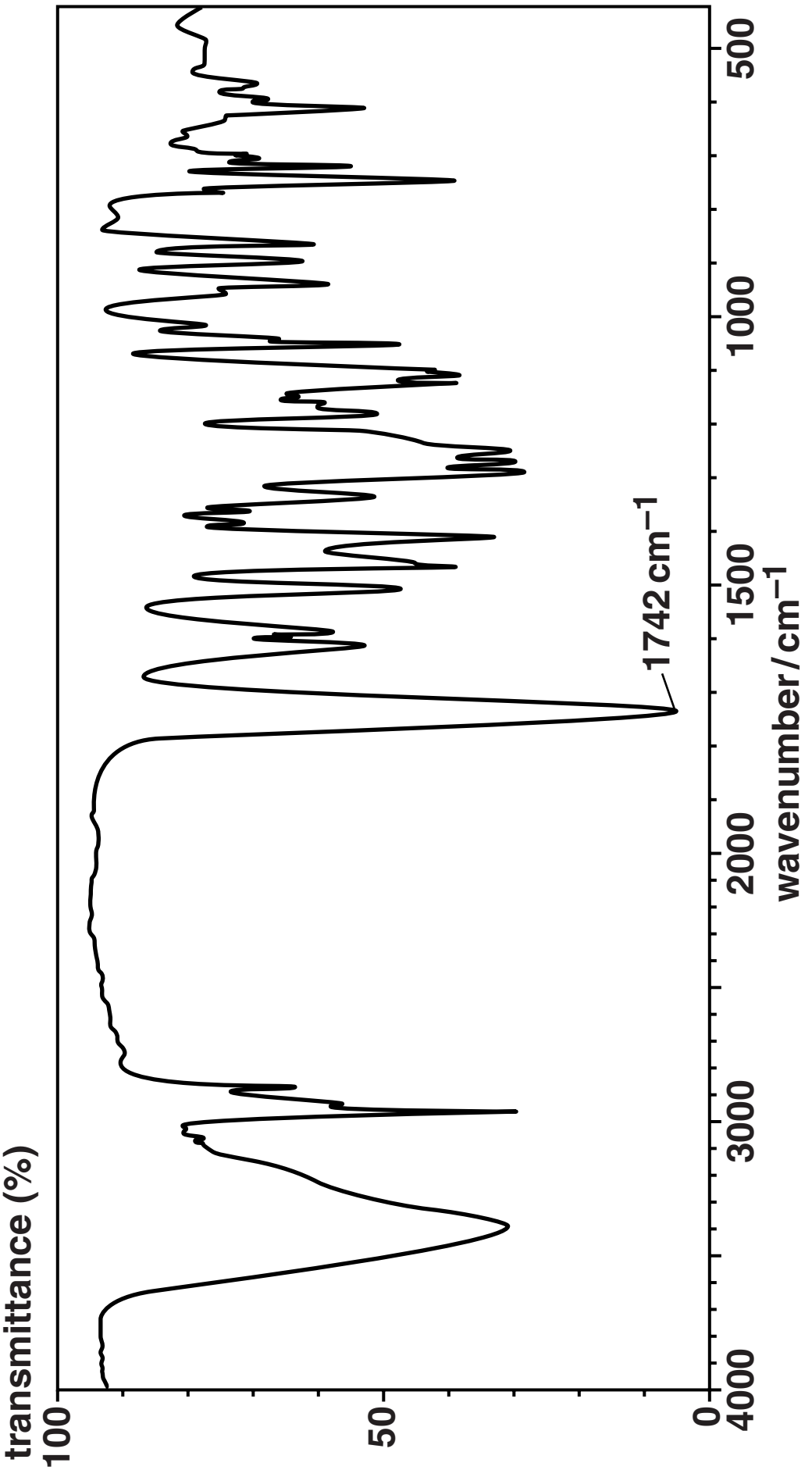
_____

_____ **[3]**

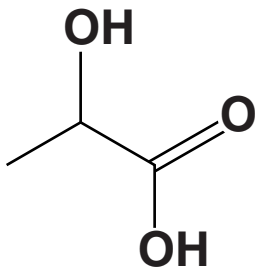
(ii) Describe how the reaction of B with neutral iron(III) chloride solution gives more information about one of these groups.

_____

_____ **[1]**


transmittance (%)
100
50
0
4000
3000
2000
1500
1000
500
wavenumber / cm^{-1}
1742 cm^{-1}

acid A



(f) Acid A can exist as two different stereoisomers.

Explain why A can exist as two different stereoisomers and describe the relationship between them.

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

_____

_____

_____

_____ **[2]**

(g) Acid A is made from glucose and can be polymerised to form a thermoplastic material which can be used in food packaging.

Enzymes in bacteria present in soil will hydrolyse the polymer.

(i) Explain why acid A can be polymerised and name the functional group which joins the monomer units together.

explanation _____

_____

functional group _____

[2]

(ii) Give TWO advantages of using this polymer in the production of food packaging.

