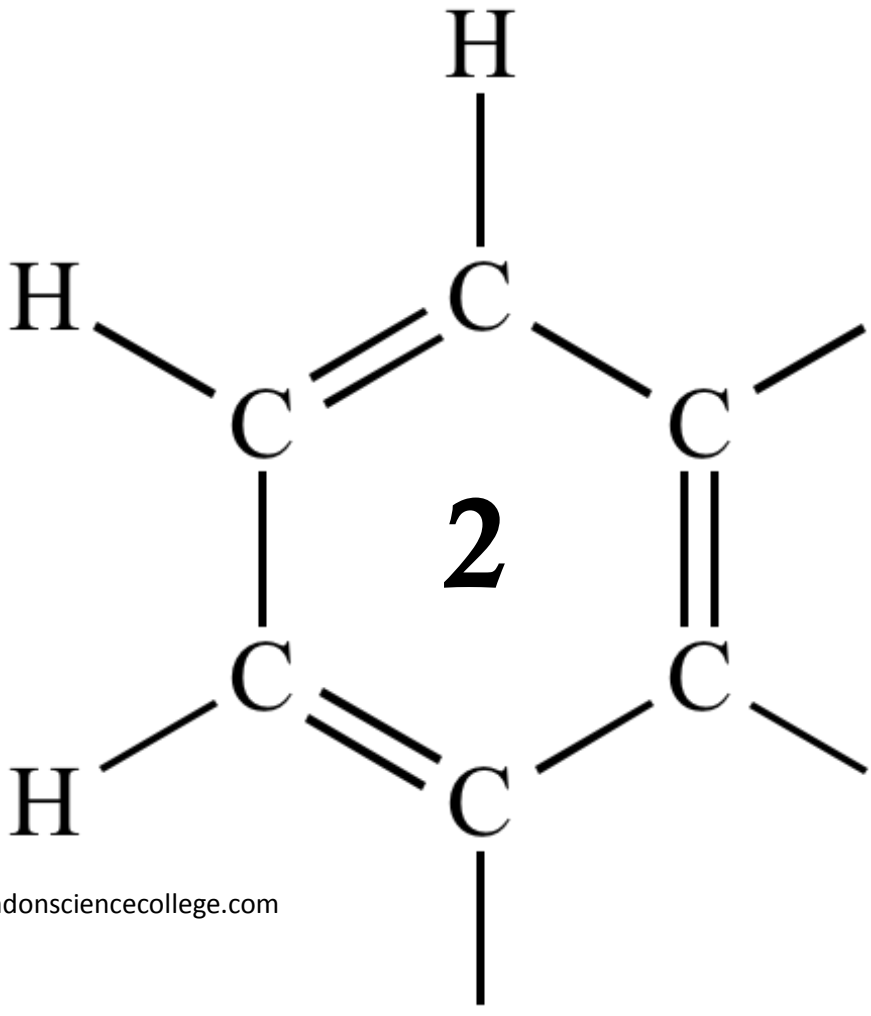
LONDON SCIENCE COLLEGE

AQA AS CHEMISTRY

ALKANES



2

1 Central heating fuel, obtained by the fractional distillation of crude oil, contains saturated hydrocarbons with the molecular formula $C_{16}H_{34}$

(a) Give the meaning of the terms **saturated** and **hydrocarbon** as applied to saturated hydrocarbons.

Saturated .....

.....

Hydrocarbon .....

.....

(2)

(b) If the boiler for a central heating system is faulty, a poisonous gas may be produced during the combustion of $C_{16}H_{34}$

Write an equation for the reaction that forms this poisonous gas and one other product only.

.....

(1)

(c) Explain why the sulfur compounds found in crude oil should be removed from the fractions before they are used for central heating fuel.

.....

.....

.....

.....

.....

(2)

(d) A hydrocarbon $C_{16}H_{34}$ can be cracked to form C_8H_{18}, ethene and propene.

(i) Write an equation to show this cracking reaction.

.....

(1)

(ii) Suggest **one** important substance manufactured on a large scale from propene.

.....

(1)

(iii) Draw the **displayed formula** of the functional group isomer of propene.

(1)

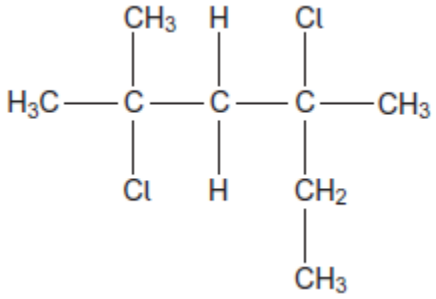
(e) There are many structural isomers with the molecular formula C_8H_{18}

Draw the structure of 2,3,3-trimethylpentane.

(1)

(f) A compound C_8H_{18} reacts with chlorine to give several haloalkanes.

