Oxford Cambridge and RSA

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Monday 19 June 2017 – Morning

Time allowed: 2 hours 15 minutes

You must have:
- the Insert (inserted)
- the Data Sheet for Chemistry B (Salters) (sent with general stationery)

You may use:
- a scientific or graphical calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- The Insert will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

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Answer **all** the questions.

1 Sodium ethanoate is used as an 'acidity regulator' in foods.

(a) Sodium ethanoate, CH_3COONa, can be made by reacting solutions of ethanoic acid, CH_3COOH, and sodium carbonate, Na_2CO_3, in the laboratory.

(i) Write an equation for this reaction.

[2]

(ii) Calculate the volume (in cm^3) of 0.500 mol dm^{-3} Na_2CO_3 that would react with 25.0 cm^3 of 0.450 mol dm^{-3} CH_3COOH.

volume of Na_2CO_3 = ... cm^3 **[2]**

(b) The ethanoate ion forms an alkaline solution in water.
Write an equation to show this.

[1]

(c) Ethanoic acid is a weak acid. $K_a = 1.7 \times 10^{-5}$ mol dm^{-3}.

(i) Write an equation for the reaction of ethanoic acid in water.

[1]

(ii) Calculate the pH of a 0.030 mol dm^{-3} solution of ethanoic acid.

pH = ... **[2]**

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(d) When sodium ethanoate is acting as an acidity regulator in food, a buffer solution is set up. This buffer involves sodium ethanoate and ethanoic acid.

Explain, with the help of an appropriate equation, how this buffer solution works when acid is added.

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

(e) Some students investigate buffers involving sodium ethanoate and ethanoic acid.

(i) They make a solution containing equal amounts of ethanoic acid and sodium ethanoate.

Calculate the pH of this solution.

$K_a = 1.7 \times 10^{-5}\,\text{mol dm}^{-3}$ for ethanoic acid.

pH = ... **[1]**

(ii) The students then set out to make a buffer solution of a known pH. They have 25.0 cm^3 of a 0.100 mol dm^{-3} solution of ethanoic acid.

Calculate the mass of sodium ethanoate they need to add to the acid solution to make a solution of pH = 5.00.

mass of sodium ethanoate = ... g **[4]**

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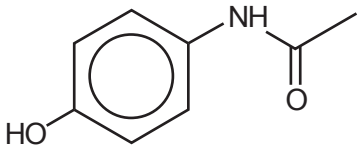
2 Paracetamol is a pain-relieving medicine.



paracetamol

(a) Name **two** functional groups in paracetamol, apart from the benzene ring.

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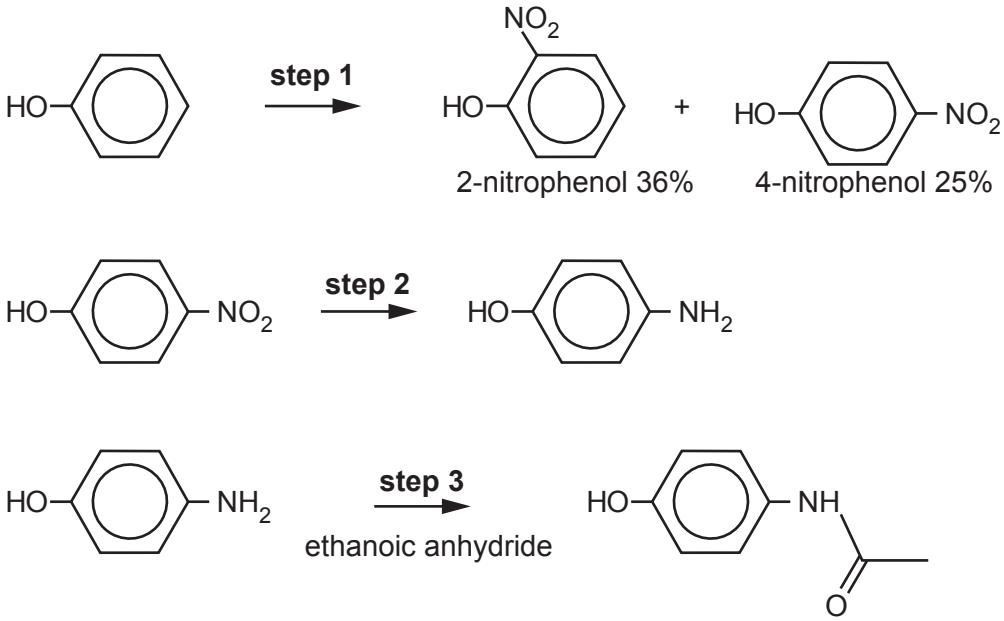
..... **[2]**

(b) Some students set out to make paracetamol by the method shown below.



