OCR
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A Level Chemistry B (Salters)
H433/01 Fundamentals of chemistry
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 2 hours 15 minutes

You must have:
• the Data Sheet for Chemistry B (Salters)

You may use:
• a scientific or graphical calculator

SPECIMEN

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
• 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.
• Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
• Write your answer to each question in the space provided.
• Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
• Do **not** write in the barcodes.

INFORMATION
• The total mark for this paper is **110**.
• 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 **36** pages.

2

SECTION A

You should spend a maximum of 40 minutes on this section.

Answer **all** the questions.

1   Which two compounds can react together to form a condensation polymer?

   A C_2H_4 and C_3H_6

   B C_2H_5OH and CH_3COOH

   C $H_2N(CH_2)_6NH_2$ and CH_3COOH

   D $HOOC(CH_2)_4COOH$ and $HOCH_2CH_2OH$

Your answer ☐

[1]

2   Which of the following is a correct statement about the test for Fe^{2+} ions in solution?

   A   add NaOH(aq); brown precipitate formed, soluble in NH_3(aq)

   B   add NaOH(aq); brown precipitate formed, insoluble in NH_3(aq)

   C   add NaOH(aq); green precipitate formed, soluble in NH_3(aq)

   D   add NaOH(aq); green precipitate formed, insoluble in NH_3(aq)

Your answer ☐

[1]

3 Instrumental techniques are crucially important in the analysis of many mixtures. These may involve wide ranging areas such as in forensic work or the analysis of a potential forged painting.

The figure below shows a graphical analysis of a mixture using a particular technique.
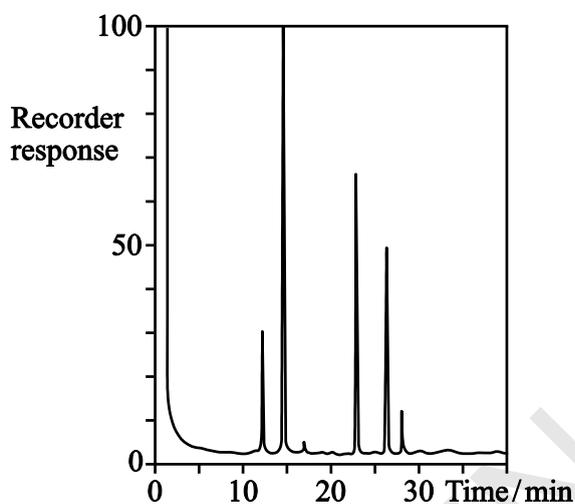
Identify the technique used to produce this graph.

A   mass spectrometry

B   infrared spectroscopy

C   proton NMR spectroscopy

D   gas–liquid chromatography

Your answer ☐

[1]

4 Which of the following factors is most important in determining the relative reactivity of the haloalkanes?

A   bond polarity

B   bond enthalpy

C   intermolecular bonding

D   molar mass

Your answer ☐

[1]

5 Choose the statement that is **not** a principle of 'green chemistry'.

    A   Cleaning up waste after it is formed.

    B   Keeping the atom economy as high as possible.

    C   Use of selective catalysts.

    D   Choosing reactants to avoid explosions.

Your answer   ☐

[1]

6 On complete combustion, a sample of a hydrocarbon produces 33 g of carbon dioxide and 18 g of water.

What is the empirical formula of this hydrocarbon?

    A C_3H_8

    B CH_2

    C C_2H_4

    D C_3H_4

Your answer   ☐

[1]

7 38.49 g of $MgSO_4 \cdot xH_2O$ crystals were heated to drive off the water. 18.79 g of solid remained.

What is the value of x?

    A   1

    B   2

    C   6

    D   7

Your answer   ☐

[1]

8 Strontium oxide reacts with water to form an alkaline solution.

What mass of water would react with 10 g strontium oxide?

A   0.94 g

B   1.7 g

C   1.9 g

D   3.5 g

Your answer ☐

[1]

9 What mass of sodium hydroxide should be dissolved in 250 cm^3 of water to make a solution that has a concentration of 0.05 mol dm^{-3}?

A   0.0125 g

B   0.5 g

C   2 g

D   8 g

Your answer ☐

[1]

10 Which of the following is a correct statement about the bonding in a CO molecule?

A   Carbon provides an electron pair in a dative covalent bond.

B   Oxygen has two lone pairs of electrons.

C   There are three covalent bonds between the atoms.

D   The molecule has no dipole.

Your answer ☐

[1]

6

11 Which molecule has the smallest bond angle?

A BCl_3

B $BeCl_2$

C NCl_3

D $SiCl_4$

Your answer

[1]

12 A student has three solutions, **X**, **Y**, **Z**. Each contains one of potassium chloride, potassium bromide and potassium iodide but it is not known which solution is which.

