OCR
Oxford Cambridge and RSA

Tuesday 18 June 2024 – Morning

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Time allowed: 2 hours 15 minutes

You must have:
- a clean copy of the Advance Notice Article (inside this document)
- the Data Sheet for Chemistry B

You can use:
- a scientific or graphical calculator
- an HB pencil

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Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Use the Insert to answer Question 5.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

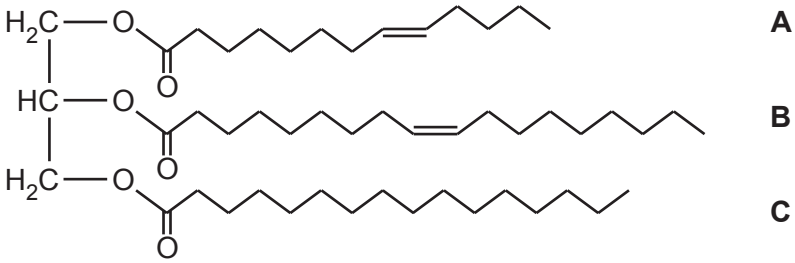
INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

1 Trans fats are made from carboxylic acids with double bonds in a trans arrangement. They sometimes improve the texture of foods, but they are harmful to health.

(a) **Fig. 1.1** shows the structure of a fat molecule.

Fig. 1.1



(i) The side-chains formed by three carboxylic acids are labelled **A**, **B** and **C**.

Give the letter of the side-chain that is:

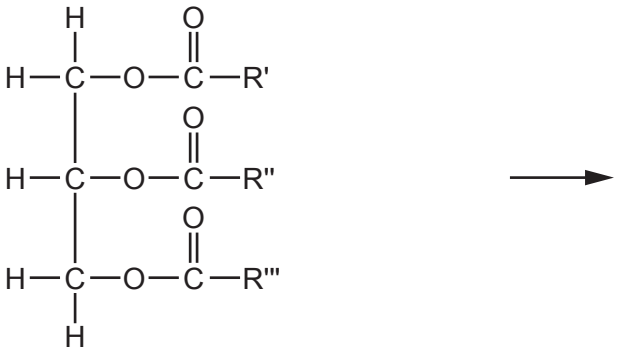
Saturated .....

Trans unsaturated .....

[1]

(ii) The fat molecule in **Fig. 1.1** can be represented as shown below.

Complete the equation for the hydrolysis of the fat with aqueous NaOH.



[3]

(b) Long-chain carboxylic acids can be identified by converting them to their methyl esters and then using gas–liquid chromatography.

Write the equation for the conversion of RCOOH to its methyl ester using the appropriate alcohol.

[2]

(c) In gas–liquid chromatography, the methyl esters are injected into a stream of carrier gas and passed through a column containing the stationary phase.

(i) Name a suitable carrier gas.

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

(ii) What does the stationary phase consist of?

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

(iii) Mass spectrometry can be used to identify the emerging esters.

Which property of the esters does mass spectrometry measure?

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

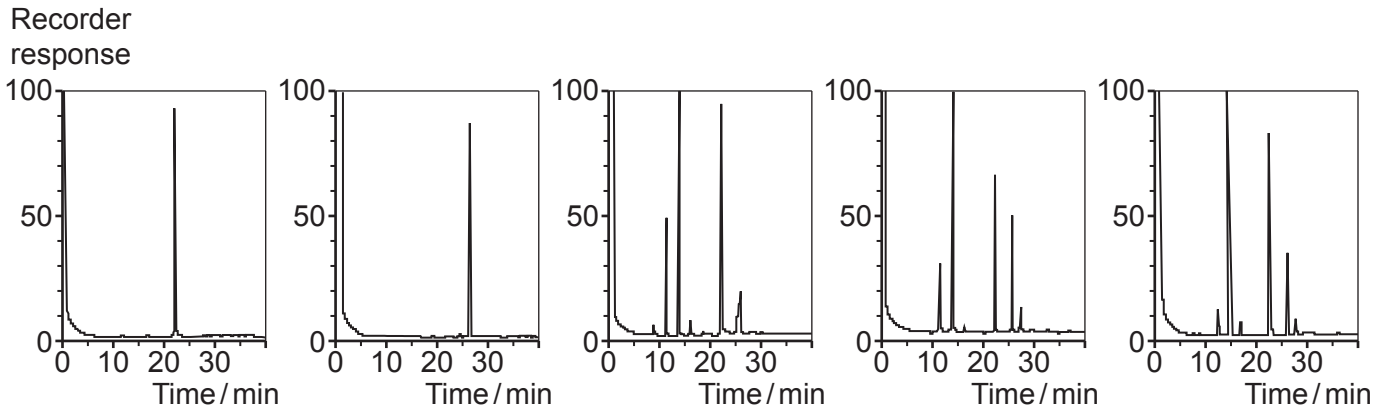
(d) Oils are fats which are liquid at room temperature. Many oils are made from palmitic and stearic acids, as well as other carboxylic acids.