(i) The students want to make 5.0 g of 4-nitrophenol in **step 1**.

Calculate the mass of phenol they should start with.

Give your answer to an **appropriate** number of significant figures.

mass of phenol = ... g **[2]**

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(ii) The two nitrophenols formed can be separated since they have different boiling points. 2-nitrophenol has a lower boiling point than 4-nitrophenol. This is because internal hydrogen bonding can occur in 2-nitrophenol.

Draw the structure of 2-nitrophenol with the –OH and $–NO_2$ groups shown as **full** structural formulae; show where the internal hydrogen bond would form.

[2]

(iii) Name the **type** of reaction that occurs in **step 2** and name the functional group that has been formed.

Type of reaction .....

Functional group formed .....

[1]

(iv) Write an equation for the reaction in **step 3**.
Use **skeletal** formulae for the organic compounds.

[2]

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(v) The students purify the product from **step 3** by recrystallisation from water.

Describe the steps in the recrystallisation of a solid product from water. Indicate how insoluble and soluble impurities are removed.

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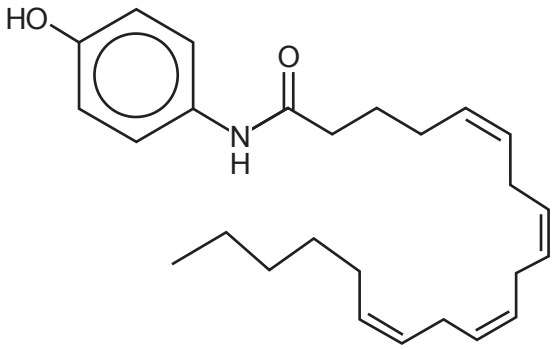
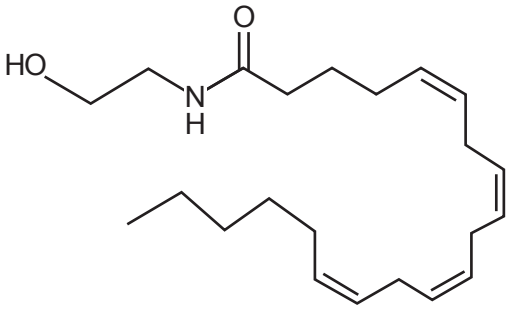
..... **[4]**

(c) Paracetamol is thought to be converted to AM404 in the body.
AM404 is thought to inhibit the enzyme-catalysed breakdown of anandamide. Anandamide reduces pain responses.



AM404



anandamide

(i) Suggest how AM404 inhibits the breakdown of anandamide.

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

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(ii) Describe the stereochemistry of the double bonds in AM404.

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

(iii) Explain how the double bonds in AM404 hold the carbon chain in shape.

.....

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

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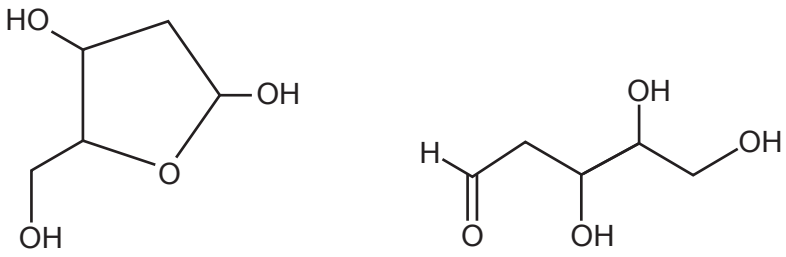
3 Deoxyribose, $C_5H_{10}O_4$, has a vital role in our biochemistry as a component of DNA.

Deoxyribose exists in solution as several forms, two of which are shown below.



ring form linear form

(a) **(i)** Circle **all** the chiral centres on **both** structures above. **[1]**

(ii) Name the functional group that is present in the linear form only.