A student adds drops of chlorine solution separately to each of **X**, **Y** and **Z**. In each case the student also adds a few drops of cyclohexane. The colours of the cyclohexane layer are shown below.

Solution X	red/brown colour
Solution Y	colourless
Solution Z	violet colour

Which represents the correct identities of solutions **X**, **Y** and **Z**?

A **X** = potassium chloride, **Y** = potassium bromide, **Z** = potassium iodide

B **X** = potassium bromide, **Y** = potassium chloride, **Z** = potassium iodide

C **X** = potassium chloride, **Y** = potassium iodide, **Z** = potassium bromide

D **X** = potassium iodide, **Y** = potassium chloride, **Z** = potassium bromide

Your answer

[1]

13 A teacher tests a solution that has been used by students in some experiments with potassium halides to see if it can be used with a different class.

The teacher adds silver nitrate solution to the solution that the students were using. A pale yellow precipitate is formed. The teacher adds a few drops of dilute ammonia solution to the precipitate. Some of the precipitate appears to dissolve and the precipitate remaining has a stronger yellow tinge. The teacher adds excess concentrated ammonia solution to the remaining precipitate. The precipitate does not dissolve.

What is the most likely conclusion that the teacher will reach about the solution that the students were using?

A The solution contains chloride ions.

B The solution contains bromide ions.

C The solution contains chloride and bromide ions.

D The solution contains chloride and iodide ions.

Your answer [ ]

[1]

14 Four gases, **W**, **X**, **Y** and **Z**, are known to be N_2, NO, NH_3 and O_2.
It is not known which gas is which.

When gases **X** and **Y** are mixed a brown gas is formed.
Gas **Y** relights a glowing splint.
Gases **W**, **X** and **Z** extinguish a burning splint.
Gas **Z** turns red litmus paper blue.

Which gas is N_2?

A Gas **W**

B Gas **X**

C Gas **Y**

D Gas **Z**

Your answer [ ]

[1]

15   A white solid has the following properties:

It all melts at the same temperature.
It gives a purple colour with neutral $FeCl_3(aq)$.
There is fizzing when $Na_2CO_3(aq)$ is added.

The white solid could be

A   A mixture of a phenol and a carboxylic acid.

B   A compound with phenol and carboxylic acid functional groups.

C   A phenol.

D   A carboxylic acid.

Your answer

[1]

16   RNA is a polymer made of nucleotides. Nucleotides are monomers made of phosphates, sugars, and bases.

Which statement is correct about RNA?

A   Phosphate and deoxyribose units join together by a condensation reaction to form the phosphate–sugar backbone in RNA.

B   In RNA, adenine forms a base pair with thymine; cytosine forms a base pair with guanine.

C   Bases join to the phosphate–sugar backbone by a condensation reaction.

D   Base pairs form by a condensation reaction between the bases.

Your answer

[1]

9

17 The process of protein synthesis involves DNA and RNA in the following steps.

    1. An anti-codon on tRNA binds to a triplet code on mRNA.
    2. A ribosome moves along a strand of mRNA.
    3. DNA transcription occurs to make a strand of mRNA.
    4. Amino acids carried by tRNA are assembled into a protein chain.

What is the correct order of these steps in protein synthesis?

A   3 – 2 – 1 – 4

B   3 – 1 – 2 – 4

C   2 – 3 – 4 – 1

D   1 – 3 – 4 – 2

Your answer ☐

[1]

18 What template DNA sequence will produce the polypeptide GluValLeu?

You may need to refer to your Data Sheet.

A   CUGGUCGAA

B   GTTCAGGAC

C   GUUCAGGAC

D   CAGGACTTC

Your answer ☐

[1]

19 The diagram below shows the structure of a penicillin. The properties of the penicillin can be modified by changing the 'R' group side chain.
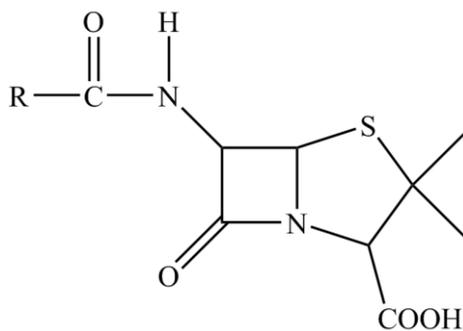
What name is given to the part of the drug that is medicinally active?

A modifier

B pharmacophore

C receptor

D chromophore

Your answer ☐

[1]

20 Which one of the following graphs correctly represents the shape of a rate versus substrate concentration plot for an enzyme-catalysed reaction?

