AQA

Please write clearly in block capitals.

Centre number	
Candidate number	
Surname	MODEL ANSWERS
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	

Do not write outside the box

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]

$C_7H_{16} + 11\ O_2 \rightarrow 7CO_2 + 8H_2O$

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 or aluminosilicate

Condition slight 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.

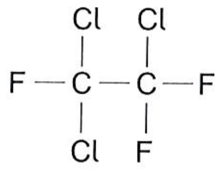
[2 marks]

$CH_3CH_2CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2\dot{C}HCH_3 + HCl$

$CH_3CH_2\dot{C}HCH_3 + Cl_2 \rightarrow CH_3CH_2CHClCH_3 + Cl\bullet$

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 $Cl\cdot$ M1

Explanation

$Cl\cdot + O_3 \rightarrow Cl\dot{O} + O_2$ M2

$Cl\dot{O} + O_3 \rightarrow Cl\cdot + 2O_2$ M3

$Cl\cdot$ is regenerated causing a chain reaction leading to the decomposition of ozone M4

10

Turn over for the next question

Do not write outside the box

0 2 Halogenoalkanes are useful compounds in synthesis. A reaction pathway is shown.

$$CH_2(OH)CH(CH_3)CH_2Br \xrightarrow[\text{NaOH}]{\text{Reaction 1}} CH_2(OH)CH(CH_3)CH_2OH$$

$$CH_2(OH)CH(CH_3)CH_2OH \xrightarrow{\text{Reaction 2}} \text{Compound Y } (C_4H_6O_2)$$

$$\text{Compound Z} \xleftarrow{\text{Reaction 3}} \text{Compound Y } (C_4H_6O_2)$$

0 2 . 1 Give the IUPAC name for $\overset{1}{C}H_2(OH)\overset{2}{C}H(CH_3)\overset{3}{C}H_2Br$

[1 mark]

3-bromo-(2)-methyl propan-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 M1
- carbon becomes partially positive (δ^+) M2
- lone pair on nucleophile attacks/attracted to partially positive carbon M3

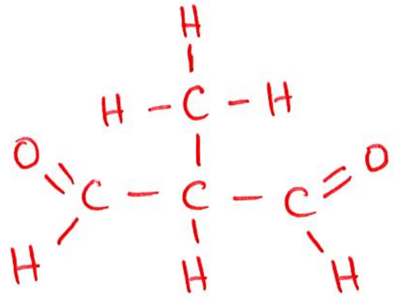
0 2 . 3 The infrared spectrum of Compound **Y** shows a significant absorption in the range 1680–1750 cm^{-1}

C=O

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

[1 mark]

Reaction 2 : oxidation of alc

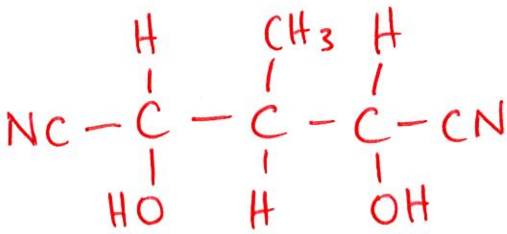


0 2 . 4 Compound **Z** has the empirical formula C_3H_4NO

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

[2 marks]

Structure



Reagent for Reaction **3** KCN / HCN + dil. acid

7

Turn over ►

Do not write outside the box

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 has dipole-dipole forces between the molecules M1

- Propan-1-ol and propanoic acid have hydrogen bonding between the molecules M2

- Dipole-dipole forces are weaker than hydrogen bonding (so propanal has a lower boiling point and will evaporate first) M3

Do not write outside the box

0 3 . 2 Give **two** ways of maximising the yield of propanal obtained by distillation of the reaction mixture.

[2 marks]

1 keep temperature of mixture below the boiling point of propan-1-ol | below 97°C

2 cool the distillate | collecting vessel

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 sodium (hydrogen)carbonate to a sample of the distillate M1
- effervescence would occur if propanoic acid was present M2

Alternatives: blue litmus → red

Question 3 continues on the next page

Do not write outside the box

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 C_2H_5OH

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 J K^{-1} g^{-1})

[3 marks]

