

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS CHEMISTRY (9620)

Unit 2: Organic 1 and Physical 1

Monday 20 January 2020 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- 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 blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- 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 70.

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



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

0 1

Hydrocarbon **A** is obtained by the cracking of an alkane.

0 1 . 1

State what is meant by the term cracking.

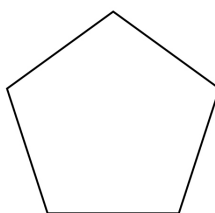
Give **one** reason why some alkanes are cracked.

[2 marks]

Meaning of the term cracking Breaking long-chain alkanes (breaking C-C bonds) into smaller, more useful molecules.

Reason for cracking Smaller molecules (e.g. petrol) are in greater demand and more valuable than long-chain alkanes.

The skeletal formula of **A** is shown.



0 1 . 2

Draw the skeletal formula of an isomer of **A** that is **not** a cyclic alkane.

[1 mark]



0 1 . 3

Identify a reagent that can be used in a simple test-tube reaction to distinguish between **A** and an isomer of **A** that is **not** a cyclic alkane.

State what is observed.

[3 marks]

Reagent Bromine water, Br₂(aq)

Observation with **A** No visible change (the solution stays orange-brown).

Observation with an isomer of **A** that is **not** a cyclic alkane The bromine water decolourises: orange-brown to colourless.

0 1 . 4

A cracking reaction forms **A**, ethane and ethene in a 1:1:2 ratio.

Write an equation for this reaction.

[1 mark]



7

Turn over for the next question

Turn over ►



0 2

This question is about some reactions of propene.

Propene reacts with hydrogen bromide to form two different products.

0 2 . 1

Name the mechanism for this reaction.

[1 mark]

Electrophilic addition

0 2 . 2

Draw the skeletal formula of the major product formed in the reaction of propene with hydrogen bromide.

Explain why this is the major product.

[3 marks]

Skeletal formula



Explanation *It forms via the secondary carbocation, $\text{CH}_3\text{C}^+\text{HCH}_3$, which is more stable than the primary carbocation, $\text{CH}_3\text{CH}_2\text{CH}_2^+$.*

The positive carbon has two electron-releasing alkyl (methyl) groups attached, which push electron density towards it and stabilise the positive charge.

0 2 . 3

Propene can form poly(propene).

Explain why propene is reactive and poly(propene) is **not** reactive.

[2 marks]

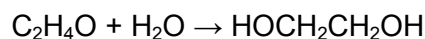
Propene has a $\text{C}=\text{C}$ double bond, an area of high electron density that attracts electrophiles.

Poly(propene) is saturated: it only has strong, non-polar $\text{C}-\text{C}$ and $\text{C}-\text{H}$ bonds, so it does not attract electrophiles.



0 3

In **acidic** conditions, epoxyethane reacts with water to form ethane-1,2-diol.



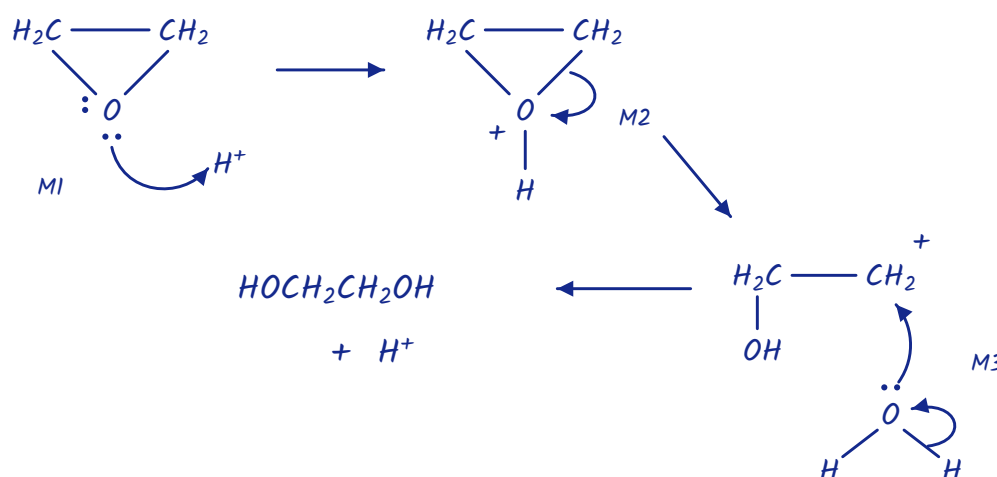
0 3 . 1

Outline the mechanism for this reaction.