A

B

C

D

Your answer ☐

[1]
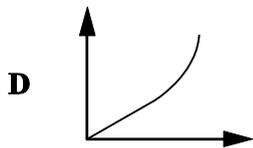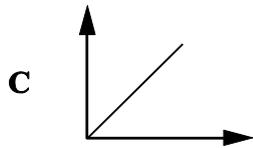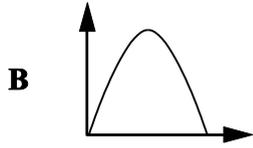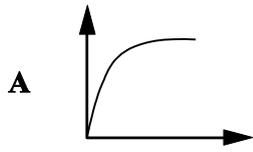
21 Aspartame is a sweetener which can be used instead of sugar. It is a methyl ester of a dipeptide formed from a reaction between the amino acids aspartic acid and phenylalanine, the structures of which are shown below.
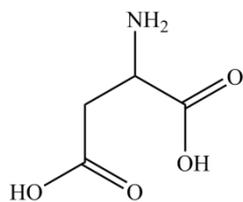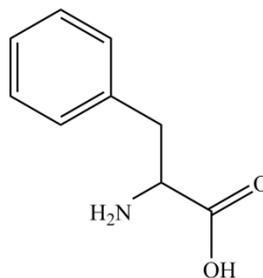
Aspartic acid   **Phenylalanine**

Alkaline hydrolysis of aspartame produces salts of the above amino acids.

Which pair of compounds is produced?

A

B

C

D

Your answer ☐

[1]

13
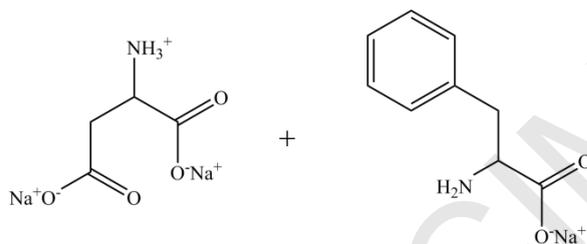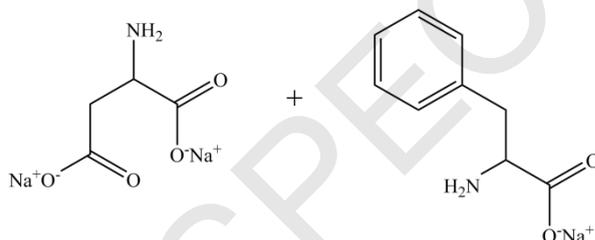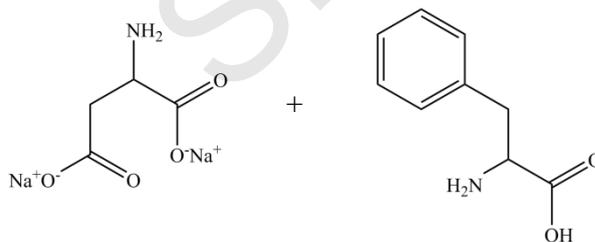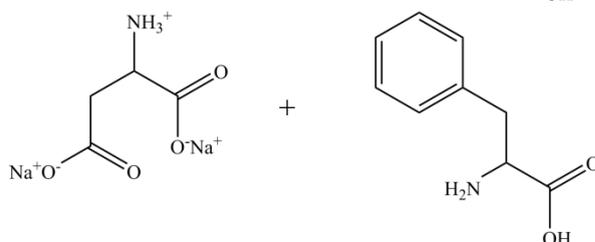
22 Below is an enthalpy-level diagram for the solution of lithium bromide.
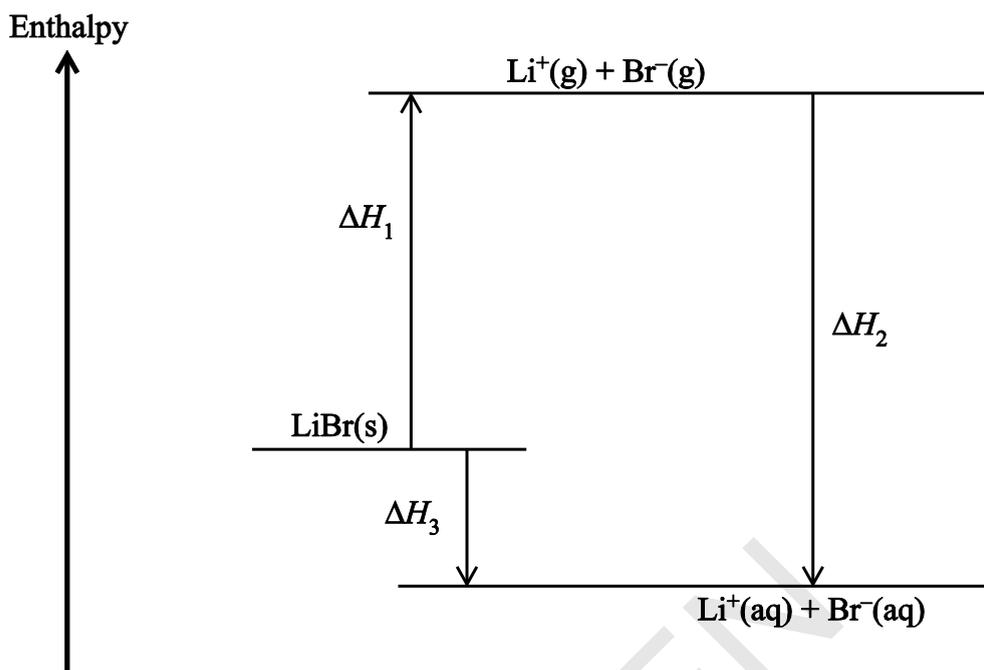
Which enthalpy change is represented by ΔH_2?

