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Centre number

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Candidate number

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Surname

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Forename(s)

Candidate signature

A-level CHEMISTRY

Paper 2 Organic and Physical Chemistry

Tuesday 12 June 2018

Afternoon

Time allowed: 2 hours

Materials

For this paper you must have:

- the Periodic Table/Data Booklet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on the blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 105.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
TOTAL	



J U N 1 8 7 4 0 5 2 0 1

Answer **all** questions in the spaces provided.

0 1

This question is about the reactions of alkanes.

0 1 . 1

Alkanes can be used as fuels.

Give an equation for the combustion of heptane (C_7H_{16}) in an excess of oxygen.

[1 mark]



0 1 . 2

Heptane can be obtained from the catalytic cracking of hexadecane ($C_{16}H_{34}$) at a high temperature.

Identify a suitable catalyst for this process.

Give **one** condition other than high temperature.

Give an equation for the catalytic cracking of one molecule of hexadecane to produce one molecule of heptane, one molecule of cyclohexane and one other product.

[3 marks]

Catalyst Zeolite (aluminosilicate)

Condition Slight (moderate) pressure

Equation $C_{16}H_{34} \rightarrow C_7H_{16} + C_6H_{12} + C_3H_6$

0 1 . 3

Alkanes can be used in free-radical substitution reactions to produce halogenoalkanes.

Give equations for the propagation steps in the reaction of butane to form 2-chlorobutane.

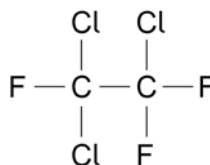
[2 marks]



0 1 . 4

Chlorofluorocarbons (CFCs) are a group of halogenoalkanes currently banned in many countries. They cannot be used as solvents or refrigerants because of their effect on the environment.

The structure of a CFC is shown.



Identify the radical produced from this CFC that is responsible for the depletion of ozone in the atmosphere.
Explain, with the aid of equations, why a single radical can cause the decomposition of many molecules of ozone.

[4 marks]

Radical $\text{Cl}\cdot$ (chlorine radical)

Explanation $\text{Cl}\cdot + \text{O}_3 \rightarrow \text{ClO}\cdot + \text{O}_2$

$\text{ClO}\cdot + \text{O}_3 \rightarrow \text{Cl}\cdot + 2\text{O}_2$

The $\text{Cl}\cdot$ radical is regenerated in the second step, so it is not used up.

It goes on to react with another ozone molecule, so a chain reaction occurs and one $\text{Cl}\cdot$ can decompose many thousands of O_3 molecules.

10

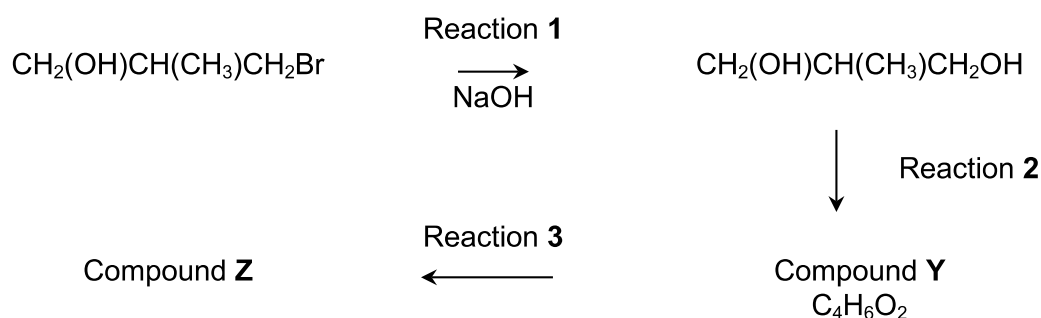
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0 2

Halogenoalkanes are useful compounds in synthesis. A reaction pathway is shown.



0 2 . 1

Give the IUPAC name for $\text{CH}_2(\text{OH})\text{CH}(\text{CH}_3)\text{CH}_2\text{Br}$

[1 mark]

3-bromo-2-methylpropan-1-ol

0 2 . 2

Reaction 1 occurs via a nucleophilic substitution mechanism.

Explain why the halogenoalkane is attacked by the nucleophile in this reaction.

[3 marks]

Bromine is more electronegative than carbon, so the C-Br bond is polar.

The carbon atom bonded to the bromine is partially positive (δ^+), so it is electron deficient.

The nucleophile (OH^-) has a lone pair of electrons, which it donates to the partially positive carbon atom, forming a new bond as the C-Br bond breaks and Br^- leaves.

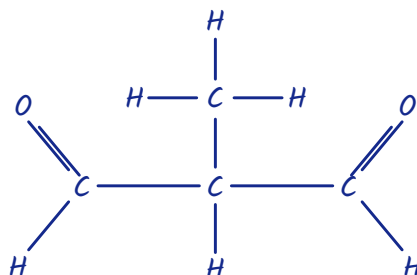


0 2 . 3

The infrared spectrum of Compound **Y** shows a significant absorption in the range $1680\text{--}1750\text{ cm}^{-1}$

Draw the displayed formula of Compound **Y**.

[1 mark]



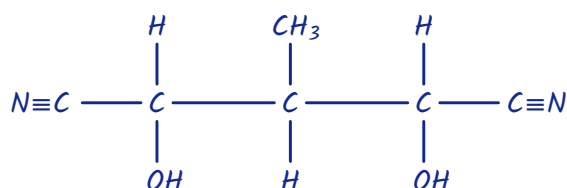
0 2 . 4

Compound **Z** has the empirical formula $\text{C}_3\text{H}_4\text{NO}$

Give the structure of Compound **Z**.
Suggest the reagent for Reaction 3.