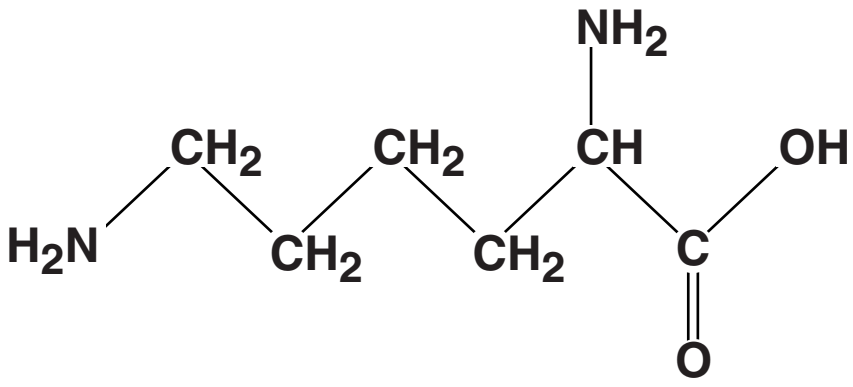
_____

_____

_____ **[2]**

(h) Enzymes present in the soil can also be hydrolysed. One such product of hydrolysis is compound C.

compound C



Give structural formulae for the ions that compound C will form in highly acidic soil and in highly alkaline soil.

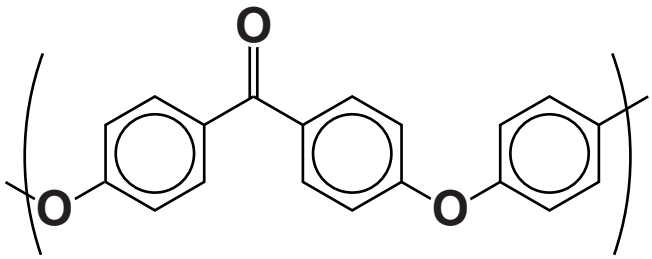
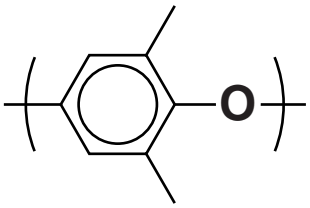
acidic soil:

alkaline soil:

[3]

[TOTAL: 31]

3 Some engineering plastics contain heat-resistant polymers and are used to make parts for machinery. The table below shows some details for two heat-resistant polymers.

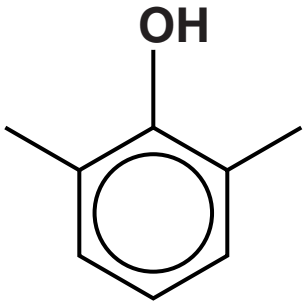
Name of polymer	Structure of repeating unit	T_g / °C	Arrangement of chains
PEEK		143	ordered
PPO		215	tangled

(a) Name TWO different functional groups, other than a benzene ring, present in PEEK.

_____ and _____ **[2]**

(b) PPO can be made by reacting compound D with O_2 in a 2:1 mole ratio.

compound D



(i) NAME the other product of the reaction that forms PPO.

_____ **[1]**

(ii) State the TYPE of polymerisation reaction in which PPO is formed.

_____ **[1]**

(iii) Suggest why the value of T_g differs for PPO and PEEK.

In your answer:

state what is meant by T_g

describe AND explain what happens when a polymer is heated above its T_g

suggest why, in terms of the arrangement of chains, T_g for PPO is higher than that for PEEK.

_____

_____

_____

_____

_____

_____

_____

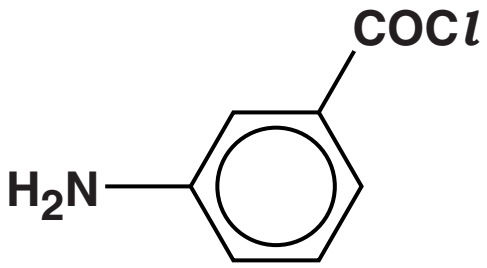
_____

_____

_____ **[5]**

(c) Polyaramids are also heat-resistant polymers.

The polyaramid X-Fiper™ is formed from the monomer shown below.



(i) Draw the repeating unit for X-Fiper™.

[1]

(ii) Circle ONE of the following terms which best describes the reaction that forms X-Fiper™ from its monomer.

acid–base

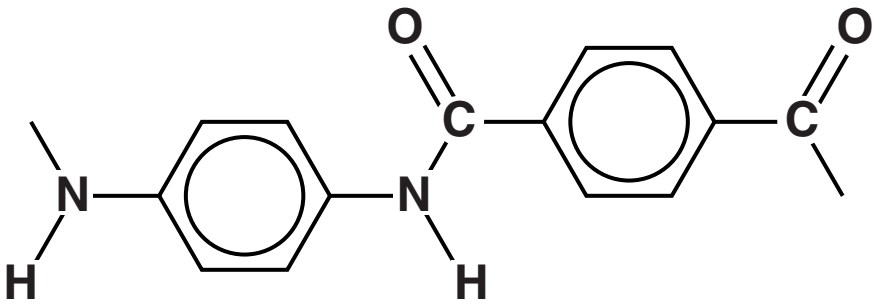
acylation

addition

substitution

[1]

(d) Twaron™ is another polyaramid with the repeating unit shown below.