A $\Delta_{sol}H\,(Li^+) \ + \ \Delta_{sol}H\,(Br^-)$

B $\Delta_{hyd}H\,(Li^+) \ + \ \Delta_{hyd}H\,(Br^-)$

C $\Delta_{LE}H\,(LiBr)$

D $\Delta_{sol}H\,(LiBr\,)$

Your answer   ☐

[1]

14

23 Four changes **W**, **X**, **Y** and **Z** have the following signs for their ΔH and $\Delta_{sys}S$ values.

	W	**X**	**Y**	**Z**
ΔH	+	+	−	−
$\Delta_{sys}S$	+	−	+	−

Which of the following is a correct statement?

A   Change **W** never occurs.

B   Change **X** could be the reaction of a solid carbonate with an acid.

C   Change **Y** could be a precipitation reaction.

D   Change **Z** could be the condensation of a gas to a liquid.

Your answer ☐

[1]

24 A pure sample of fat was known to be a triester of propane-1,2,3-triol with a fatty acid.

0.15 mol of the fat required 10.8 dm^3 of hydrogen at room temperature and pressure for complete hydrogenation.

Identify which fatty acid formed the triester.

A   Palmitic acid, $C_{15}H_{31}COOH$

B   Linoleic acid, $C_{17}H_{31}COOH$

C   Oleic acid, $C_{17}H_{33}COOH$

D   Stearic acid, $C_{17}H_{35}COOH$

Your answer ☐

[1]

25 Chemists use knowledge of bonding between molecules and ions to explain why different substances are soluble in water.

Which of the following statements is correct?

A pentane is insoluble in water because pentane molecules are non-polar and **do not** form hydrogen bonds with water molecules

B propanone is soluble in water even though water molecules **do not** form hydrogen bonds with propanone molecules

C sodium chloride is soluble in water because water molecules are polar and form hydrogen bonds with Na^+ ions and Cl^- ions

D carbon dioxide is insoluble in water because it is non-polar and **does not** form hydrogen bonds with water

Your answer ☐

[1]

26 The decomposition of calcium carbonate is a reaction that takes place in cement manufacture.

$$CaCO_3 \rightarrow CaO + CO_2 \qquad \Delta_f H = +178 \text{ kJ mol}^{-1}$$

	$CaCO_3$	CaO	CO_2
S / J mol^{-1} K^{-1}	93	40	214

What is $\Delta_{tot}S$ for this reaction at 298 K?

A -436 J mol^{-1} K^{-1}

B $+160$ J mol^{-1} K^{-1}

C $+161$ J mol^{-1} K^{-1}

D $+758$ J mol^{-1} K^{-1}

Your answer ☐

[1]

16

27 A few drops of universal indicator solution are added to a solution of sodium chloride. Two carbon electrodes are dipped into the solution. The electrodes are connected to a power pack which is switched on.

The following statements describe changes that might be seen around the positive electrode during electrolysis. Which of the statements is/are true?

Statement 1: The solution turns red

Statement 2: The solution turns colourless

Statement 3: The solution turns green

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

28 Some possible ligands are shown below.

Which of the following could be bidentate ligands?