Give the IUPAC name of the following haloalkane.



.....

(1)

(Total 10 marks)

2 There are many uses of halogenated organic compounds despite environmental concerns.

(a) Bromotrifluoromethane is used in fire extinguishers in aircraft.
Bromotrifluoromethane is formed when trifluoromethane reacts with bromine.

$$CHF_3 + Br_2 \longrightarrow CBrF_3 + HBr$$

The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

(i) Write an equation for each of the following steps in the mechanism for the reaction of CHF_3 with Br_2

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step

.....

(4)

(ii) State **one** condition necessary for the initiation of this reaction.

.....

(1)

(b) Bromine-containing and chlorine-containing organic compounds may have a role in the decomposition of ozone in the upper atmosphere.

(i) Draw an appropriate **displayed formula** in the space provided to complete the following equation to show how $CBrF_3$ may produce bromine atoms in the upper atmosphere.

$$CBrF_3 \longrightarrow \text{.....} + Br^{\bullet}$$

(1)

(ii) In the upper atmosphere, it is more likely for $CBrF_3$ to produce bromine atoms than it is for $CClF_3$ to produce chlorine atoms.

Suggest **one** reason for this.

.....

.....

.....

(1)

(iii) Bromine atoms have a similar role to chlorine atoms in the decomposition of ozone. The overall equation for the decomposition of ozone is

$$2O_3 \longrightarrow 3O_2$$

Write **two** equations to show how bromine atoms (Br•) act as a catalyst in the decomposition of ozone.

Explain how these two decomposition equations show that bromine atoms behave as a catalyst.

Equation 1

.....

Equation 2

.....

Explanation .....

.....

.....

(3)

(Total 10 marks)

3 Some oil-fired heaters use paraffin as a fuel.
One of the compounds in paraffin is the straight-chain alkane, dodecane ($C_{12}H_{26}$).

(a) Give the name of the substance from which paraffin is obtained.
State the name of the process used to obtain paraffin from this substance.

Substance .....

Process .....

(2)

(b) The combustion of dodecane produces several products.

Write an equation for the **incomplete** combustion of dodecane to produce gaseous products only.

.....

(1)

(c) Oxides of nitrogen are also produced during the combustion of paraffin in air.

(i) Explain how these oxides of nitrogen are formed.

.....

.....

.....

.....

(2)

(ii) Write an equation to show how nitrogen monoxide in the air is converted into nitrogen dioxide.

.....

(1)

(iii) Nitric acid (HNO_3) contributes to acidity in rainwater.

Deduce an equation to show how nitrogen dioxide reacts with oxygen and water to form nitric acid.

.....

(1)

(d) Dodecane ($C_{12}H_{26}$) can be cracked to form other compounds.

(i) Give the general formula for the homologous series that contains dodecane.

.....

(1)

(ii) Write an equation for the cracking of one molecule of dodecane into equal amounts of two different molecules each containing the same number of carbon atoms.
State the empirical formula of the straight-chain alkane that is formed.
Name the catalyst used in this reaction.

Equation .....

Empirical formula of alkane .....

Catalyst .....

.....

(3)

(iii) Explain why the melting point of dodecane is higher than the melting point of the straight-chain alkane produced by cracking dodecane.

.....

.....

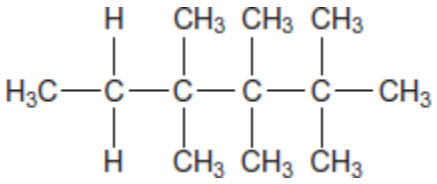
.....

.....

.....

(2)

(e) Give the IUPAC name for the following compound and state the type of structural isomerism shown by this compound and dodecane.



IUPAC name .....

Type of structural isomerism .....

(2)

(f) Dodecane can be converted into halododecanes.

Deduce the formula of a substance that could be reacted with dodecane to produce 1-chlorododecane and hydrogen chloride only.

.....

(1)
(Total 16 marks)

4 Trifluoromethane (CHF_3) can be used to make the refrigerant chlorotrifluoromethane($CClF_3$).

(a) Chlorotrifluoromethane is formed when trifluoromethane reacts with chlorine.

$$CHF_3 + Cl_2 \longrightarrow CClF_3 + HCl$$

The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

(i) Write an equation for each of the following steps in the mechanism for the reaction of CHF_3 with Cl_2

Initiation step

.....

First propagation step

.....

Second propagation step

.....

Termination step to form hexafluoroethane

.....

(4)

(ii) Give **one** essential condition for this reaction.

.....

(1)

(b) In some refrigeration systems, CHF_3 has replaced $CClF_3$ because of concerns about ozone depletion.

(i) Identify the species formed from $CClF_3$ that is responsible for the catalytic decomposition of ozone in the upper atmosphere.