$q = mc\Delta T$

$= 150 \times 4.18 \times 15.1$

$= 9467.7\,J \Rightarrow 9.4677\,kJ$ M1

$\Delta H = \frac{q}{n}$

n ethanol $= \frac{457 \times 10^{-3}}{46} = 9.93 \times 10^{-3}$ M2

$\Delta H = \frac{9.4677}{9.93 \times 10^{-3}} = 952.99$

Enthalpy of combustion -953 kJ mol^{-1} M3

(3 s.f. + negative)

allow -953 to -954

Do not write outside the box

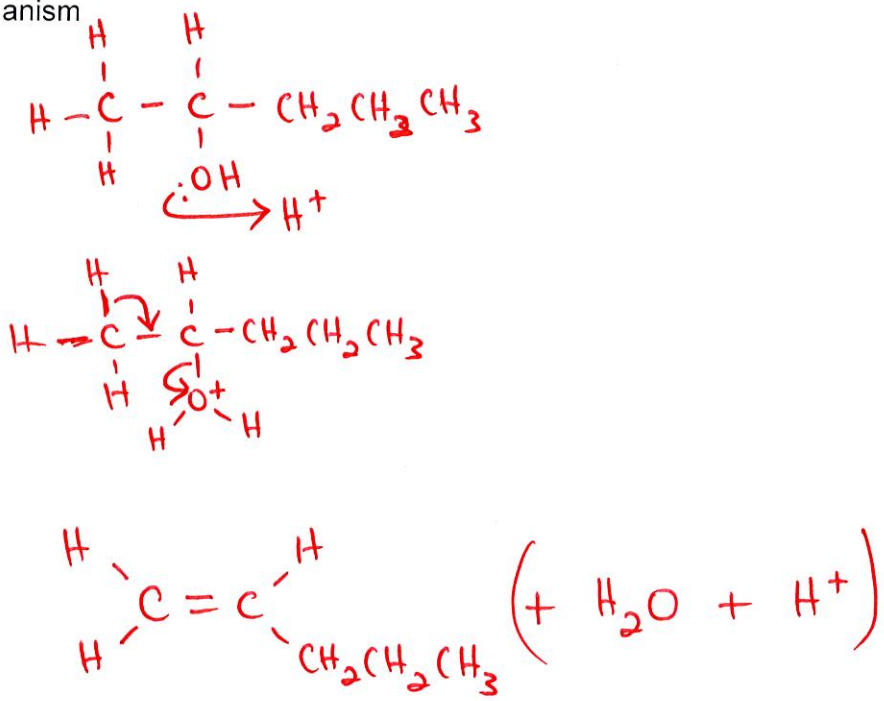
0 3 . 5 A mixture of isomeric alkenes is produced when pentan-2-ol is dehydrated in the presence of hot concentrated sulfuric acid. Pent-1-ene is one of the isomers produced.

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

[4 marks]

Name of mechanism elimination M1

Mechanism



M2

M3

M4

0 3 . 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 M1

Explanation

· restricted rotation of the C=C both for M2

· each carbon in the double bond has different groups attached

16

Do not write outside the box

0 4 Compounds **A** and **B** react together to form an equilibrium mixture containing compounds **C** and **D** according to the equation

$$2A + B \rightleftharpoons 3C + D$$

0 4 . 1 A beaker contained 40 cm^3 of a 0.16 mol dm^{-3} aqueous solution of **A**.
9.5×10^{-3} mol of **B** and 2.8×10^{-2} mol of **C** were added to the beaker and the mixture was left to reach equilibrium.
The equilibrium mixture formed contained 3.9×10^{-3} mol of **A**.

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

[5 marks]

	$2A$	+	B	$\rightleftharpoons$	$3C$	+	D
moles Initially	$0.16 \times 40 \times 10^{-3}$ $= 6.4 \times 10^{-3}$		9.5×10^{-3}		2.8×10^{-2}		0
moles eqm	3.9×10^{-3}						

change in moles A: $6.4 \times 10^{-3} - 3.9 \times 10^{-3} = 2.5 \times 10^{-3}$

change in moles B: $9.5 \times 10^{-3} - 1.25 \times 10^{-3} = 8.25 \times 10^{-3}$

change in moles C: $2.8 \times 10^{-2} + 3.75 \times 10^{-3} = 3.18 \times 10^{-2}$

change in moles D: $0 + 1.25 \times 10^{-3} = 1.25 \times 10^{-3}$

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]

$$K_c = \frac{[C]^3[D]}{[A]^2[B]} = \frac{(mol\ dm^{-3})^{\cancel{3}}\cancel{(mol\ dm^{-3})}}{\cancel{(mol\ dm^{-3})^2}\cancel{(mol\ dm^{-3})}}$$

Units $mol\ dm^{-3}$

Do not write outside the box

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 5.00×10^2 cm^3 of solution. Total volume $= 5 \times 10^2 \times 10^{-3} = 0.5 dm^3$
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]