1: $NH_2CH_2CH_2NH_2$

2: $(COO^-)_2$

3: C_2H_5OH

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

29 Which statement(s) about the reaction of aqueous sodium hydroxide with 1-chloropentane is/are correct?

Statement 1: The reaction is a substitution reaction

Statement 2: The reaction occurs at a slower rate than with 1-bromopentane

Statement 3: 'Curly arrows' can be used to show the movement of pairs of electrons in the mechanism for this reaction

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

30 Which of the following quantities increase from left to right along the series:
$MgSO_4$; $CaSO_4$; $SrSO_4$; $BaSO_4$?

1: Size of the metal ions

2: The magnitude of enthalpy change of hydration of the metal ions

3: The magnitude of lattice enthalpy of the compounds

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

18

SECTION B

Answer **all** the questions.

31 Ceria, CeO_2, is used in a thermochemical cycle for splitting water. A simplified diagram of the process is shown below.
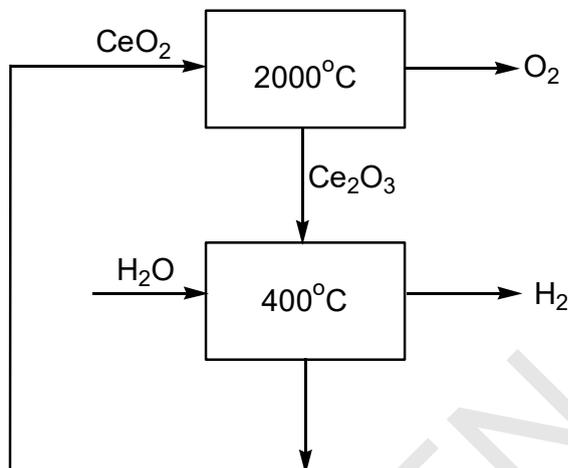
(a) (i) Give the systematic name for ceria.

.... **[1]**

(ii) Give chemical equations for the **two** reactions involved in the cycle.

State symbols are not required.

equation 1: ....

equation 2: ....

[2]

(iii) One of the reactions in the cycle is endothermic.

What data for each reactant and product is required to decide which reaction is endothermic?

....

....

.... **[1]**

19

(b) Aqueous solutions of $Ce(SO_4)_2$ and $KMnO_4$ can be used as oxidising agents in redox titrations. In both cases reactions are carried out in acidic solutions.

(i) $KMnO_4$ should **not** be acidified with hydrochloric acid.

Select and use data from the table below to determine which acid can be used with Ce^{4+} to oxidise Cl^-.

Explain your answer.

Half-reaction	$E^{\ominus}$ / V
$Ce^{4+} + e^- \rightleftharpoons Ce^{3+}$	+1.28 measured in 1 mol dm^{-3} HCl(aq)
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$Ce^{4+} + e^- \rightleftharpoons Ce^{3+}$	+1.44 measured in 1 mol dm^{-3} H$_2$SO$_4$(aq)
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.51

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.... **[3]**

(ii) A student devises an experiment to find out how much cerium is present in an impure sample of ceria.

First the student converts 2.5 g of powdered ceria into 100 cm^3 of a solution of $Ce(SO_4)_2$ in sulfuric acid. Then 25.0 cm^3 of this $Ce(SO_4)_2$ solution is titrated with a standard solution of arsenic(III) in sulfuric acid. In the reaction Ce^{4+} is reduced to Ce^{3+}.

1.00 dm^3 of solution is made up by dissolving 0.250 mol of As_2O_3 in sulfuric acid. The arsenic is present in the solution as AsO_3^{3-} ions. 25.0 cm^3 samples of the $Ce(SO_4)_2$ solution required an average titre of 3.00 cm^3 of this AsO_3^{3-} solution.

The half-equation for the oxidation of AsO_3^{3-} ions is given below.

$$AsO_3^{3-} + H_2O \rightarrow AsO_4^{3-} + 2H^+ + 2e^-$$

Calculate the percentage purity of the student's ceria sample.

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

percentage purity = **……………………………** % **[5]**

(iii) Suggest one improvement to the student's method that will reduce the percentage error in the answer to **(ii)** without changing the apparatus.

Give a reason for your choice.

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…… **[1]**

(iv) Calculate the number of oxygen atoms in 2.5 g of **pure** ceria.

number of atoms = **.................................** **[2]**

(v) Ceria is also used as a heterogeneous oxidation catalyst for self-cleaning ovens. Ceria is incorporated on the surface of the inside panels of an oven.

Describe how a heterogeneous catalyst works.

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.... **[4]**

32 Ethanol is sometimes used as a biofuel to replace petrol in car engines. However it has several disadvantages.

(a) Give **two** disadvantages of ethanol as a replacement fuel for petrol.