[2 marks]

Structure



Reagent for Reaction 3 *KCN followed by dilute acid*

Turn over ►



0 3

The oxidation of propan-1-ol can form propanal and propanoic acid. The boiling points of these compounds are shown in **Table 1**.

Table 1

Compound	Boiling point / °C
propan-1-ol	97
propanal	49
propanoic acid	141

In a preparation of propanal, propan-1-ol is added dropwise to the oxidising agent and the aldehyde is separated from the reaction mixture by distillation.

0 3**. 1**

Explain, with reference to intermolecular forces, why distillation allows propanal to be separated from the other organic compounds in this reaction mixture.

[3 marks]

Propanal molecules have permanent dipole-dipole forces between them (but no hydrogen bonding).

Propan-1-ol and propanoic acid both have hydrogen bonding between their molecules, because of their O-H groups.

Hydrogen bonds are stronger than dipole-dipole forces, so the forces between propanal molecules are the weakest. Less energy is needed to overcome them, so propanal has the lowest boiling point (49 °C) and evaporates first, distilling off while the alcohol and acid stay in the flask.



0 3 . 2

Give **two** ways of maximising the yield of propanal obtained by distillation of the reaction mixture.

[2 marks]

1 *Keep the temperature of the reaction mixture below the boiling point of propan-1-ol (below 97 °C, e.g. about 60 °C), so the propanal distils off but the alcohol does not.*

2 *Cool the collecting vessel (distillate) in an ice bath, so the volatile propanal condenses and does not evaporate away.*

0 3 . 3

Describe how you would carry out a simple test-tube reaction to confirm that the sample of propanal obtained by distillation does **not** contain any propanoic acid.

[2 marks]

Add a small amount of solid sodium carbonate (or sodium hydrogencarbonate) to a sample of the distillate in a test tube.

If there is no effervescence (no bubbles of CO₂), then no propanoic acid is present; fizzing would show that the acid is present.

Question 3 continues on the next page

Turn over ►



0 3 . 4

A student carried out an experiment to determine the enthalpy of combustion of ethanol.

Combustion of 457 mg of ethanol increased the temperature of 150 g of water from 25.1 °C to 40.2 °C

Calculate a value, in kJ mol^{-1} , for the enthalpy of combustion of ethanol in this experiment.

Give your answer to the appropriate number of significant figures.

(The specific heat capacity of water is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$)

[3 marks]

$$\Delta T = 40.2 - 25.1 = 15.1 \text{ K}$$

$$q = mc\Delta T = 150 \times 4.18 \times 15.1 = 9467.7 \text{ J} = 9.4677 \text{ kJ}$$

$$n(\text{ethanol}) = 0.457 \text{ g} \div 46.0 \text{ g mol}^{-1} = 9.93 \times 10^{-3} \text{ mol}$$

$$\Delta H = -9.4677 \div 9.93 \times 10^{-3} = -952.99 \text{ kJ mol}^{-1}$$

$$= -953 \text{ kJ mol}^{-1} \text{ (3 s.f., negative as exothermic)}$$

Enthalpy of combustion - 953 kJ mol^{-1}



03.5

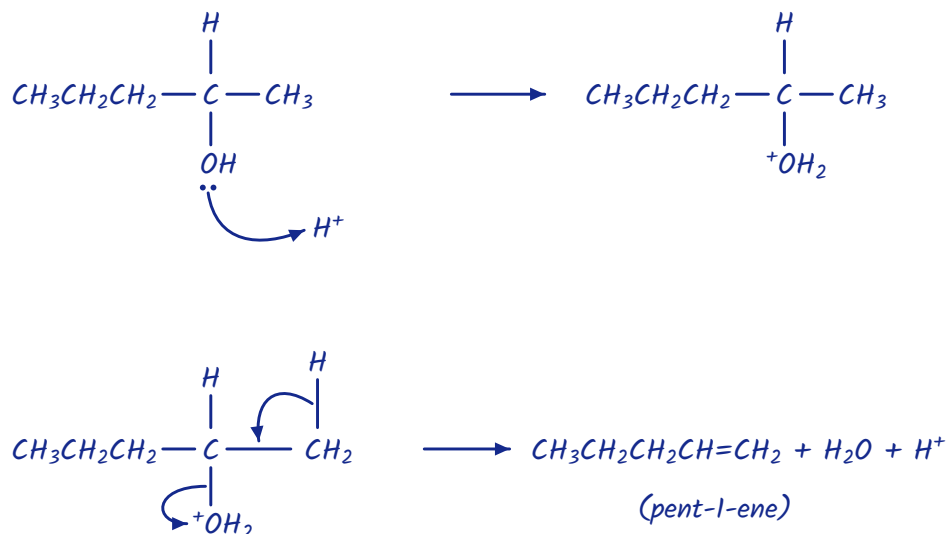
A mixture of isomeric alkenes is produced when pentan-2-ol is dehydrated in the presence of hot concentrated sulfuric acid. Pent-1-ene is one of the isomers produced.

Name and outline a mechanism for the reaction producing pent-1-ene.

[4 marks]

Name of mechanism Elimination

Mechanism



03.6

A pair of stereoisomers is also formed in the reaction in Question 03.5.