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

(iii) Describe a laboratory test for the functional group identified in **(a)(ii)**.

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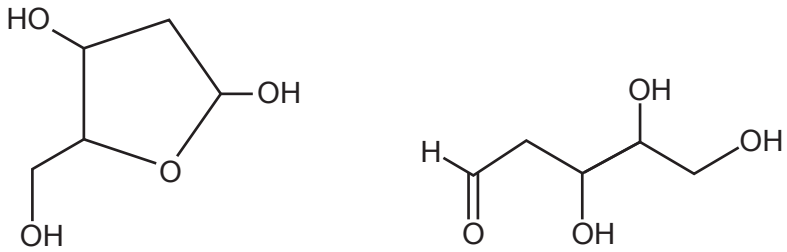
..... **[2]**

(iv) Circle a primary alcohol group on each structure below, giving a reason for your choice.



Reason .....

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

(v) Explain why the reaction in which the linear form changes to the ring form is **not** condensation.

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

(vi) Complete the equation that shows the reaction when the linear form changes to the ring form.

–CHO + HO– $\rightarrow$

[1]

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(b) In DNA, deoxyribose is always present as the ring form.
The primary alcohol group in the ring form of deoxyribose and the alcohol group on the adjacent carbon condense with phosphate groups.
A sugar-phosphate backbone is formed.

Draw a section of the sugar-phosphate backbone.

Show one deoxyribose and two phosphate groups.

[2]

(c) The structure of a fragment of DNA is sometimes represented by a sequence of letters, e.g. GCA. The letters stand for guanine, cytosine and adenine.

(i) What single term describes guanine, adenine and cytosine?
How and where do they attach to the sugar-phosphate backbone?

term .....

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

(ii) Give the DNA sequence that would produce the CUG sequence in RNA.

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

(iii) The sequence given in **(c)(ii)** codes for an amino acid in a protein chain.

Name the amino acid. Use the *Data Sheet* to help you.

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

(iv) Explain how a sequence in DNA codes for an amino acid.

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

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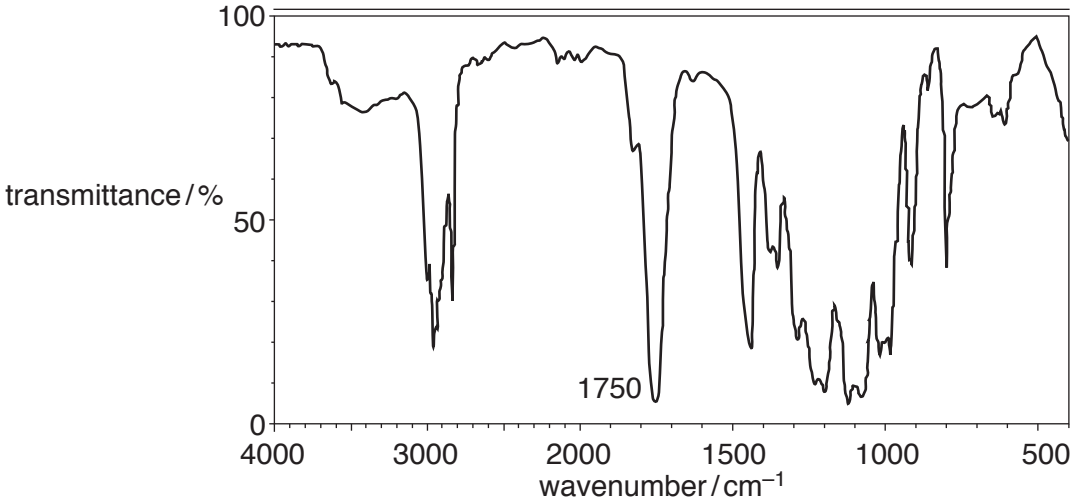
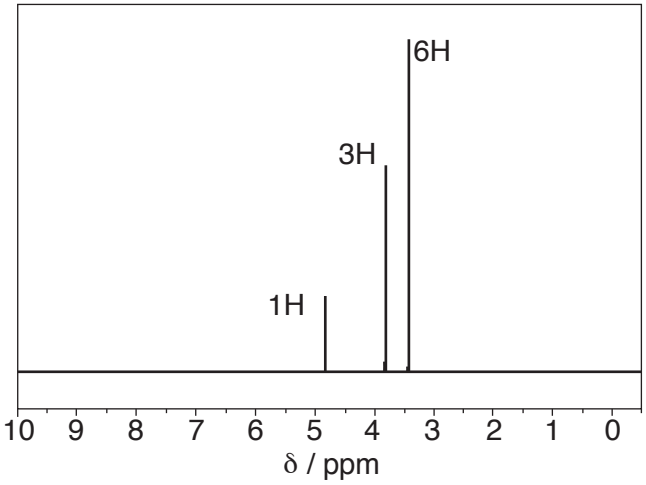
(d)* Compound **B** is a structural isomer of deoxyribose with the molecular formula $C_5H_{10}O_4$.