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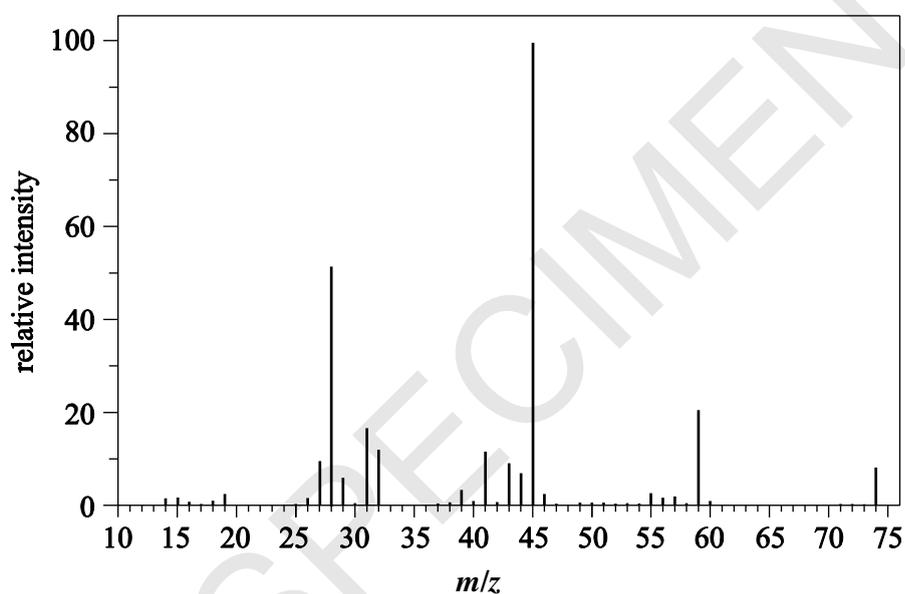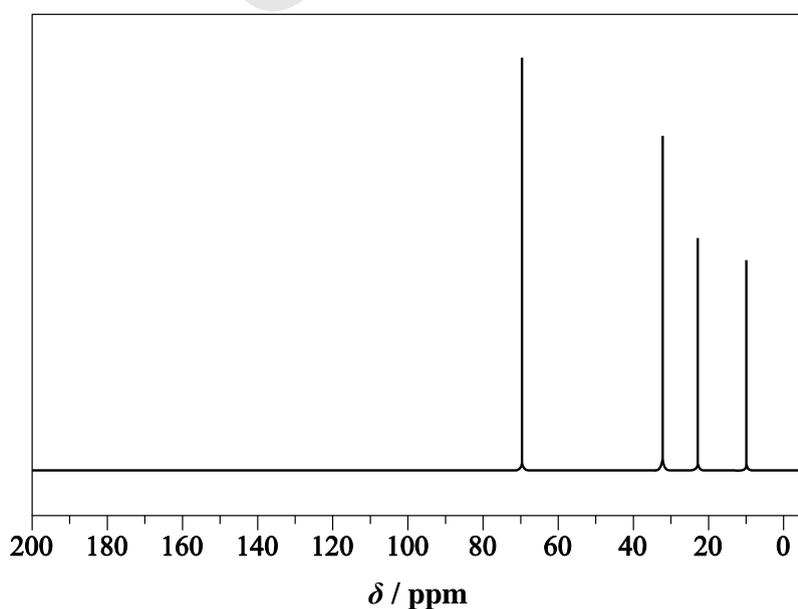... [2]

(b)* The mass spectrum and ^{13}C NMR spectrum for compound **A** are given below.

Mass spectrum (Compound A)

^{13}C NMR spectrum (Compound A)

23

Use the information below and the spectral data given on the previous page to work out the **structural formulae** of compounds **A**, **B**, **C** and **D**.

Compound **A** has the molecular formula C_xH_yO.

Compound **A** reacts when heated with acidified $K_2Cr_2O_7$ to form compound **B**.

Compound **B** does **not** react with Tollens' reagent or NaOH.

Compound **A** reacts with heated Al_2O_3 to form two unsaturated compounds, **C** and **D**.

Include evidence to support your choice of structures. **[6]**

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Additional answer space if required.

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(c) The electricity-tolerant bacteria used to convert methanoic acid contain an enzyme used to synthesise compound **A**. This enzyme is specific to this synthesis.

Explain why an enzyme is specific for a particular reaction.

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…… **[2]**

(d) A mixture of 4.0 g of ethanol vapour and 25 dm^3 of air is ignited.

Determine whether the ethanol will be completely burned.

All volumes are measured at room temperature and pressure.
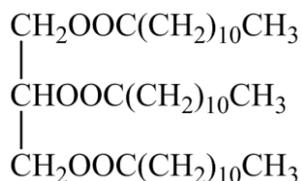
Assume air contains 21% oxygen.