To identify an oil, the methyl esters of the carboxylic acids, including methyl palmitate and methyl stearate, are made from the oil.

The oil can be identified from the gas–liquid chromatogram of the methyl esters using the ratio of methyl palmitate:methyl stearate from the peak heights.

Linseed oil has a methyl palmitate:methyl stearate ratio of 5:4.

Use the gas–liquid chromatograms below to decide which of the oils **D**, **E** or **F** is linseed oil. Give your reasoning.



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

(e) Oleic acid, $C_{18}H_{34}O_2$, has the structural formula $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$.

(i) The iodine value of a fat or carboxylic acid is the mass of iodine that will combine with 100 g of the substance, saturating the double bonds.

Calculate the iodine value of oleic acid.

iodine value = ... g **[2]**

(ii) A student suggests treating oleic acid with steam and H_3PO_4, using high temperature and pressure.

The student says that the product will be

$CH_3(CH_2)_7CH(OH)CH(OH)(CH_2)_7COOH$.

Comment on the student's statement.

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

2 This question is about some substances used as medicines.

(a)

(i) People use magnesium carbonate to neutralise excess stomach acid.

Magnesium carbonate reacts with hydrochloric acid in the stomach as shown in the equation.

$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$

A tablet contains 305 mg of $MgCO_3$.

Calculate the volume of CO_2 (in cm^3) produced by this tablet at RTP.

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

volume of CO_2 = ... cm^3 **[4]**

(ii) A student wishes to check this value by doing an experiment.

Draw a labelled diagram of an apparatus the student could use.

[2]

(b) People also use magnesium trisilicate ($Mg_2O_8Si_3$) to neutralise stomach acid.

(i) Complete the electron configurations of:

A Si atom: $1s^2$ .....

A Mg^{2+} ion: $1s^2$ ..... **[2]**

(ii) The first ionisation enthalpy of silicon is larger than that of magnesium.

A student says that this is because silicon atoms are larger than magnesium atoms.

Comment on the student's statement, giving the correct chemistry where necessary.

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

(c) People use iron tablets if their bodies lack iron.

One type of iron tablet contains iron(II) sulfate.

(i) Iron(II) sulfate has the formula $FeSO_4 \cdot xH_2O$.

When 5.6 g of $FeSO_4 \cdot xH_2O$ is heated gently, 3.1 g of $FeSO_4$ is left.

Calculate the value of x in $FeSO_4 \cdot xH_2O$, where x is a whole number.

x = ... **[3]**

(ii) When $FeSO_4$ is heated more strongly, a brown solid (M_r = 159.6) remains and two acidic gases are formed.

Suggest an equation for this reaction.

Give your reasoning.

Equation:

Reasoning: .....

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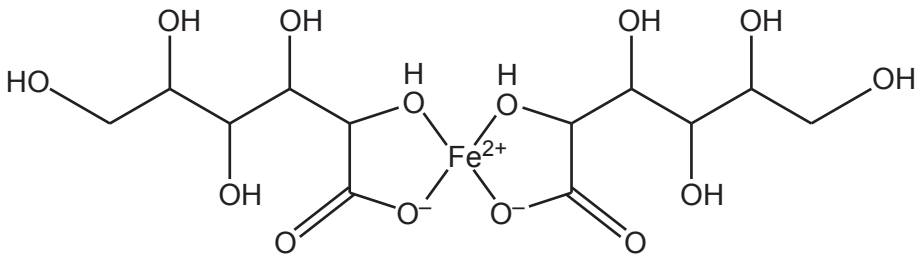
[3]

(d) Other iron tablets contain iron(II) gluconate. This contains the complex shown in **Fig. 2.1**.