(i) NAME the functional group linking arene units together in Twaron™.

_____ **[1]**

(ii) Garments made with Twaron™ are bullet-proof, unlike those made from X-Fiper™. This is because the chains of Twaron™ are straighter.

Explain this difference in garment strength in terms of intermolecular bonding between the polymer chains.

_____

_____

_____ **[2]**

[TOTAL: 14]

4 A group of researchers has discovered a type of bacterium on the shores of a lake in California. The lake contains one of the highest natural concentrations of arsenic in the world.

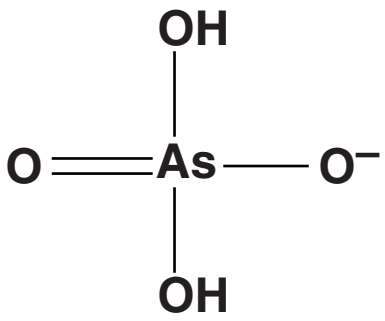
This led them to consider that bacteria may be able to incorporate arsenic into biomolecules in place of phosphorus. They claimed that they had isolated DNA containing arsenic instead of phosphorus in the 'phosphate' sugar backbone.

(a) (i) Give a chemical reason why arsenic might be able to replace phosphorus.

_____

_____ **[1]**

(ii) The structural formula for the dihydrogenarsenate ion, $H_2AsO_4^-$ is shown below.



Draw a 'dot-and-cross' diagram for $H_2AsO_4^-$.

Show outer electrons only.

As

[2]

(iii) Use the electron pair repulsion theory to name the shape of $H_2AsO_4^-$ and give an approximate bond angle for an O–As–O bond.

Explain your answer.

In your answer, you should indicate how the points that you make link together.

_____

_____

_____

_____

_____

_____

_____ **[4]**

(iv) Name the TYPE of reaction which occurs if $H_2AsO_4^-$ reacts with deoxyribose to form a backbone for DNA.

_____ **[1]**

(v) In this question you should refer to the information provided in the Data sheet.

Draw the structure of the ion formed when a $H_2AsO_4^-$ ion reacts with a PRIMARY hydroxyl group of a deoxyribose molecule.

[3]

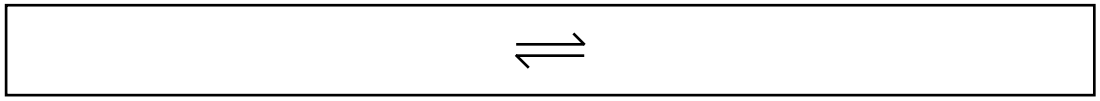
(b) $H_2AsO_4^-$ exists in weakly acidic solutions.

(i) Suggest a formula for the arsenic compound formed from $H_2AsO_4^-$ in strongly acidic solutions.

_____ **[1]**

(ii) In a strongly alkaline solution, OH^- ions remove two protons from $H_2AsO_4^-$.

Write an ionic equation for the reaction.



[2]

(iii) Circle TWO proton acceptors in your equation in (ii). **[1]**

(c) Many other scientists have concerns about the validity of the evidence provided by the researchers.
One concern is that arsenates are more reactive than phosphates. The arsenate–sugar backbone in DNA would break down very easily in the presence of sulfur compounds in the environment.

Half-reaction	$E^{\ominus}$/V
$H_3PO_4(aq) + 2H^+(aq) + 2e^- \rightarrow H_3PO_3(aq) + H_2O(l)$	–0.28
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow SO_2(aq) + 2H_2O(l)$	+0.17
$H_3AsO_4(aq) + 2H^+(aq) + 2e^- \rightarrow H_3AsO_3(aq) + H_2O(l)$	+0.56

(i) Use the data in the table to show why H_3AsO_4 will react with sulfur dioxide but H_3PO_4 will not.

_____

_____

_____ **[2]**

(ii) Write the equation for the reaction between H_3AsO_4 and sulfur dioxide in acid solution.

[2]

(d) Another concern about the existence of arsenic-containing DNA is that the arsenate–sugar backbone would be quickly hydrolysed in the body. The arguments are based on the reactivity of As–O bonds in SMALL organic molecules. Scientists have estimated a constant half-life of 10 minutes for the hydrolysis of As–O bonds.

(i) State the order, with respect to the arsenic compound, for the hydrolysis reaction.

Explain your answer.

_____

_____ **[2]**

(ii) Suggest one reason why some scientists might disagree that the arsenate–sugar backbone in DNA will hydrolyse easily.

_____

_____ **[1]**

[TOTAL: 22]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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

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