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…… **[3]**

25
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H433/01   **Turn over**

33 Coconut oil contains a large amount of compound **E**. The sodium salt, **F**, of compound **E** is used as a soap.

$$CH_2OOC(CH_2)_{10}CH_3$$
$$|$$
$$CHOOC(CH_2)_{10}CH_3$$
$$|$$
$$CH_2OOC(CH_2)_{10}CH_3$$

Compound E

(a) Circle an ester group on the diagram of the structure of **E** above.

[1]

(b) After **F** is formed from **E**, **F** remains dissolved in the solution. **F** is precipitated out as a solid soap by adding NaCl.

(i) Using Na^+L^- to represent the solid **F**, give the mathematical equation for the solubility product of **F**.

[1]

(ii) Explain why adding NaCl to a solution of **F** causes the salt to precipitate out.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

27

(iii) The solubility in water of **F** is 24.0 g dm^{-3} at 24 °C.

The molar mass of **F** is 222 g mol^{-1}.

Calculate the minimum mass (in g) of solid NaCl that is needed to form a precipitate when added to 500 cm^3 of a 1.00×10^{-2} mol dm^{-3} of **F** at 24 °C.

Assume you can neglect the [Na$^+$(aq)] from salt **F** in comparison with the [Na$^+$(aq)] from NaCl.

Give one **other** assumption you make in your calculation.

minimum mass of NaCl = **………………………….** g

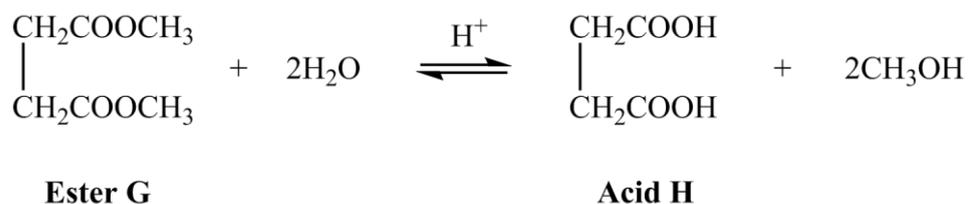assumption: **………………………………………………………………………………….**

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……………………………………………………………………………………………………

[5]

(c) Ester **G** is a fruit-flavoured additive for some ice cream and chewing gum. Ester **G** can be hydrolysed to form acid **H** and methanol.

$$\begin{array}{c} CH_2COOCH_3 \\ | \\ CH_2COOCH_3 \end{array} \; + \; 2H_2O \; \rightleftharpoons \; \begin{array}{c} CH_2COOH \\ | \\ CH_2COOH \end{array} \; + \; 2CH_3OH$$

Ester G   **Acid H**

A mixture of ester **G** and water is left to reach equilibrium with a small amount of acid catalyst.
The initial concentrations are:
- Ester **G**: 2.0 mol dm^{-3}
- Water: 5.0 mol dm^{-3}

The equilibrium concentration of ester **G** is 1.4 mol dm^{-3}.

Calculate the value of K_c for this equilibrium.

K_c = …………………………..   **[4]**

(d) Sodium ethanoate may be used in the production of ester **G**. It can also be used in buffer solutions.

Calculate the mass of solid sodium ethanoate (molar mass = 82 g mol^{-1}) that would need to be added to ethanoic acid (concentration 1.0 mol dm^{-3}) in order to make 250 cm^3 of buffer solution with a pH of 4.80.

K_a of ethanoic acid is 1.74×10^{-5} mol dm^{-3}.

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

34 Raspberry ketone, extracted from various berries, is widely used as a flavouring, a constituent of perfumes and as a diet supplement. The cost of natural raspberry ketone is often over 2000 times the cost of raspberry ketone manufactured synthetically.

(a) Suggest a reason why natural raspberry ketone is expensive to produce.

………………………………………………………………………………………………………..

……………………………………………………………………………………………… **[1]**

(b)* The structures of raspberry ketone and cyclohexanol are shown below.

raspberry ketone   **cyclohexanol**
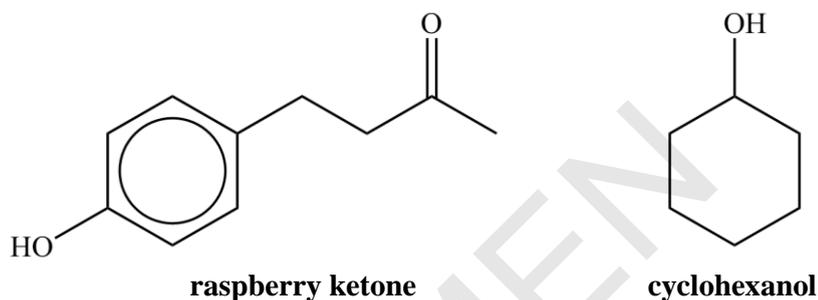
The difference between the structures of the carbon ring in raspberry ketone and cyclohexanol has an effect on the chemical properties of the hydroxyl group.