Fig. 2.1



(i) The complex contains two gluconate ions.

What **type** of ligand is the gluconate ion?

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

(ii) Name the **type** of bonds between the O atoms and Fe^{2+} ions in the structure.

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

(iii) Suggest the shape around the Fe^{2+} ion in **Fig. 2.1**.

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

(e) A student does a titration to find the mass of iron in an iron tablet.

The student follows these instructions:

- Dissolve three iron tablets in 1.5 mol dm^{-3} sulfuric acid and make up to 0.250 dm^3 in a volumetric flask.
- Pipette out 25.0 cm^3 portions and titrate with 0.00277 mol dm^{-3} $KMnO_4$ solution.

The equation is:

$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

The student obtains a mean titre of 25.5 cm^3.

(i) Calculate the mass of iron (in mg) in **one** iron tablet.

mass of iron in one tablet = ... mg **[4]**

(ii) The student uses a volumetric pipette to transfer 25.0 cm^3 of the acidic solution to a conical flask.

Give the practical details of the student's next steps to get an accurate mean titre.

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

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Turn over for the next question

3 Enzymes are proteins made up of amino acids.

(a) Dipeptides are made by a condensation reaction between two amino acids.

Some students have a solid that is a dipeptide of alanine and serine.

(i) The 'R-groups' for alanine and serine are $-CH_3$ and $-CH_2OH$.

Draw a possible structure for this dipeptide.

[2]

(ii) The link between the amino acids is often described as a peptide bond.

Give another chemical name for the link.

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

(iii) Explain why the reaction between the amino acids is **not** called addition.

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

(b)* The students boil the dipeptide from **(a)** with 6 mol dm^{-3} hydrochloric acid.
They want to show that the resulting mixture contains alanine and serine.
They use paper chromatography and solutions of alanine and serine.

Describe what they would do and draw the results they would expect to obtain.

R_f value of alanine = 0.40
R_f value of serine = 0.28

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Drawing:

[6]

Extra answer space if required.

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(c) The amino acid chain of a protein is often twisted into a helix.

(i) What name is given to the helix part of the protein structure?

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

(ii) Name the main bonds that hold the helix in shape.

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

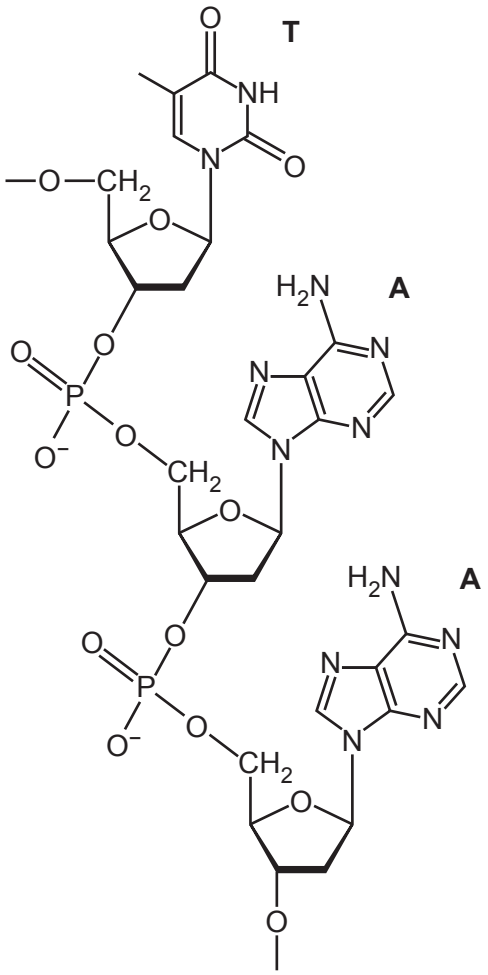
(d) Deoxyribonucleases are enzymes that break down DNA.

One of their functions is to break down incorrectly coded DNA.

Deoxyribonucleases work by hydrolysing the bonds formed by condensation between the phosphate groups and deoxyribose.

(i) **Fig. 3.1** shows the structure of a DNA chain.