The infrared, ^1H and ^{13}C NMR spectra of compound **B** are shown below.

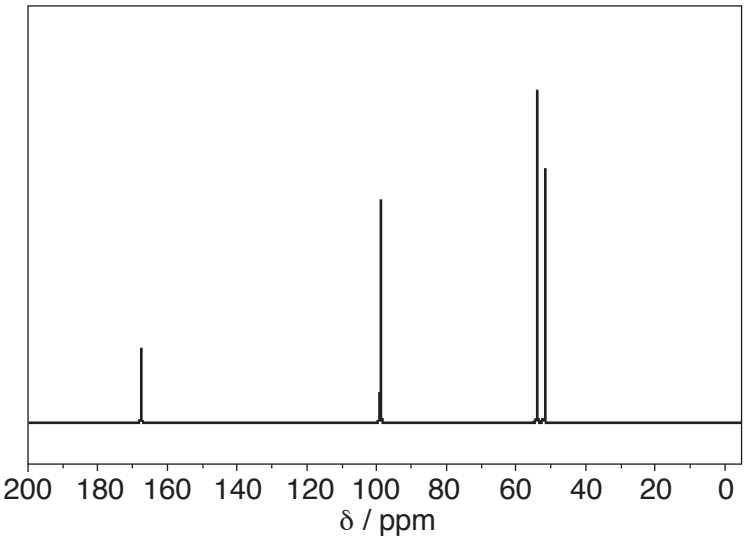
Infrared spectrum



^1H NMR spectrum



^{13}C NMR spectrum



You may do rough working on this page but only information written on page 11 opposite will score marks.

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Work out the structure of compound **B**.

Give evidence from **each** spectrum and show how it relates to the structure you have given.

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..... **[6]**

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4 Chromium is a metal with many uses, one of which is the production of a shiny chromium plating on steel.

(a) Chromium is made from its ore chromite, $FeCr_2O_4$, by the following reactions. Iron has one of its common oxidation states in chromite.

$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$ **equation 4.1**

$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$ **equation 4.2**

$Na_2Cr_2O_7 + 2C \rightarrow Cr_2O_3 + Na_2CO_3 + CO$ **equation 4.3**

$Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$ **equation 4.4**

(i) Complete the table below showing the oxidation states of chromium species in the equations above.
For each equation state whether chromium has been reduced, oxidised or neither.

Equation no.	**Oxidation state of Cr in reactant**	**Oxidation state of Cr in product**	**Has Cr been oxidised, reduced or neither?**
4.1			
4.2			
4.3			
4.4			

[4]

(ii) Calculate the maximum mass of chromium (in kg) that could be obtained from 1000 g of chromite.

mass = ...kg **[2]**

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(b) Chromium plating is carried out using a solution of chromium(III) chloride with a graphite anode.

(i) Write the electron configuration of a Cr^{3+} ion, using sub-shells and atomic orbitals.

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

(ii) Draw a labelled diagram of a simple apparatus to carry out chromium plating of a steel object in a student laboratory.

[3]

(iii) Write a half-equation for the cathode reaction in the cell in **(b)(ii)**.

[1]

(iv) A 'mole of electrons' is 96 500 coulombs and a coulomb is a current of 1 amp flowing for 1 second.

Calculate the time (in hours) needed to deposit 26 g of chromium at a current of 5.0 amps in the cell in **(b)(ii)**.

time = ... hours **[3]**

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(c) In a solution of chromium(III) chloride an equilibrium exists, as shown in **equation 4.5**.

$$\underset{\text{green}}{[CrCl_2(H_2O)_4]^+} + 2H_2O \rightleftharpoons \underset{\text{violet}}{[Cr(H_2O)_6]^{3+}} + 2Cl^- \quad \textbf{equation 4.5}$$

(i) **Name** the ligands in the green complex.