Give **one** use of ethane-1,2-diol.

[4 marks]

Mechanism



Use As antifreeze (or to make polyesters)

0 3 . 2

A sample of 4.3 g of epoxyethane reacts with an excess of water to form 4.6 cm³ of ethane-1,2-diol.

Calculate the percentage yield for the formation of ethane-1,2-diol.

The density of ethane-1,2-diol is 1.11 g cm⁻³

[4 marks]

$$M_r(\text{C}_2\text{H}_4\text{O}) = 44.0, n = 4.3 \div 44.0 = 0.0977 \text{ mol}$$

$$M_r(\text{HOCH}_2\text{CH}_2\text{OH}) = 62.0$$

$$\text{max mass of diol} = 0.0977 \times 62.0 = 6.06 \text{ g}$$

$$\text{max volume} = 6.06 \div 1.11 = 5.46 \text{ cm}^3$$

$$\% \text{ yield} = (4.6 \div 5.46) \times 100 = 84.3 \%$$

Percentage yield 84.3 %

8

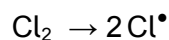
Turn over ►



0 4

This question is about halogenoalkanes.

The first step in the mechanism of the reaction between chlorine and methane to form chloromethane is shown.



0 4 . 1

Name the mechanism of the reaction to form chloromethane from methane.

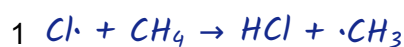
[1 mark]

Free-radical substitution

0 4 . 2

Give equations for two steps in this reaction that involve $\text{Cl}^\bullet$ as a reactant.

[2 marks]

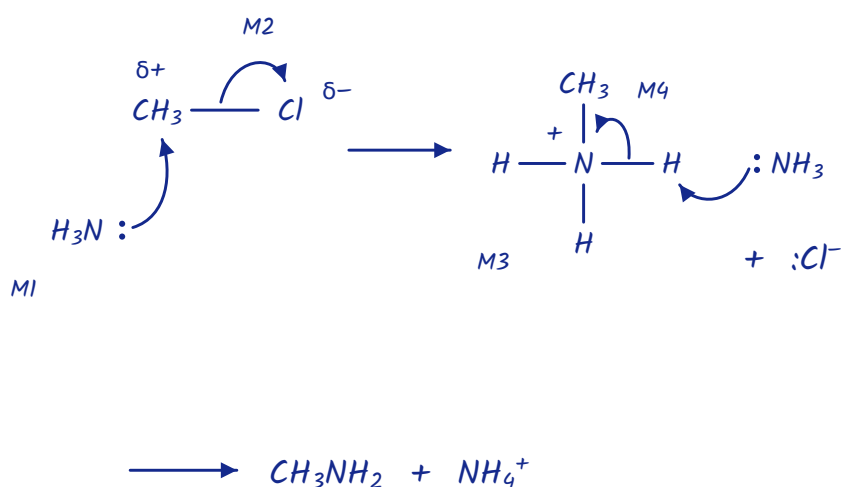


0 4 . 3

Chloromethane reacts with an excess of ammonia.

Outline a mechanism for this reaction.

[4 marks]



0 4 . 4

Cyanide acts as a nucleophile in the reaction between potassium cyanide and chloromethane.

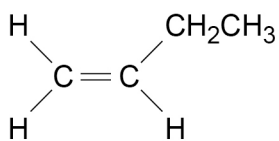
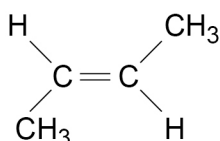
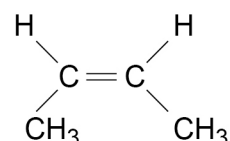
State why cyanide is able to act as a nucleophile in this reaction.