Name the less polar stereoisomer formed.

Explain how this type of stereoisomerism arises.

[2 marks]

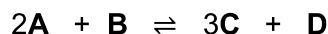
Name E-pent-2-ene (trans-pent-2-ene)

Explanation The C=C double bond cannot rotate (restricted rotation),
and each carbon atom in the double bond has two different groups
attached.



0 4

Compounds **A** and **B** react together to form an equilibrium mixture containing compounds **C** and **D** according to the equation



0 4 . 1

A beaker contained 40 cm^3 of a 0.16 mol dm^{-3} aqueous solution of **A**.
 $9.5 \times 10^{-3} \text{ mol}$ of **B** and $2.8 \times 10^{-2} \text{ mol}$ of **C** were added to the beaker and the mixture was left to reach equilibrium.
 The equilibrium mixture formed contained $3.9 \times 10^{-3} \text{ mol}$ of **A**.

Calculate the amounts, in moles, of **B**, **C** and **D** in the equilibrium mixture.

[5 marks]

$$\text{Initial } n(\text{A}) = (40 \div 1000) \times 0.16 = 6.4 \times 10^{-3} \text{ mol}$$

$$\text{A reacted} = 6.4 \times 10^{-3} - 3.9 \times 10^{-3} = 2.5 \times 10^{-3} \text{ mol} = 2x$$

$$\text{so } x = 1.25 \times 10^{-3} \text{ mol}$$

$$\text{B} = 9.5 \times 10^{-3} - 1.25 \times 10^{-3} = 8.25 \times 10^{-3} \text{ mol}$$

$$\text{C} = 2.8 \times 10^{-2} + 3(1.25 \times 10^{-3}) = 3.18 \times 10^{-2} \text{ mol}$$

$$\text{D} = 0 + x = 1.25 \times 10^{-3} \text{ mol}$$

Amount of **B** 8.25×10^{-3} mol

Amount of **C** 3.18×10^{-2} mol

Amount of **D** 1.25×10^{-3} mol

0 4 . 2

Give the expression for the equilibrium constant (K_c) for this equilibrium **and** its units.

[2 marks]

$$K_c = \frac{[\text{C}]^3[\text{D}]}{[\text{A}]^2[\text{B}]}$$

Units mol dm^{-3}



0 4 . 3

A different equilibrium mixture of these four compounds, at a different temperature, contained 0.21 mol of **B**, 1.05 mol of **C** and 0.076 mol of **D** in a total volume of $5.00 \times 10^2 \text{ cm}^3$ of solution.

At this temperature the numerical value of K_c was 116

Calculate the concentration of **A**, in mol dm^{-3} , in this equilibrium mixture.
Give your answer to the appropriate number of significant figures.

[3 marks]

$$[A]^2 = [C]^3[D] \div (K_c [B])$$

$$[B] = 0.21 \div 0.500 = 0.42, [C] = 1.05 \div 0.500 = 2.10,$$

$$[D] = 0.076 \div 0.500 = 0.152 \text{ mol dm}^{-3}$$

$$[A]^2 = (2.10^3 \times 0.152) \div (116 \times 0.42) = 1.408 \div 48.72 = 0.0289$$

$$[A] = \sqrt{0.0289} = 0.170 = 0.17 \text{ mol dm}^{-3} \text{ (2 s.f.)}$$

Concentration of **A** 0.17 mol dm^{-3}

0 4 . 4

Justify the statement that adding more water to the equilibrium mixture in Question **04.3** will lower the amount of **A** in the mixture.

[3 marks]

Adding water dilutes the mixture, so the concentrations of all four compounds fall.

The position of equilibrium shifts to the side with more moles, the right (4 moles of C and D compared with 3 moles of A and B), to oppose the decrease in concentration and keep K_c constant.

So more A reacts and the amount of A falls.

13

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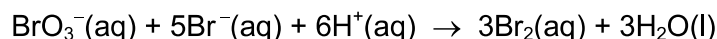
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0 5

Bromate(V) ions and bromide ions react in acid conditions according to the equation

**0 5 . 1**

A series of experiments was carried out at a given temperature. The results were used to deduce the rate equation for the reaction.

$$\text{rate} = k [\text{BrO}_3^-][\text{Br}^-][\text{H}^+]^2$$

Table 2 shows an incomplete set of results.**Table 2**

Experiment	Initial $[\text{BrO}_3^-]$ / mol dm^{-3}	Initial $[\text{Br}^-]$ / mol dm^{-3}	Initial $[\text{H}^+]$ / mol dm^{-3}	Initial rate of reaction / $\text{mol dm}^{-3} \text{s}^{-1}$
1	0.10	0.20	0.30	2.4×10^{-2}
2	0.15	0.20	0.30	3.6×10^{-2}
3	0.20	0.40	0.50	0.27
4	0.10	0.10	0.45	2.7×10^{-2}

Use the data from Experiment 1 to calculate a value for the rate constant, k , at this temperature and give its units.

Give your answer to an appropriate number of significant figures.