$[B] = \frac{0.21}{0.5} = 0.42$

$[C] = \frac{1.05}{0.5} = 2.1$

$[D] = \frac{0.076}{0.5} = 0.152$

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

$[A]^2 = \frac{(2.1)^3 \times 0.152}{116 \times 0.42} = 0.0289$

$[A] = \sqrt{0.0289}$

Concentration of **A** 0.17 (2 s.f.) 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]

- concentration of all will decrease M1
- equilibrium will move to side with more moles (RHS) (so amount of A will be lower) M2
- to oppose decrease in concentration to keep K_c constant M3

13

Turn over ►

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 5 Bromate(V) ions and bromide ions react in acid conditions according to the equation

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

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.

$$rate = k[BrO_3^-][Br^-][H^+]^2$$

Table 2 shows an incomplete set of results.

Table 2

Experiment	Initial $[BrO_3^-]$ / mol dm^{-3}	Initial $[Br^-]$ / mol dm^{-3}	Initial $[H^+]$ / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} 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	0·26
4	0.10	0.10	0·46	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]

$$k = \frac{rate}{[BrO_3^-][Br^-][H^+]^2}$$

$$= \frac{2.4 \times 10^{-2}}{0.1 \times 0.2 \times 0.3^2} \qquad \frac{\cancel{mol\ dm^{-3}}\ s^{-1}}{(mol\ dm^{-3})(mol\ dm^{-3})(mol\ dm^{-3})^{\cancel{2}}}$$ M1

k 13 (2 s.f.) Units $mol^{-3}\ dm^{9}\ s^{-1}$ M2+M3

0 5 . 2 Complete **Table 2**.

[3 marks]

Space for working

$$2: [BrO_3^-] = \frac{rate}{k[Br^-][H^+]^2} = \frac{3.6 \times 10^{-2}}{13 \times 0.2 \times 0.3^2} = 0.15$$

$$3: rate = 13 \times 0.2 \times 0.4 \times 0.5^2 = 0.26$$

$$4: [H^+] = \sqrt{\frac{rate}{k[BrO_3^-][Br^-]}} = \sqrt{\frac{2.7 \times 10^{-2}}{13 \times 0.1 \times 0.1}} = 0.46$$

Question 5 continues on the next page

0 5 . 3 A second series of experiments was carried out to investigate how the rate of the reaction varies with temperature.

CHALLENGING

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} (x)	**Time, t / s**	$\frac{1}{t}$ / s^{-1}	$\ln \frac{1}{t}$ (y)
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

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

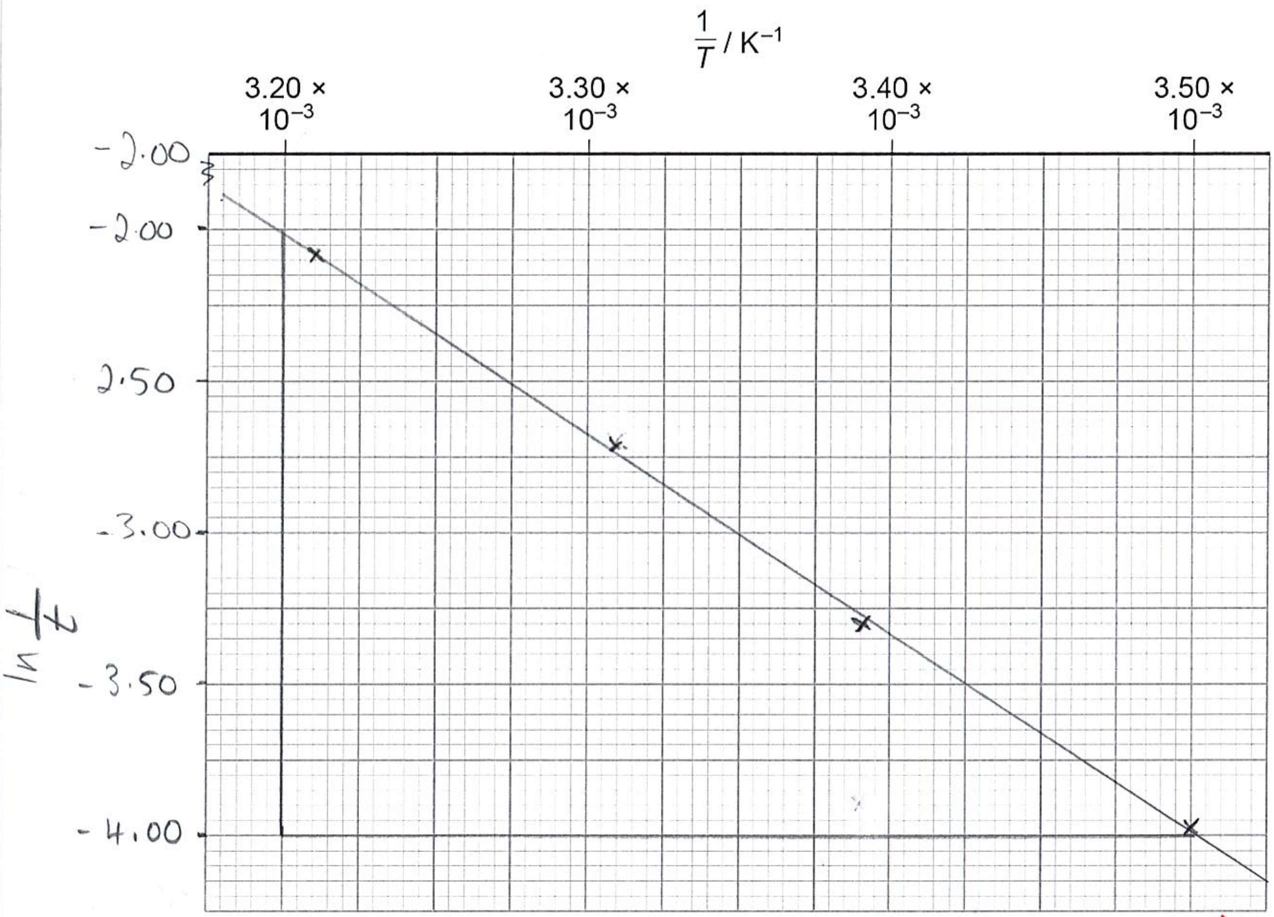
where C_1 and C_2 are constants.