[1 mark]

The carbon atom in the cyanide ion has a lone pair of electrons (and a negative charge) that it can donate to the δ^+ carbon atom.



Hydroxide ions react with 2-chlorobutane to form the three isomers shown.

**P****Q****R**

0 4 . 5 State the role of hydroxide ions in this reaction.

[1 mark]

It acts as a base (proton, H^+ , acceptor).

0 4 . 6 **P** and **Q** are isomers.

Name this type of isomerism.

[1 mark]

Positional (position) isomerism

0 4 . 7 **Q** and **R** are stereoisomers.

Define the term stereoisomers.

[2 marks]

Compounds with the same structural formula (same molecular formula and same order of bonding of atoms) but a different arrangement of the atoms in space.

0 4 . 8 **R** is Z-but-2-ene.

State why **R** is the Z isomer.

[1 mark]

The higher priority CH_3 groups are on the same side of the $\text{C}=\text{C}$.

Turn over ►



0 5

This question is about alcohols and their oxidation products.

0 5 . 1

Some alcohols can be oxidised.

Identify a suitable oxidising agent.

State the colour change observed in the oxidation.

[2 marks]

Oxidising agent Acidified potassium dichromate(VI)Colour change Orange to green

0 5 . 2

Butan-1-ol is oxidised to form an aldehyde.

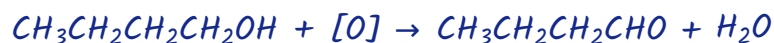
Write an equation for this reaction.

You should use [O] to represent the oxidising agent.

State how the aldehyde is obtained from the reaction mixture.

[2 marks]

Equation



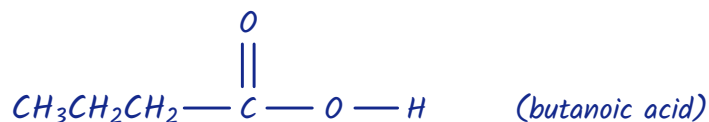
How aldehyde is obtained

Distil the aldehyde off as soon as it forms (distillation).

0 5 . 3

Draw the structure of the carboxylic acid formed by the oxidation of butan-1-ol.

[1 mark]



0 5 . 4

Use IUPAC rules to name the organic compound formed when butan-2-ol is oxidised.

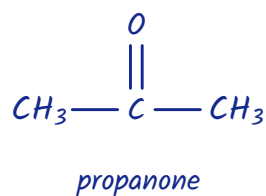
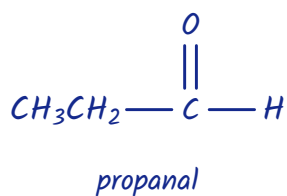
[1 mark]

Butanone

0 5 . 5

Compounds **S** and **T** are isomers with $M_r = 58.0$ When heated with Tollens' reagent, **S** forms a silver mirror but **T** does not.Draw the structures of **S** and **T**.

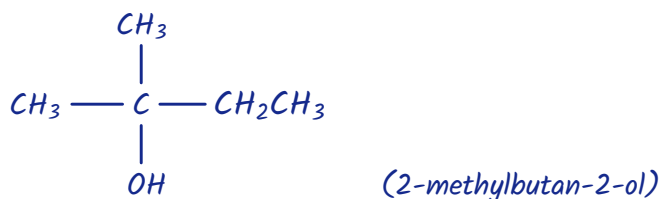
[2 marks]

S**T**

0 5 . 6

Draw the structure of the alcohol with molecular formula $\text{C}_5\text{H}_{12}\text{O}$ that is **not** easily oxidised.

[1 mark]



Question 5 continues on the next page

Turn over ►



0 5 . 7

Compound **U** has $M_r = 60.0$ The infrared spectrum of **U** has absorptions in the ranges $2500\text{--}3000\text{ cm}^{-1}$ and $1680\text{--}1750\text{ cm}^{-1}$ Name compound **U**.Identify a reagent that can be used in a simple test-tube reaction to confirm the presence of the functional group in **U**.

State what is observed.