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

(ii) Some students have a violet solution of chromium(III) chloride.

Use your knowledge of equilibria to suggest and explain how they might make the violet solution turn green.

Give the **name** of any reagent required.

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

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(d) The concentration of an ethanol solution can be measured using the following steps.

- add excess acidified dichromate, $Cr_2O_7^{2-}$, some of which reacts with the ethanol.
- add excess iodide that reacts with the remaining dichromate.
- titrate the iodine produced with sodium thiosulfate.

$3C_2H_5OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$ **equation 4.6**

$Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$ **equation 4.7**

$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2I^-$ **equation 4.8**

(i) Some students add acid and 20.0 cm^3 of 0.200 mol dm^{-3} $Cr_2O_7^{2-}$ to 25.0 cm^3 of a 'low-alcohol' beer.

They add excess iodide ions and find that the iodine produced reacts with 27.6 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3$.

Calculate the concentration of the ethanol in the beer (in mol dm^{-3}) and then the percentage of ethanol (in g per 100 cm^3).

concentration of ethanol = ... mol dm^{-3}

% ethanol = ... g/100 cm^3 **[6]**

(ii) Suggest one assumption the students have to make when giving their result.

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

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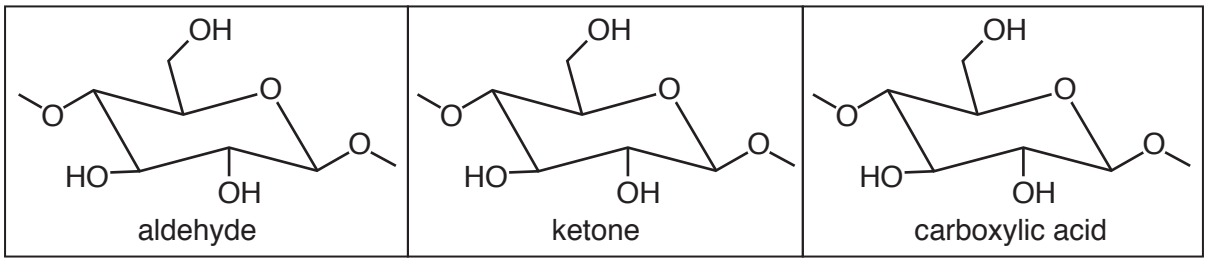
5 This question is based on the article **Saving paper** from *Education in Chemistry*, March 2013, published by the Royal Society of Chemistry which comes as an insert with this paper.

(a) The article says that hydroxyl groups in cellulose can be oxidised to aldehydes, ketones and carboxylic acids. The structures below each show part of a cellulose chain.

On each chain, **circle** the hydroxyl group(s) that can be oxidised to give the named group.



[3]

(b) (i)* Lignin contains chromophores that absorb in the uv, whereas the decomposition products look yellow.

Explain what affects the frequency of radiation absorbed and why the decomposition products look yellow.

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..... **[6]**

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(ii) Calculate the energy (in $kJ\,mol^{-1}$) that corresponds to a wavelength of 350 nm absorbed by lignin.
($1\,nm = 10^{-9}\,m$)

energy = ...$kJ\,mol^{-1}$ **[3]**

(c) **(i)** What is acting as the acid in the equation shown below?

$$[Al(H_2O)_6]^{3+} + H_2O \rightarrow [Al(OH)(H_2O)_5]^{2+} + H_3O^+$$

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

(ii) Draw a diagram to illustrate the shape of the $[Al(OH)(H_2O)_5]^{2+}$ ion, naming the shape.

name of shape ..... **[2]**

(d) The article gives two equations for the 'Fenton mechanism'.

Give the overall equation represented by the two equations.

Explain why the two equations alone do not show that Fe^{2+} is acting as a catalyst.

Overall equation:

Explanation: .....

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

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(e) The article describes several methods of neutralising the acidity in paper.
One of these is 'washing in a bath of mild alkali'.

Describe **two other** methods given in the article.

Write equations where appropriate.

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

END OF QUESTION PAPER

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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).

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