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, $R = 8.31$ J K^{-1} mol^{-1}

[6 marks]



M1 = y axis labelled with values - plotted points over half axis

M2 = points plotted correctly +/- small square for line of best fit

M3

Gradient = $\frac{dy}{dx} = \frac{2-4}{3.5\times10^{-3} - 3.2\times10^{-3}} = \frac{-2}{3\times10^{-4}}$

$= -6.67 \times 10^{3}$ K (range: -6.5×10^{3} to -6.8×10^{3}) M4

Gradient = $-\frac{Ea}{R}$

Ea = -(gradient × R) M5

= 6.67 × 8.31

= 55.4 (range: 54.0 - 56.5)

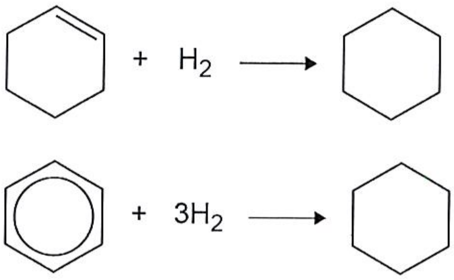
M6

Activation energy 55.4 kJ mol^{-1}

14

Do not write outside the box

0 6 Data about the hydrogenation of cyclohexene and of benzene are given.



$\Delta H^{\ominus} = -120\ \text{kJ mol}^{-1}$

$\Delta H^{\ominus} = -208\ \text{kJ mol}^{-1}$

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.

LEVELLED

[6 marks]

Bonding:

- Benzene forms an hexagonal ring with each carbon making 3 covalent bonds
- The spare electrons overlap (to form a π bond)
- They become delocalised

Shape:

- Benzene forms a planar molecule
- Hexagonal ring with identical bond angles 120°
- C-C bonds are equal in length between single and double bonds

Stability:

- Enthalpy of hydrogenation of theoretical triene can be calculated at $-360\ \text{kJ mol}^{-1}$
- Enthalpy of hydrogenation of benzene is lower by $152\ \text{kJ mol}^{-1}$
- Benzene is more stable (due to delocalisation) or benzene is lower in energy

Do not write outside the box

0 6 . 2 The enthalpy of hydrogenation of cyclohexa-1,3-diene is **not** exactly double that of cyclohexene.

CHALLENGING

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

[3 marks]

• (If double : $2 \times -120 = -240$)

Not exactly double so suggest $-200\ kJ\ mol^{-1}$ M1

(Range: -239 to -121)

• Two double bonds separated by single bond M2

• allows some delocalisation M3

9

Turn over ►

0 7 Acyl chlorides are useful reagents in synthesis. They react with aromatic compounds and also with alcohols.