[3 marks]Name of **U** Ethanoic acidReagent Sodium carbonate solution, $\text{Na}_2\text{CO}_3(\text{aq})$ Observation Effervescence (fizzing): a colourless gas, CO_2 , is given off

0 5 . 8

Which compound is a secondary alcohol?

Tick (✓) **one** box.**[1 mark]**

2,2-dimethylpropan-1-ol

☐

2,3-dimethylbutan-2-ol

☐

3,3-dimethylpentan-2-ol

☒

13

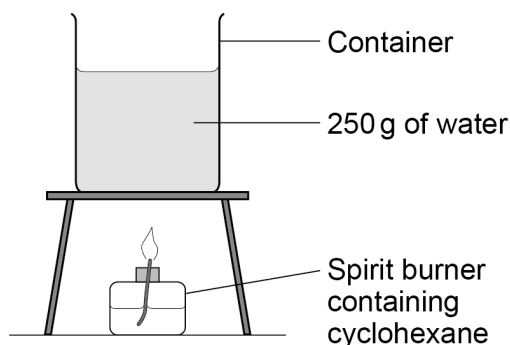


0 6

This question is about cyclohexane, C_6H_{12}

0 6 . 1

A student collects data to calculate the enthalpy of combustion of liquid cyclohexane.



Method

- Weigh the spirit burner containing the cyclohexane and place it under the container of water.
- Measure the initial temperature of the water.
- Allow the cyclohexane to burn for five minutes.
- Measure the maximum temperature of the water.
- Reweigh the spirit burner containing the cyclohexane.

Results

Initial temperature of water	18.5 °C
Maximum temperature of water	49.0 °C
Mass of cyclohexane burned	1.51 g

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

The specific heat capacity of water, $c = 4.18 \text{ J K}^{-1} \text{ g}^{-1}$
 You should ignore the heat capacity of the container.

[4 marks]

$$\Delta T = 49.0 - 18.5 = 30.5 \text{ K}$$

$$q = mc\Delta T = 250 \times 4.18 \times 30.5 = 31\,873 \text{ J} = 31.9 \text{ kJ}$$

$$n(C_6H_{12}) = 1.51 \div 84.0 = 0.0180 \text{ mol}$$

$$\Delta H = -31.873 \div 0.0180 = -1773 \text{ kJ mol}^{-1}$$

Enthalpy of combustion -1773 kJ mol^{-1}

Turn over ►



A value for the enthalpy of combustion of cyclohexane can be calculated from mean bond enthalpy data.

0 6 . 2

Define the term mean bond enthalpy.

[1 mark]

The energy needed to break one mole of a particular covalent bond (in the gas phase), averaged over many different compounds.

0 6 . 3

Cyclohexane (C₆H₁₂) burns in oxygen as shown.

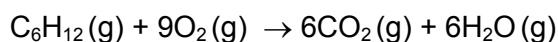


Table 1 shows some mean bond enthalpy data.

Table 1

	C—C	C—H	O=O	C=O	O—H
Mean bond enthalpy / kJ mol ⁻¹	348	412	496	743	463

Use the equation and the data in **Table 1** to calculate a value for the enthalpy of combustion, in kJ mol⁻¹, of cyclohexane.

[3 marks]

$$\text{bonds broken} = 6 \text{ C-C} + 12 \text{ C-H} + 9 \text{ O=O}$$

$$= (6 \times 348) + (12 \times 412) + (9 \times 496) = 11\,496$$

$$\text{bonds made} = 12 \text{ C=O} + 12 \text{ O-H}$$

$$= (12 \times 743) + (12 \times 463) = 14\,472$$

$$\Delta H = \Sigma(\text{broken}) - \Sigma(\text{made}) = 11\,496 - 14\,472$$

$$\Delta H = -2976 \text{ kJ mol}^{-1}$$

Enthalpy of combustion -2976 kJ mol⁻¹



06.4

The enthalpy of combustion value calculated using bond enthalpy data in **Question 06.3** is different from the value calculated in the experiment in **Question 06.1**.

Give **two** reasons why these values are different.