[3 marks]

$$k = \text{rate} \div ([\text{BrO}_3^-][\text{Br}^-][\text{H}^+]^2)$$

$$= 2.4 \times 10^{-2} \div (0.10 \times 0.20 \times 0.30^2) = 13.33$$

 k 13Units $\text{mol}^{-3} \text{dm}^3 \text{s}^{-1}$ **0 5 . 2**Complete **Table 2**.**[3 marks]**

Space for working

$$\text{Exp 2: rate} \times 1.5 \text{ so } [\text{BrO}_3^-] = 1.5 \times 0.10 = 0.15$$

$$\text{Exp 3: rate} = 13.33 \times 0.20 \times 0.40 \times 0.50^2 = 0.267 = 0.27$$

$$\text{Exp 4: } [\text{H}^+]^2 = 2.7 \times 10^{-2} \div (13.33 \times 0.10 \times 0.10) = 0.2025, [\text{H}^+] = 0.45$$

Question 5 continues on the next page**Turn over ►**

0 5 . 3

A second series of experiments was carried out to investigate how the rate of the reaction varies with temperature.

The results were used to obtain a value for the activation energy of the reaction, E_a

Identical amounts of reagents were mixed at different temperatures.

The time taken, t , for a fixed amount of bromine to be formed was measured at different temperatures.

The results are shown in **Table 3**.

Table 3

Temperature, T / K	$\frac{1}{T}$ / K ⁻¹	Time, t / s	$\frac{1}{t}$ / s ⁻¹	$\ln \frac{1}{t}$
286	3.50×10^{-3}	54	1.85×10^{-2}	-3.99
295	3.39×10^{-3}	27	3.70×10^{-2}	-3.30
302	3.31×10^{-3}	15	6.67×10^{-2}	-2.71
312	3.21×10^{-3}	8	1.25×10^{-1}	-2.08

Complete **Table 3**.

[2 marks]

0 5 . 4

The Arrhenius equation can be written as

$$\ln k = -\frac{E_a}{R} \left(\frac{1}{T} \right) + C_1$$

In this experiment, the rate constant, k , is directly proportional to $\frac{1}{t}$

Therefore

$$\ln \frac{1}{t} = -\frac{E_a}{R} \left(\frac{1}{T} \right) + C_2$$

where C_1 and C_2 are constants.

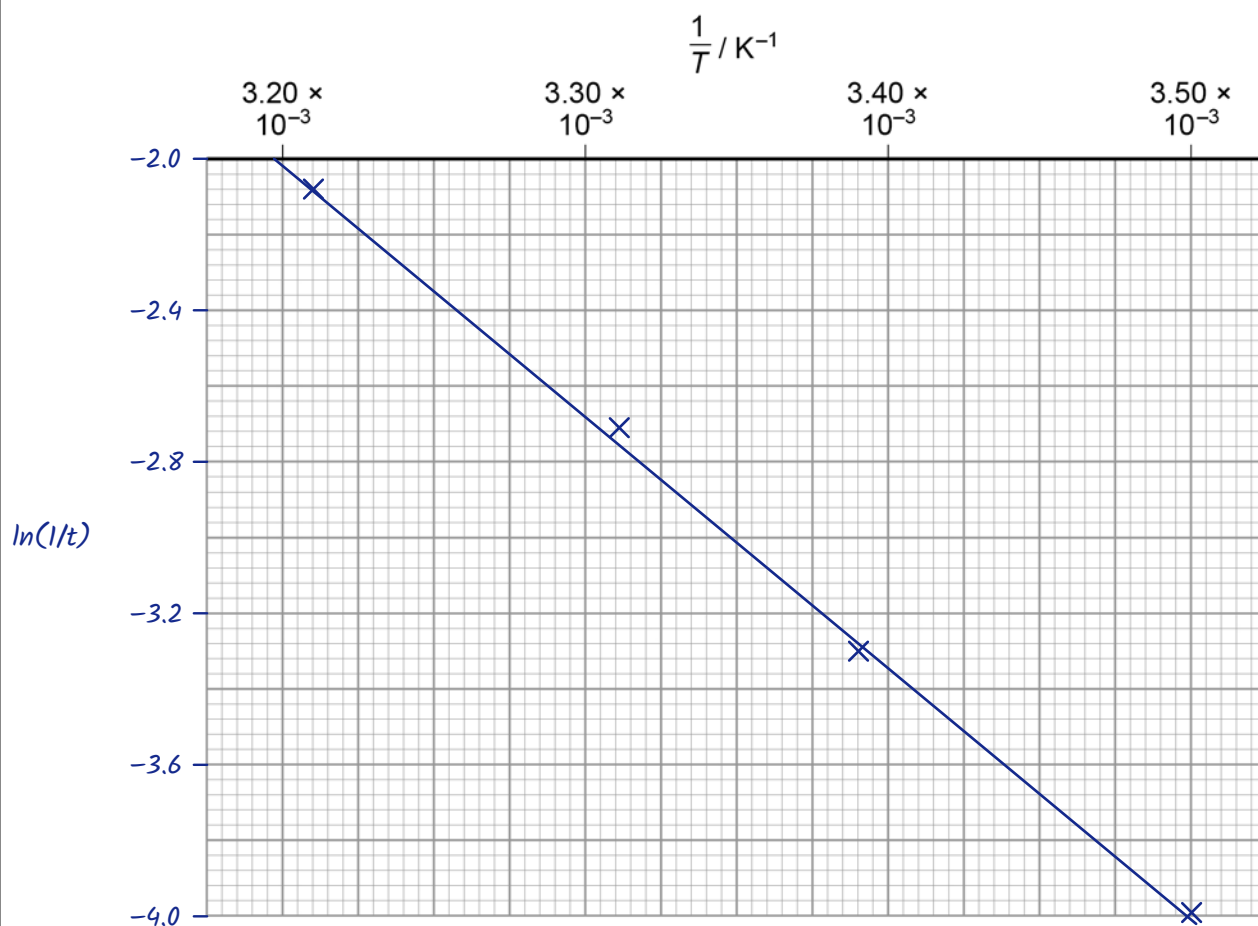
Use values from **Table 3** to plot a graph of $\ln \frac{1}{t}$ (y axis) against $\frac{1}{T}$ on the grid.