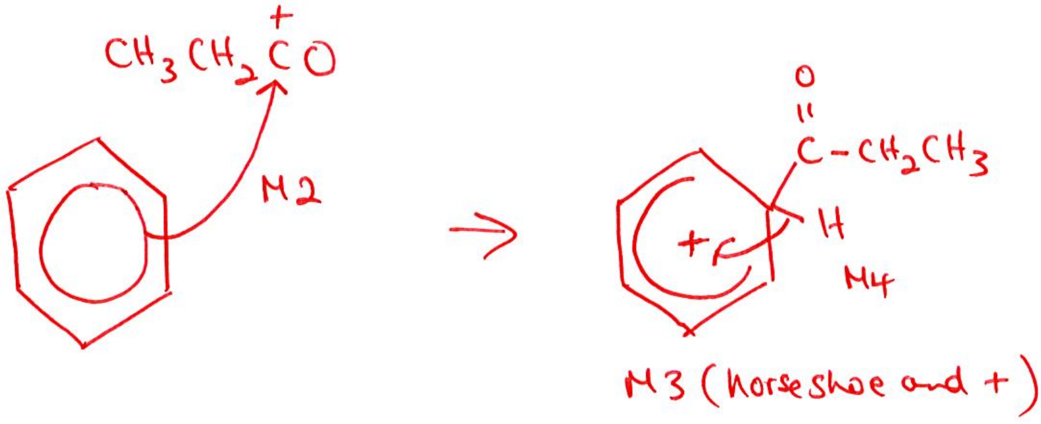
0 7 . 1 CH_3CH_2COCl reacts with benzene in the presence of $AlCl_3$ in an electrophilic substitution reaction.

Give an equation for the reaction of CH_3CH_2COCl with $AlCl_3$ to form the electrophile.
Outline a mechanism for the reaction of this electrophile with benzene.

[4 marks]

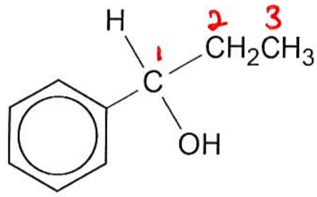
Equation $CH_3CH_2COCl + AlCl_3 \rightarrow CH_3CH_2\overset{+}{C}O + AlCl_4^-$ M1

Mechanism



Do not write outside the box

0 7 . 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 $NaBH_4$ / $LiAlH_4$ or H_2 with Ni

Name of mechanism nucleophilic addition ... or addition/hydrogenation

0 7 . 3 The alcohol shown in Question **07.2** reacts with ethanoyl chloride to form an ester.

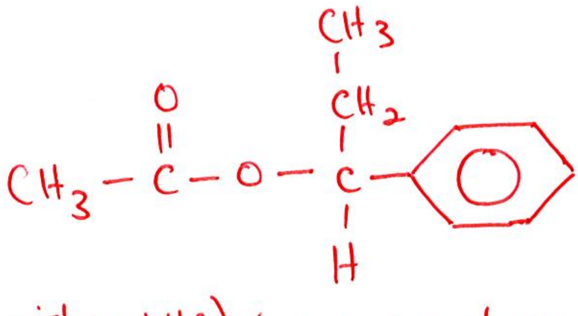
Describe what would be observed when the alcohol reacts with ethanoyl chloride.
Name the mechanism for the reaction to form the ester.
Draw the structure of the ester.

[3 marks]

Observation misty/steamy fumes (from HCl)

Name of mechanism (nucleophilic) addition-elimination

Structure of ester



(acid on LHS) (alcohol part on RHS)

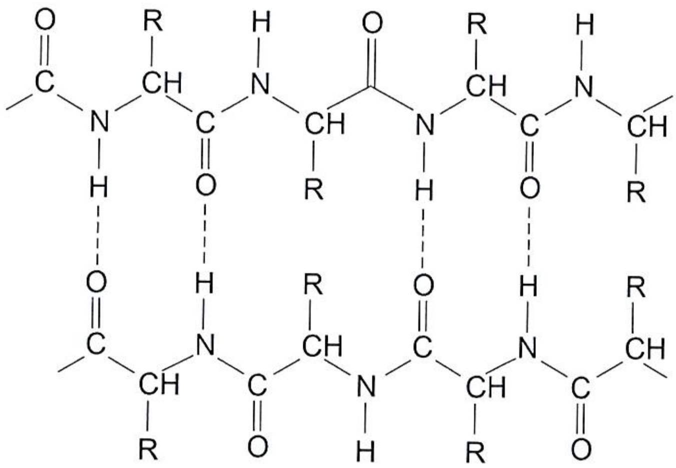
10

Turn over for the next question

Do not write outside the box

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]

