2.7 Organic Chemistry: 30-minute Pack

AQA 7405 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question is about naming organic compounds and identifying different types of structural isomerism.

(a) Give the IUPAC name of the following compound: CH_3-CH_2-$CH(CH_3)$-CH_2-OH **(2)**

(b) State the molecular formula of 2-methylbutan-1-ol, and give the structural formula of a chain isomer of this compound that is still an alcohol. **(2)**

(c) 1-Methoxybutane, CH_3-O-$CH_2CH_2CH_2CH_3$, is also an isomer of 2-methylbutan-1-ol. State the molecular formula of 1-methoxybutane, identify the type of isomerism shown between 1-methoxybutane and 2-methylbutan-1-ol, and explain your answer by reference to the functional groups present in each. **(3)**

(d) Define the term structural isomers. **(2)**

(Total for Question 1 is 9 marks)

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2 This question is about alkane combustion and the free-radical substitution reaction between methane and chlorine.

(a) Write a balanced symbol equation for the complete combustion of propane, C_3H_8, in a plentiful supply of oxygen. **(2)**

(b) Incomplete combustion of hydrocarbon fuels in car engines can produce carbon monoxide gas. Explain why the formation of carbon monoxide is hazardous to health. **(2)**

(c) Methane reacts with chlorine gas in the presence of ultraviolet (UV) radiation, via a free-radical substitution mechanism, to form chloromethane. Write an equation for the initiation step of this reaction. **(1)**

(d) Write equations for the two propagation steps that lead to the formation of chloromethane. **(2)**

(e) Suggest why this reaction typically produces a mixture of chlorinated products (such as CH_2Cl_2 and $CHCl_3$), rather than pure chloromethane. **(2)**

(Total for Question 2 is 9 marks)

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3 Halogenoalkanes can undergo nucleophilic substitution or elimination reactions, and the carbon-halogen bond strength affects their reactivity.

(a) 1-chlorobutane, 1-bromobutane and 1-iodobutane are each warmed with aqueous silver nitrate dissolved in ethanol. State and explain the order in which precipitates form, in terms of carbon-halogen bond enthalpy. **(3)**

(b) 2-bromopropane can react with hydroxide ions to form either a substitution product (propan-2-ol) or an elimination product (propene), depending on the conditions used. Give the reagent and solvent, and state the type of mechanism, that would favour nucleophilic substitution to form propan-2-ol. **(2)**

(c) Give the reagent and solvent, and state the type of mechanism, that would favour elimination of 2-bromopropane to form propene. **(2)**

(Total for Question 3 is 7 marks)

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Mark scheme · 2.7 Organic Chemistry: 30-minute Pack

Question 1

(a) longest carbon chain containing the -OH group correctly identified as a 4-carbon (butan-1-ol) chain **B1**

(a) 2-methylbutan-1-ol cao (correct locant and stem name) **B1**

(a) Answer: 2-methylbutan-1-ol

(b) $C_5H_{12}O$ cao **B1**

(b) any valid structural (chain) isomer that is an alcohol with formula $C_5H_{12}O$, e.g. pentan-1-ol ($CH_3CH_2CH_2CH_2CH_2OH$), pentan-2-ol, pentan-3-ol or 2,2-dimethylpropan-1-ol; must show a different carbon skeleton, not the same compound as (a) **B1**

(b) Answer: $C_5H_{12}O$; e.g. pentan-1-ol, $CH_3CH_2CH_2CH_2CH_2OH$

(c) $C_5H_{12}O$ cao (same molecular formula as 2-methylbutan-1-ol) **B1**

(c) functional group isomerism **B1**

(c) 2-methylbutan-1-ol contains an -OH (alcohol) functional group, whereas 1-methoxybutane contains a C-O-C (ether) linkage; same molecular formula but different functional groups oe **B1**

(c) Answer: $C_5H_{12}O$; functional group isomerism, because one compound is an alcohol (-OH) and the other is an ether (C-O-C), with the same molecular formula.

(d) compounds with the same molecular formula **B1**

(d) but a different structural arrangement of atoms (different connectivity/structural formula) oe **B1**

(d) Answer: Compounds with the same molecular formula but a different arrangement of atoms (different structural formula).

Question 2

(a) correct formulae for products, CO_2 and H_2O **M1**

(a) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$, correctly balanced cao **A1**

(a) Answer: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

(b) carbon monoxide binds to haemoglobin in red blood cells (forming carboxyhaemoglobin) in preference to oxygen **B1**

(b) this reduces the oxygen-carrying capacity of the blood, starving cells/tissues of oxygen, which can be toxic/fatal oe **B1**

(b) Answer: CO binds to haemoglobin in place of oxygen, reducing the oxygen-carrying capacity of the blood; this can starve cells of oxygen and is toxic.

(c) $Cl_2 \rightarrow Cl^* + Cl^*$ (homolytic fission of Cl-Cl, forming two chlorine radicals), initiated by UV light cao **B1**

(c) Answer: $Cl_2 \rightarrow 2Cl^*$ (homolytic fission, initiated by UV light)

(d) $CH_4 + Cl^* \rightarrow CH_3^* + HCl$ **M1**

(d) $CH_3^* + Cl_2 \rightarrow CH_3Cl + Cl^*$ cao (both equations needed, radical regenerated in step 2) **A1**

(d) Answer: Step 1: $CH_4 + Cl^* \rightarrow CH_3^* + HCl$. Step 2: $CH_3^* + Cl_2 \rightarrow CH_3Cl + Cl^*$.

(e) chloromethane formed can itself undergo further free-radical substitution with Cl_2 (the propagation steps can repeat on the substituted product) oe **B1**

(e) to minimise this and favour monosubstitution, methane is used in a large excess relative to chlorine oe **B1**

(e) Answer: Chloromethane can react further with Cl_2 in a repeat of the propagation steps, giving CH_2Cl_2, $CHCl_3$ etc; using excess methane favours monosubstitution.

Question 3

(a) 1-iodobutane reacts fastest (precipitate forms first), then 1-bromobutane, then 1-chlorobutane (slowest) cao **B1**

(a) the C-I bond has the lowest bond enthalpy (is the weakest) of the three carbon-halogen bonds; C-Cl has the highest bond enthalpy (strongest) **B1**

(a) the weaker the C-X bond, the more easily it is broken, so the faster the nucleophilic substitution by water occurs oe **B1**

(a) Answer: Rate: iodide > bromide > chloride, because the C-I bond has the lowest bond enthalpy (weakest bond) and the C-Cl bond has the highest bond enthalpy (strongest bond).

(b) aqueous NaOH (or KOH), warmed **B1**

(b) nucleophilic substitution cao **B1**

(b) Answer: Aqueous NaOH (or KOH), warmed; nucleophilic substitution.

(c) NaOH (or KOH) dissolved in ethanol, heated under reflux **B1**

(c) elimination cao **B1**

(c) Answer: NaOH (or KOH) in ethanol, heated under reflux; elimination.

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