Use your graph to calculate a value for the activation energy, in kJ mol⁻¹, for this reaction.

The value of the gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[6 marks]





$$\text{Gradient} = (-4.01 - (-2.02)) \div (3.50 \times 10^{-3} - 3.20 \times 10^{-3})$$

$$= -1.99 \div 0.30 \times 10^{-3} = -6633 \text{ K} = -6.63 \times 10^3 \text{ K}$$

$$\text{Gradient} = -E_a \div R, \text{ so } E_a = -\text{gradient} \times R$$

$$E_a = 6633 \times 8.31 = 55\,120 \text{ J mol}^{-1} = 55.1 \text{ kJ mol}^{-1}$$

Activation energy 55.1 kJ mol⁻¹

Turn over ►



0 6

Data about the hydrogenation of cyclohexene and of benzene are given.



0 6 . 1

Explain the bonding in and the shape of a benzene molecule.
Compare the stability of benzene with that of the hypothetical cyclohexa-1,3,5-triene molecule.
Use the data in your answer.

[6 marks]

Bonding: each carbon atom in benzene forms three covalent (σ) bonds, two to the neighbouring carbon atoms and one to a hydrogen atom.

Each carbon atom has one spare electron in a p orbital. The p orbitals overlap sideways, above and below the plane of the ring, to form a π cloud, so the six π electrons are delocalised over all six carbon atoms.

Shape: benzene is planar. The six carbon atoms form a regular hexagon (6 carbon ring) with bond angles of 120° . All the C–C bonds are the same length, in between the length of a C–C single bond and a C=C double bond.

Stability: hydrogenation of one C=C bond in cyclohexene has $\Delta H^\ominus = -120 \text{ kJ mol}^{-1}$, so for the hypothetical cyclohexa-1,3,5-triene, with three C=C bonds, the expected $\Delta H^\ominus$ of hydrogenation = $3 \times (-120) = -360 \text{ kJ mol}^{-1}$.

The actual $\Delta H^\ominus$ of hydrogenation of benzene is -208 kJ mol^{-1} , which is 152 kJ mol^{-1} less exothermic than expected ($-360 - (-208) = -152 \text{ kJ mol}^{-1}$).



So more energy would be needed to break the bonding in benzene:

benzene is 152 kJ mol^{-1} lower in energy than cyclohexa-1,3,5-triene, so

benzene is more stable, because of the delocalisation of its π electrons.

0 6 . 2

The enthalpy of hydrogenation of cyclohexa-1,3-diene is **not** exactly double that of cyclohexene.

Suggest a value for the enthalpy of hydrogenation of cyclohexa-1,3-diene and justify your value.

[3 marks]

Suggested value: -230 kJ mol^{-1}

In cyclohexa-1,3-diene the two $\text{C}=\text{C}$ double bonds are separated by one single bond (alternating double and single bonds).

So the p orbitals can overlap, allowing some delocalisation of electrons, which makes the diene slightly more stable than two separate $\text{C}=\text{C}$ bonds. Its enthalpy of hydrogenation is therefore a little less exothermic than $2 \times (-120) = -240 \text{ kJ mol}^{-1}$.

Turn over ►



0 7

Acyl chlorides are useful reagents in synthesis. They react with aromatic compounds and also with alcohols.

0 7 . 1

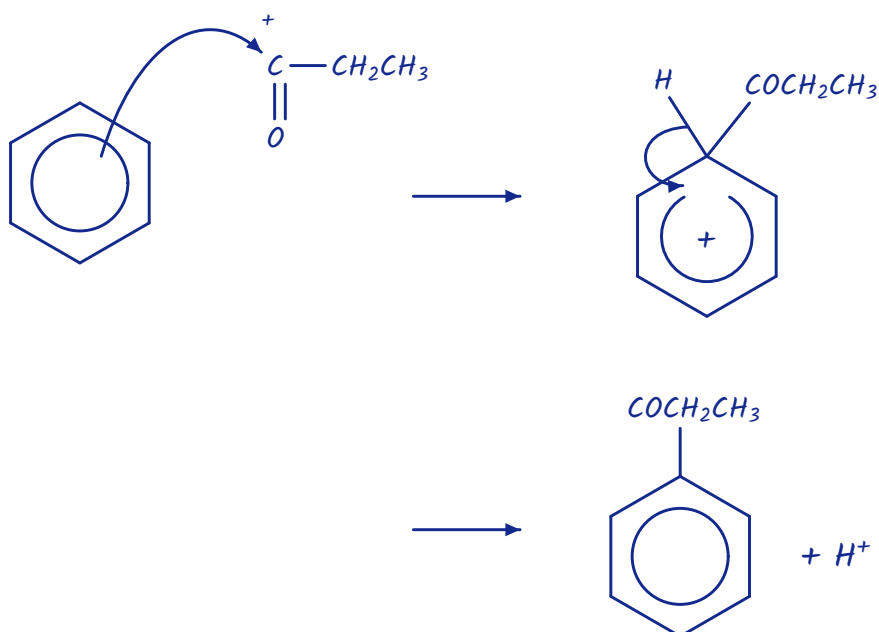
$\text{CH}_3\text{CH}_2\text{COCl}$ reacts with benzene in the presence of AlCl_3 in an electrophilic substitution reaction.