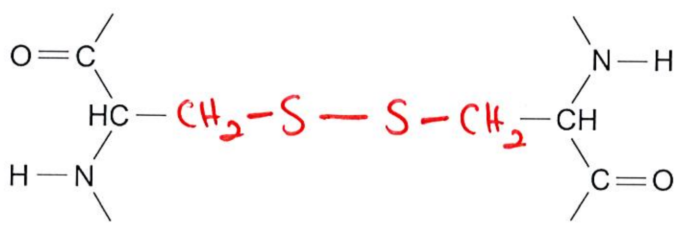
• hydrogen bonded to very electronegative nitrogen so electron is withdrawn towards nitrogen giving $H^{\delta+}$ M1

• lone pair of electrons on oxygen attracted towards $H^{\delta+}$ M2

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]



Do not write outside the box

0 8 . 3 The type of bond in Question **08.2** between two polypeptide chains influences the three-dimensional structure of the protein.

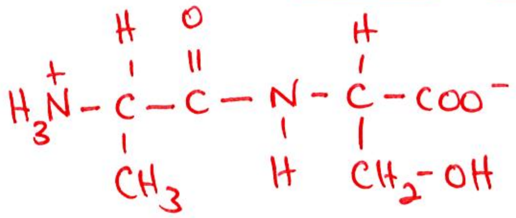
Name this type of protein structure.

[1 mark]

tertiary or quaternary

0 8 . 4 Draw the structure of the zwitterion of a dipeptide formed by alanine and serine.

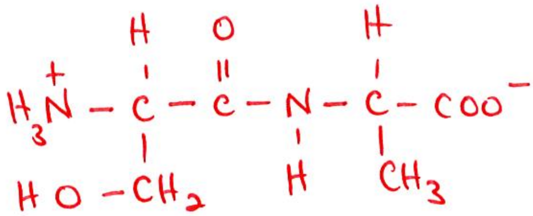
[2 marks]



M1 = dipep

M2 = charg

OR

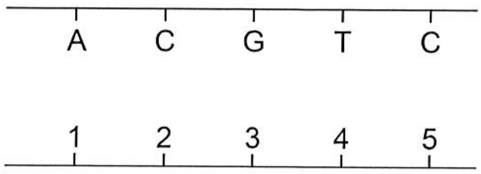


6

Turn over for the next question

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.

A = T
C ≡ G

Tick (✓) **one** box.

[1 mark]

10	12	13	15
		✓	

Do not write outside the box

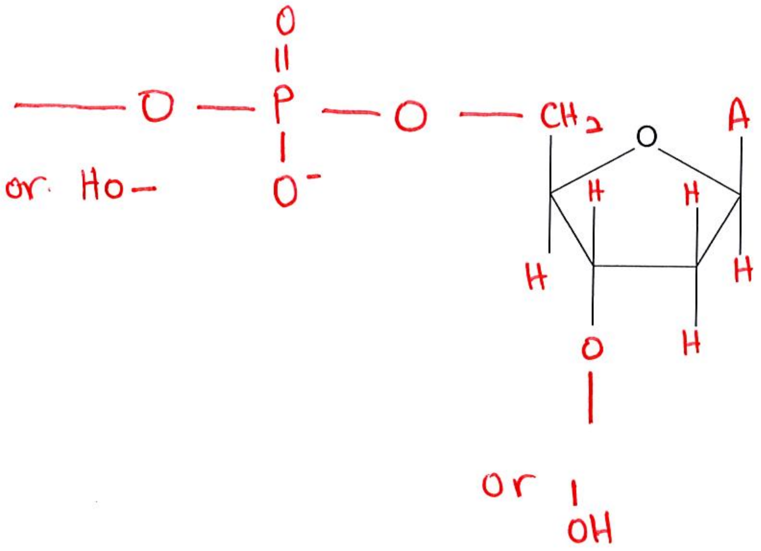
0 9 . 3 Base A is part of a nucleotide in the DNA strand shown in **Figure 2**.
A nucleotide contains a 2-deoxyribose molecule.
An incomplete 2-deoxyribose molecule is shown.

CHALLENGING

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

[2 marks]