Fig. 3.1



Draw an arrow on **Fig. 3.1** pointing to **one** of the bonds hydrolysed under the action of a deoxyribonuclease. **[1]**

(ii) Give the **general** name of the parts in **Fig. 3.1** labelled **A** and **T**.

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

(e) Some deoxyribonucleases are specific. They only cause hydrolysis of certain parts of the DNA chain.

(i) Explain this specificity in terms of the enzyme active site.

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

(ii) Suggest why the removal of incorrectly coded DNA helps to maintain the accurate replication of genetic information.

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

4 Some students investigate ethanoic acid and its reactions.

(a) Ethanoic acid, CH_3COOH, is a weak acid with $K_a = 1.7 \times 10^{-5}\,mol\,dm^{-3}$.

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ **Equation 4.1**

(i) Write the expression for K_a.

$K_a =$

[1]

(ii) Calculate the pH of a $0.15\,mol\,dm^{-3}$ solution of CH_3COOH.

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

(iii) A student says that the pH would be higher if the ethanoic acid was stronger.

Comment on this statement.

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

(b) The students carry out a reaction between a $0.15\,mol\,dm^{-3}$ solution of sodium hydroxide and a $0.15\,mol\,dm^{-3}$ solution of ethanoic acid.

- Student 1 says that equal volumes will be needed for complete reaction as the substances react in a 1:1 mole ratio in the equation.
- Student 2 says that less sodium hydroxide is required since ethanoic acid is a weak acid.

Which student is **wrong**?

Explain the error using **Equation 4.1**.

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

(c) For the salt of a weak acid and a strong base,

$[OH^-]^2 = [salt] \times K_w/K_a$

Use this formula to work out the pH of a 0.075 mol dm^{-3} sodium ethanoate solution.

(The value of K_w is given in the Data Sheet.)

pH = ... **[3]**

(d) A student makes a buffer solution by mixing 20 cm^3 of 0.15 mol dm^{-3} ethanoic acid with 10 cm^3 of 0.15 mol dm^{-3} sodium ethanoate solution.

(i) Calculate the value of $[H^+]$ in the student's buffer solution.

$[H^+]$ = ... mol dm^{-3} **[2]**

(ii) The student adds a small amount of acid to this buffer.

Explain why the pH changes very little.

Use **Equation 4.1**: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

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

5 This question concerns the Advance Notice Article 'Reactive Oxygen Species' that is included as an insert with this paper.

(a) The article contains a paragraph describing the cause of the hole in the ozone layer.

(i) Chlorine radicals are formed when CFCs are 'shredded' with ultraviolet radiation, as in:

$$HF_2C—Cl \longrightarrow HF_2C + Cl$$

Draw 'half curly arrows' on the CFC structure above to show the electron movement when this initiation reaction occurs. **[1]**

(ii) State the **type** of bond breaking that occurs in **(a)(i)**.

Explain why you have chosen this answer.

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

(iii) Write equations for **two** propagation reactions in which chlorine radicals catalyse the breakdown of ozone.

Equation 1:

Equation 2:

[2]

(iv) The article says:
'A single gram of freon will often destroy as much as 70 kg of ozone.'

Calculate how many ozone molecules are destroyed by **one** Cl radical if 1.0 g of $CHClF_2$ destroys 70 kg ozone.

Give your answer in standard form to **1** decimal place.

number of ozone molecules = ... **[3]**

(b)

(i) Draw a 'dot-and-cross' diagram for an H_2O_2 molecule.

[1]

(ii) Explain why the H-O-O bond angle in H_2O_2 is less than 109.5°.

Use your diagram from **(b)(i)**.

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

(iii) Write two half-equations to show how H_2O_2 can either act as an oxidising agent or a reducing agent 'depending on the company it keeps'.

Oxidising agent:

Reducing agent:

[3]

(c) Give the oxidation states of oxygen in OH and O_2^-.

OH .....

O_2^- .....

[2]

Question 5(d) begins on page 18

(d)* Of the three reactive oxygen species, hydroxyl radicals cause the most damage to the body. Hydrogen peroxide and superoxide are damaging in the presence of iron.

Give examples from the article that show that these statements are correct.

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Extra answer space if required.

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END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.