Give an equation for the reaction of $\text{CH}_3\text{CH}_2\text{COCl}$ with AlCl_3 to form the electrophile. Outline a mechanism for the reaction of this electrophile with benzene.

[4 marks]

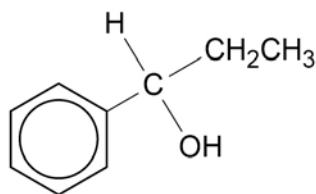
Equation $\text{CH}_3\text{CH}_2\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CH}_2\text{C}^+=\text{O} + \text{AlCl}_4^-$

Mechanism



07.2

The organic product in Question 07.1 can be converted into the alcohol shown.



Give the IUPAC name of the alcohol.

Give the reagent needed for this reaction and name the mechanism.

[3 marks]

IUPAC name 1-phenylpropan-1-ol

Reagent NaBH₄

Name of mechanism Nucleophilic addition

07.3

The alcohol shown in Question 07.2 reacts with ethanoyl chloride to form an ester.

Describe what would be observed when the alcohol reacts with ethanoyl chloride.

Name the mechanism for the reaction to form the ester.

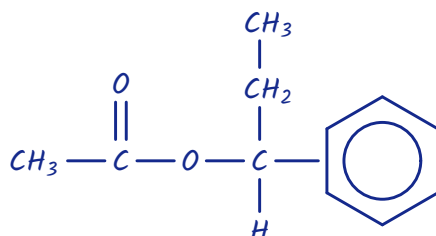
Draw the structure of the ester.

[3 marks]

Observation Misty (steamy) white fumes of HCl are given off.

Name of mechanism (Nucleophilic) addition-elimination

Structure of ester



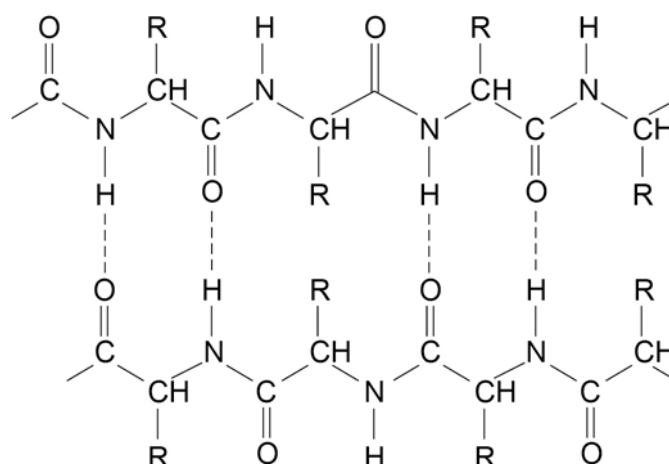
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0 8

Use the Data Booklet to help you answer this question about amino acids.
Figure 1 shows parts of two polypeptide chains in a beta-pleated sheet of a protein.

Figure 1

0 8 . 1

The polypeptide chains are held together by hydrogen bonding as shown in **Figure 1**.

Explain how these hydrogen bonds form.

[2 marks]

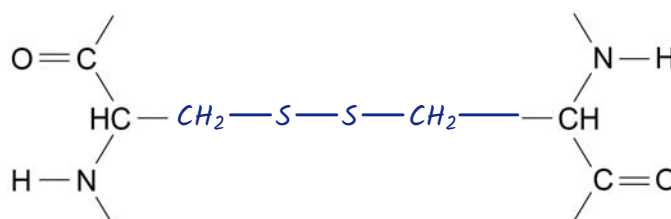
The H atom bonded to N is electron deficient ($\delta+$), because nitrogen is much more electronegative than hydrogen.

This $\delta+$ H atom is attracted to a lone pair of electrons on the $\delta-$ oxygen atom of a $C=O$ group in the other chain.

0 8 . 2

A different type of bond can form between two polypeptide chains when the chains each contain the amino acid cysteine.

Complete the structure to show the bond that forms between the side chains of two cysteine molecules.

[1 mark]

08.3

The type of bond in Question 08.2 between two polypeptide chains influences the three-dimensional structure of the protein.

Name this type of protein structure.

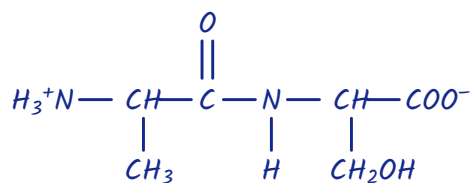
[1 mark]

Tertiary (structure)

08.4

Draw the structure of the zwitterion of a dipeptide formed by alanine and serine.

[2 marks]



6

Turn over for the next question

Turn over ►



0 9

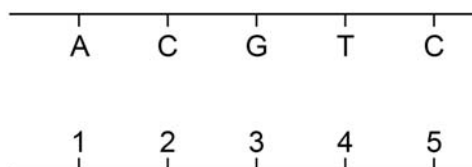
Use the Data Booklet to help you answer this question about DNA.

Figure 2 shows a fragment of a DNA double helix.

The letters A, C, G and T represent the four bases in one strand.