[2 marks]

Reason 1 Heat is lost to the surroundings (and to the container) in the experiment.

Reason 2 Combustion is incomplete in the experiment, but the calculation assumes complete combustion.

10

Turn over for the next question

Turn over ►



07Compound **Y** was analysed in a combustion experiment.**07.1**Complete combustion of 0.220 g of **Y** formed 0.524 g of carbon dioxide and 0.267 g of water.Calculate the percentage by mass of carbon and of hydrogen in **Y**.**[3 marks]**

$$\text{mass of C} = 0.524 \times 12.0 \div 44.0 = 0.143 \text{ g}$$

$$\text{mass of H} = 0.267 \times 2.0 \div 18.0 = 0.0297 \text{ g}$$

$$\% \text{ C} = (0.143 \div 0.220) \times 100 = 65.0 \%$$

$$\% \text{ H} = (0.0297 \div 0.220) \times 100 = 13.5 \%$$

C 65.0 %H 13.5 %**07.2**Compound **Y** contains carbon, hydrogen and oxygen only.Use your answers to **Question 07.1** to calculate the empirical formula of **Y**.(If you were unable to answer **Question 07.1** you should use the values 68.1% carbon and 13.7% hydrogen. These are **not** the correct values.)**[3 marks]**

$$\% \text{ O} = 100 - 65.0 - 13.5 = 21.5 \%$$

$$\text{C} : \text{H} : \text{O} = 65.0 \div 12.0 : 13.5 \div 1.0 : 21.5 \div 16.0$$

$$= 5.42 : 13.5 : 1.34$$

$$\div 1.34: 4.03 : 10.0 : 1 = 4 : 10 : 1$$

Empirical formula C₄H₁₀O

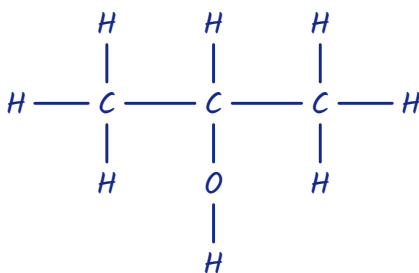
0 7 . 3

Compound **Y** and compound **Z** both have an absorption at 3330 cm^{-1} in their infrared spectra.

Z is a symmetrical molecule with molecular formula $\text{C}_3\text{H}_8\text{O}$

Draw the displayed formula of **Z**

[1 mark]



 7

Turn over for the next question

Turn over ►



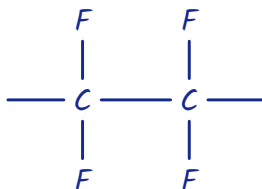
0	8
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The polymer poly(tetrafluoroethene) is made from the monomer C_2F_4

0	8	.	1
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Draw the repeating unit of poly(tetrafluoroethene).

[1 mark]



0	8	.	2
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Define the term standard enthalpy of formation.

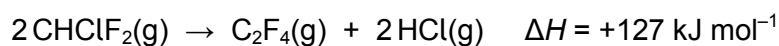
[2 marks]

The enthalpy change when one mole of a substance is formed from its elements, with all substances in their standard states (100 kPa, 298 K).



0 8 . 3

The monomer C_2F_4 can be made as shown in the equation.



Some standard enthalpies of formation are shown.

Substance	$C_2F_4(g)$	$HCl(g)$
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	-658	-92.3

Calculate the standard enthalpy of formation, in kJ mol^{-1} , of $CHClF_2$

Give your answer to 3 significant figures.

[3 marks]

$$\Delta H = \Sigma \Delta_f H(\text{products}) - \Sigma \Delta_f H(\text{reactants})$$

$$+127 = [-658 + 2(-92.3)] - 2\Delta_f H(CHClF_2)$$

$$2\Delta_f H(CHClF_2) = -842.6 - 127 = -969.6$$

$$\Delta_f H(CHClF_2) = -969.6 \div 2 = -484.8$$

$$= -485 \text{ kJ mol}^{-1} \text{ (3 s.f.)}$$

Enthalpy of formation -485 kJ mol^{-1}

6

END OF QUESTIONS



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