M1 = 2-deoxyribose plus A
M2 = phosphate



4

Turn over for the next question

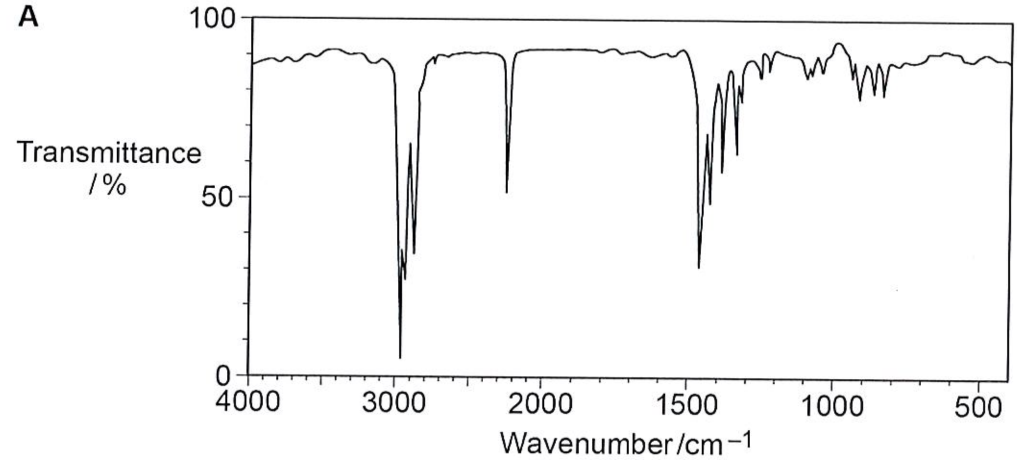
Do not write outside the box

1 0 This question is about amines.

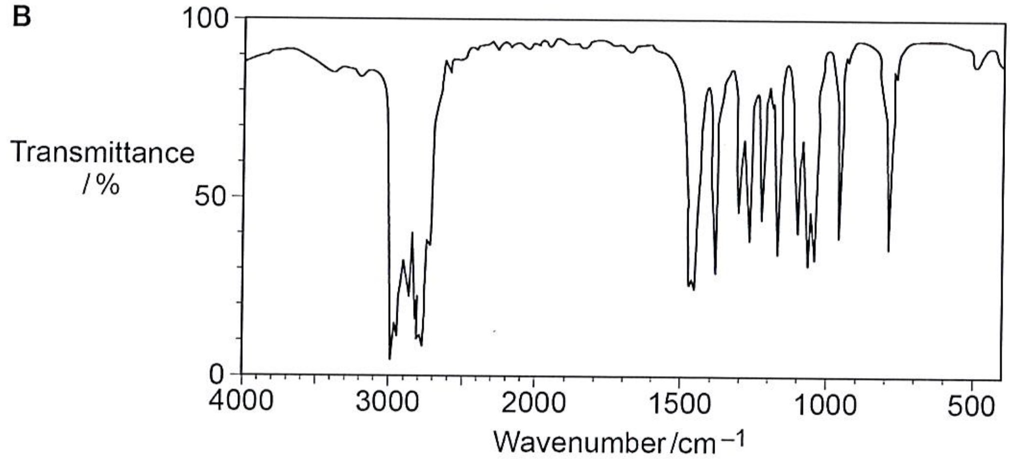
N-H no N-H

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.

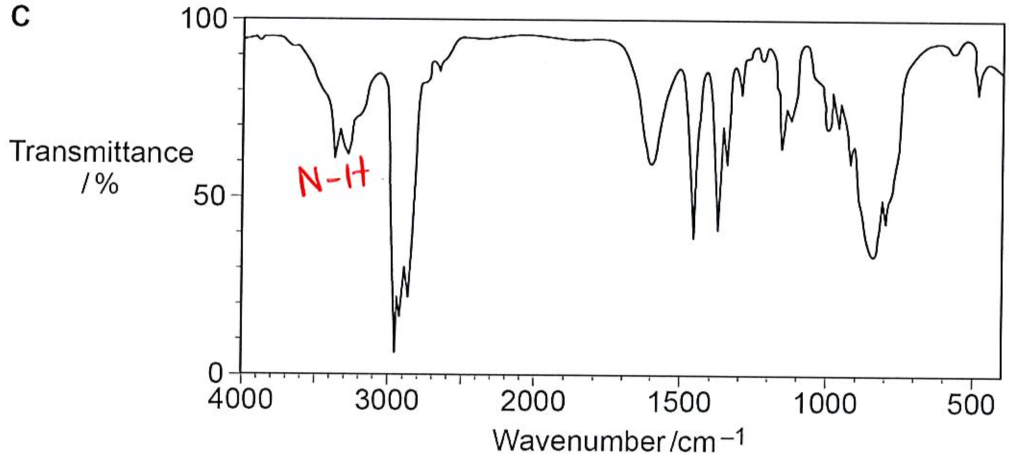
A



B



C



Give the letter of each compound in the correct box.