The numbers 1, 2, 3, 4 and 5 represent the bases in the complementary strand.

Figure 2



0 9 . 1

Complete **Table 4** to show the correct sequence of bases in the complementary strand represented by the numbers 1 to 5

[1 mark]

Table 4

1	2	3	4	5
T	G	C	A	G

0 9 . 2

Deduce the total number of hydrogen bonds formed between the five bases in each strand.

Tick (✓) **one** box.

[1 mark]

10	12	13	15
		✓	

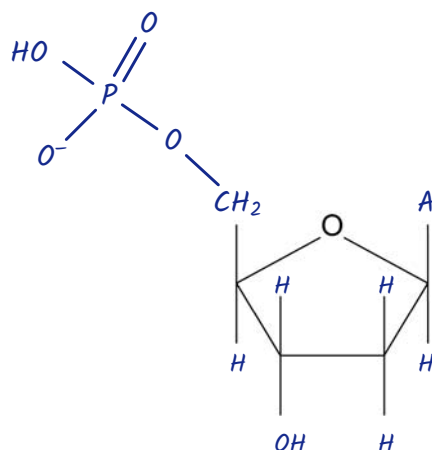


0 9 . 3

Base A is part of a nucleotide in the DNA strand shown in **Figure 2**.
A nucleotide contains a 2-deoxyribose molecule.
An incomplete 2-deoxyribose molecule is shown.

Complete the structure to show the nucleotide that contains base A.
You should represent base A by the letter A.

[2 marks]



 4

Turn over for the next question

Turn over ►

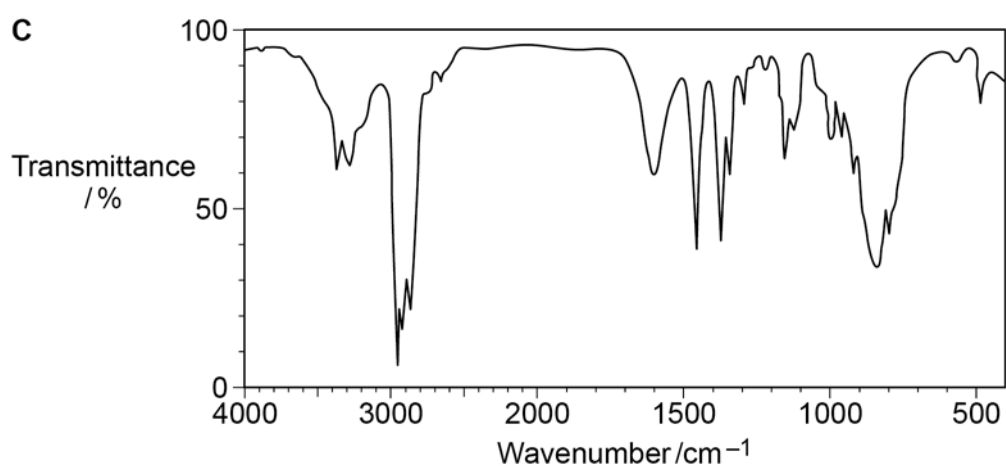
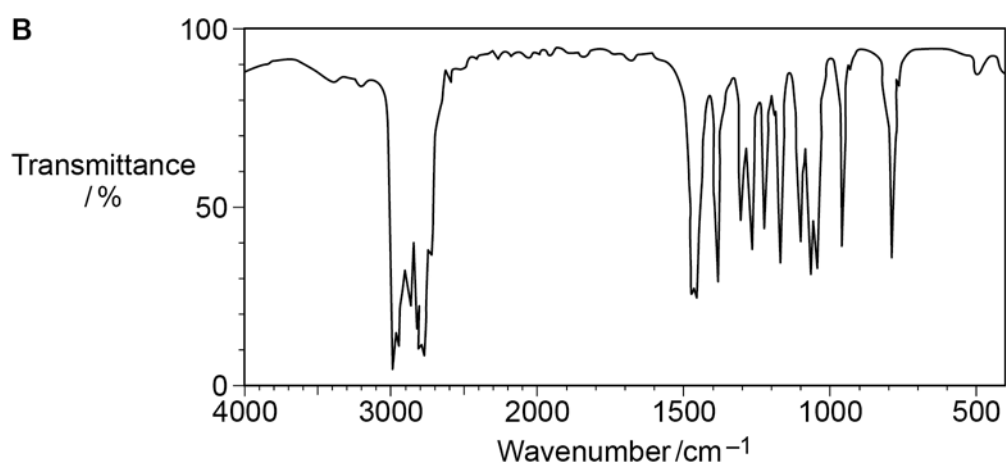
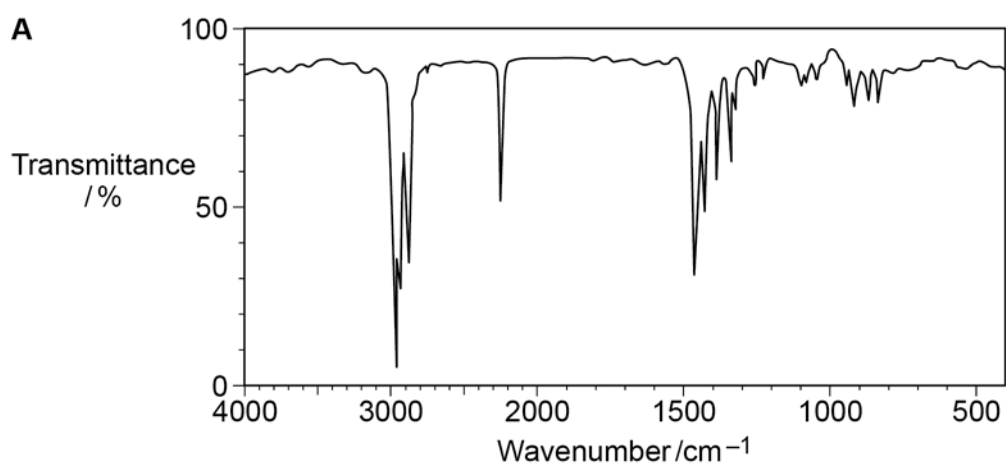


1 0

This question is about amines.