Describe the difference between the structures of the two carbon rings and how the reactions of the hydroxyl group are different in the two compounds.

Include examples, and at least two equations. **[6]**

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.... **[4]**

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Additional answer space if required.

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(c) Raspberry ketone reacts with chloromethane in the presence of anhydrous aluminium chloride to form a mixture of two structural isomers.

What technique could be used to show that two organic products are present in the mixture?

.... **[1]**

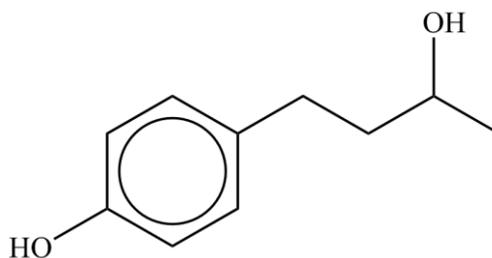**(d)** Cyanide ions will react with raspberry ketone.

Complete the diagram below to show the mechanism for the formation of a cyanhydrin, showing the intermediate and the product.

Include curly arrows and partial charges where appropriate.
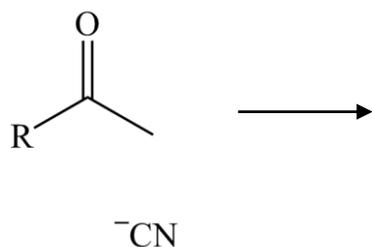
[4]

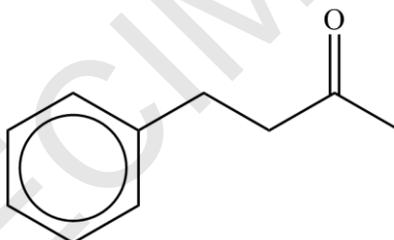**(e)** Raspberry ketone can be reduced to the compound shown below.

Explain why this compound has two stereoisomers and describe how they differ.

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…… **[2]**

(f) 4-Phenylbutan-2-one is a liquid which boils at 235 °C whereas raspberry ketone is a solid, melting at 83 °C.

4-phenylbutan-2-one

Explain this difference in properties.

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…… **[3]**

35 Aluminium is produced by the electrolysis of molten aluminium oxide, Al_2O_3.

(a) Demonstrate how the formula of aluminium oxide can be deduced using the periodic table.

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…………………………………………………………………………………………………… **[1]**

(b) (i) Write the equation for the reaction at the cathode when molten aluminium oxide is electrolysed.

[1]

(ii) The oxygen produced at the anode reacts with the carbon electrodes.

Calculate the maximum volume of carbon dioxide (measured at RTP) that would be produced during the electrolysis of 100 kg of Al_2O_3.

SPECIMEN

volume = **…………………………** dm^3 **[3]**

34

(c) (i) Aluminium is not produced at the cathode when a solution of an aluminium salt is electrolysed.

A solution of aluminium sulfate is electrolysed.

Suggest equations for:

- the reaction at the cathode
- the reaction at a carbon anode.

[2]

(ii) Give details of a simple test that can be used to test for the sulfate ion in solution.

………………………………………………………………………………………………

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

(d) Aluminium can be used to clean silver cutlery that has been 'tarnished' by a layer of black silver sulfide. The silver object is placed in a hot solution of sodium carbonate in contact with a piece of aluminium foil. An electrochemical reaction occurs and the tarnished silver becomes shiny again.

	$E^\ominus$/ V
$Al^{3+} + 3e^- \rightleftharpoons Al$	−1.66
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80

(i) Draw a labelled diagram of the cell you could set up in a laboratory to measure the $E^\ominus_{cell}$ of the reaction involved in cleaning tarnished silver.

[3]

(ii) When $[Al^{3+}]$ is changed, the value for the electrode potential of an aluminium half-cell, E, is given by

$$E = E^\circ + \frac{RT}{nF} \ln [Al^{3+}]$$

Where R = gas constant
T = temperature in kelvin
F = Faraday constant, 9.65×10^4 C mol^{-1}
n = number of electrons transferred

Calculate the electrode potential, E, of an aluminium half-cell at $T = 298$ K and $[Al^{3+}] = 0.1$ mol dm^{-3}.

$E =$ V   **[2]**

END OF QUESTION PAPER