[1 mark]

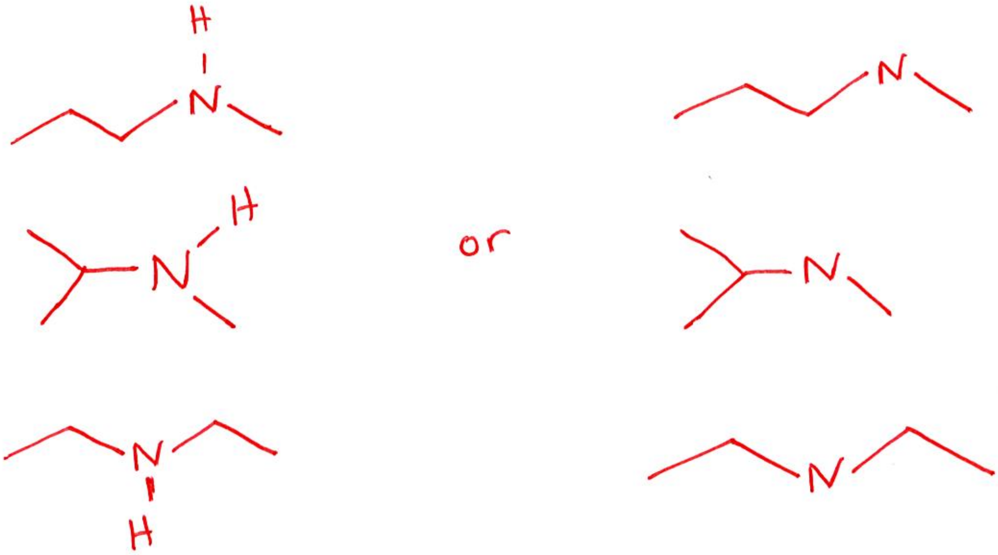
primary amine	tertiary amine	nitrile
C	B	A

Do not write outside the box

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.

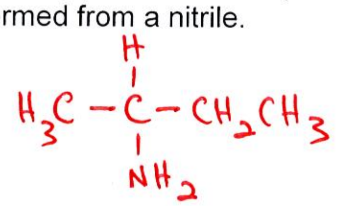
[2 marks]

• Reduction from nitriles produces only the 1° amine M1

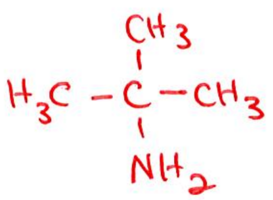
• Nucleophilic substitution of halogenoalkane with ammonia produces a mixture of amines due to further substitution M2

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

[1 mark]



or



Turn over ►

Do not write outside the box

1 0 . 5 A student dissolves a few drops of propylamine in 1 cm^3 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 $CH_3CH_2CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2CH_2\overset{+}{N}H_3 + OH^-$

Observation turn 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]

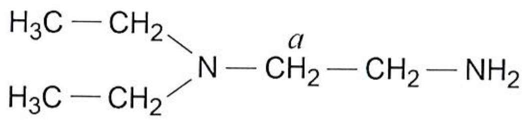
Equation $C_6H_5NO_2 + 6[H] \rightarrow C_6H_5NH_2 + 2H_2O$

Explanation phenylamine exists as an ionic salt $C_6H_5\overset{+}{N}H_3$

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 ^{1}H NMR spectrum.

[3 marks]

Number of ^{13}C peaks 4

Splitting pattern triplet

Explanation adjacent C has two Hs

1 1 . 2 Draw the structure of the isomer of $C_6H_{16}N_2$ used to make nylon 6,6

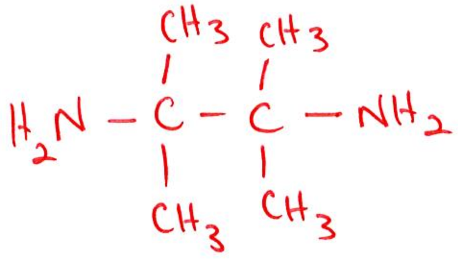
[1 mark]

$H_2N-(CH_2)_6-NH_2$

Question 11 continues on the next page

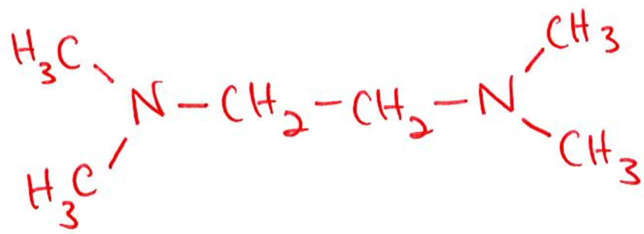
1 1 . 3 Draw the structure of the isomer of $C_6H_{16}N_2$ that contains two **primary** amine groups and has only two peaks in its ^{13}C NMR spectrum.

[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]



6

END OF QUESTIONS