1 0 . 1

The infrared spectra **A**, **B** and **C** are those of a primary amine, a tertiary amine and a nitrile, but not necessarily in that order.



Give the letter of each compound in the correct box.

[1 mark]

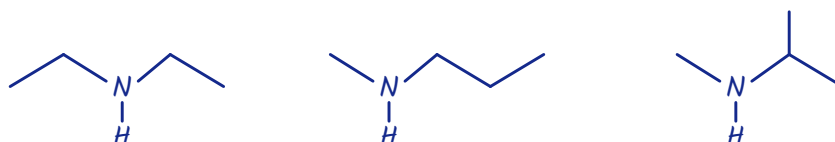
primary amine	tertiary amine	nitrile
<i>C</i>	<i>B</i>	<i>A</i>



1 0 . 2 There are **three** secondary amines that contain four carbon atoms per molecule.

Draw the skeletal formulas of these **three** secondary amines.

[2 marks]



1 0 . 3 Primary amines can be prepared by the reaction of halogenoalkanes with ammonia or by the reduction of nitriles.

Justify the statement that it is better to prepare primary amines from nitriles rather than from halogenoalkanes.

[2 marks]

With halogenoalkanes, the primary amine formed can react further with more halogenoalkane, giving secondary and tertiary amines and a quaternary ammonium salt, so a mixture of products (impure product) forms.

Reduction of a nitrile has no further reaction, so the primary amine is the only (single) product.

1 0 . 4 Draw the structure of a primary amine with four carbon atoms that **cannot** be formed from a nitrile.

[1 mark]



Turn over ►



1 0 . 5

A student dissolves a few drops of propylamine in 1 cm³ of water in a test tube.

Give an equation for the reaction that occurs.

Describe what is observed when Universal Indicator is added to this solution.

[2 marks]

Equation $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_3^+ + \text{OH}^-$

Observation The Universal Indicator turns (from green to) blue.

1 0 . 6

Phenylamine can be prepared by a process involving the reduction of nitrobenzene using tin and an excess of hydrochloric acid.

Give an equation for the reduction of nitrobenzene to form phenylamine. Use [H] to represent the reducing agent.

Explain why an aqueous solution is obtained in this reduction even though phenylamine is insoluble in water.

[2 marks]

Equation $\text{C}_6\text{H}_5\text{NO}_2 + 6[\text{H}] \rightarrow \text{C}_6\text{H}_5\text{NH}_2 + 2\text{H}_2\text{O}$

Explanation The phenylamine reacts with the excess HCl, so it is
present as an ionic salt, phenylammonium chloride ($\text{C}_6\text{H}_5\text{NH}_3^+\text{Cl}^-$), which
dissolves in water.

10

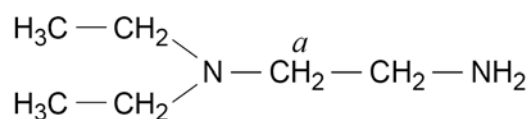


1 1

There are several isomers with the molecular formula $C_6H_{16}N_2$

1 1 . 1

One isomer is shown.

Give the number of peaks in the ^{13}C NMR spectrum of this isomer.State and explain the splitting pattern of the peak for the hydrogens labelled a in its ^1H NMR spectrum.**[3 marks]**Number of ^{13}C peaks 4Splitting pattern Triplet

Explanation The adjacent CH_2 group (on the neighbouring carbon) has two hydrogens, so the peak is split into $n + 1 = 3$. The N next to a has no H atoms, so causes no splitting.

1 1 . 2

Draw the structure of the isomer of $C_6H_{16}N_2$ used to make nylon 6,6**[1 mark]**

Question 11 continues on the next page

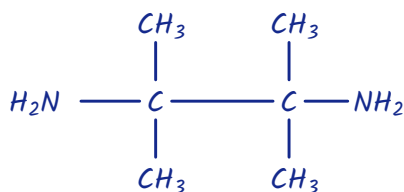
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1 1 . 3

Draw the structure of the isomer of $C_6H_{16}N_2$ that contains two **primary** amine groups and has only two peaks in its ^{13}C NMR spectrum.

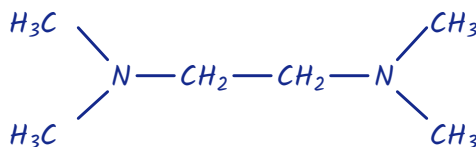
[1 mark]



1 1 . 4

Draw the structure of the isomer of $C_6H_{16}N_2$ that contains two **tertiary** amine groups and has only two peaks in its ^{13}C NMR spectrum.

[1 mark]



END OF QUESTIONS

6

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