.....

(1)

(ii) Write an overall equation to represent the decomposition of ozone into oxygen.

.....

(1)

(Total 7 marks)

5 (a) The hydrocarbon but-1-ene (C_4H_8) is a member of the homologous series of alkenes. But-1-ene has structural isomers.

(i) State the meaning of the term *structural isomers*.

.....

.....

.....

.....

(2)

(ii) Give the IUPAC name of the **position** isomer of but-1-ene.

.....

(1)

(iii) Give the IUPAC name of the **chain** isomer of but-1-ene.

.....

(1)

(iv) Draw the displayed formula of a **functional group** isomer of but-1-ene.

(1)

(b) But-1-ene burns in a limited supply of air to produce a solid and water only.

(i) Write an equation for this reaction.

.....

(1)

(ii) State **one** hazard associated with the solid product in part (b)(i).

.....

(1)

(c) One mole of compound **Y** is cracked to produce two moles of ethene, one mole of but-1-ene and one mole of octane (C_8H_{18}) only.

(i) Deduce the molecular formula of **Y**.

.....

(1)

(ii) Other than cracking, give **one** common use of **Y**.

.....

(1)

(d) In cars fitted with catalytic converters, unburned octane reacts with nitrogen monoxide to form carbon dioxide, water and nitrogen only.

(i) Write an equation for this reaction.

.....

(1)

(ii) Identify a catalyst used in a catalytic converter.

.....

(1)

(Total 11 marks)

6 Chlorine can be used to make chlorinated alkanes such as dichloromethane.

(a) Write an equation for each of the following steps in the mechanism for the reaction of chloromethane (CH_3Cl) with chlorine to form dichloromethane (CH_2Cl_2).

Initiation step

.....

First propagation step

.....

Second propagation step

.....

The termination step that forms a compound with empirical formula CH_2Cl.

.....

(4)

(b) When chlorinated alkanes enter the upper atmosphere, carbon-chlorine bonds are broken. This process produces a reactive intermediate that catalyses the decomposition of ozone. The overall equation for this decomposition is

$$2O_3 \rightleftharpoons 3O_2$$

(i) Name the type of reactive intermediate that acts as a catalyst in this reaction.

.....

(1)

(ii) Write **two** equations to show how this intermediate is involved as a catalyst in them decomposition of ozone.

Equation 1.....

Equation 2.....

(2)
(Total 7 marks)

7 The following table shows the boiling points of some straight-chain alkanes.

	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}
Boiling point / °C	−162	−88	−42	−1	36

(a) State a process used to separate an alkane from a mixture of these alkanes.

.....

(1)

(b) Both C_3H_8 and C_4H_{10} can be liquefied and used as fuels for camping stoves.

Suggest, with a reason, which of these two fuels is liquefied more easily.

.....

.....

.....

(1)

(c) Write an equation for the complete combustion of C_4H_{10}

.....

(1)

(d) Explain why the complete combustion of C_4H_{10} may contribute to environmental problems.

.....

.....

.....

(1)

(e) Balance the following equation that shows how butane is used to make the compound called maleic anhydride.

..... $CH_3CH_2CH_2CH_3$ + ... O_2 ⟶ ..... $C_2H_2(CO)_2O$ + ... H_2O

(1)

(f) Ethanethiol (C_2H_5SH), a compound with an unpleasant smell, is added to gas to enable leaks from gas pipes to be more easily detected.

(i) Write an equation for the combustion of ethanethiol to form carbon dioxide, water and sulfur dioxide.

.....

(1)

(ii) Identify a compound that is used to react with the sulfur dioxide in the products of combustion before they enter the atmosphere.

Give **one** reason why this compound reacts with sulfur dioxide.

Substance .....

Reason .....

.....

(2)

(iii) Ethanethiol and ethanol molecules have similar shapes.

Explain why ethanol has the higher boiling point.

.....

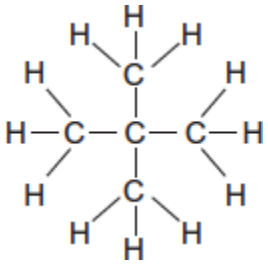
.....

.....

.....

(2)

(g) The following compound **X** is an isomer of one of the alkanes in the table on above.



(i) Give the IUPAC name of **X**.

.....

(1)

(ii) **X** has a boiling point of 9.5 °C.

Explain why the boiling point of **X** is lower than that of its straight-chain isomer.

.....

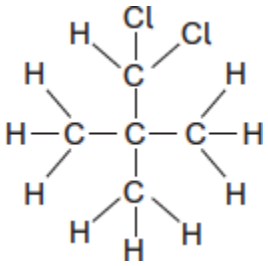
.....

.....

.....

(2)

(iii) The following compound **Y** is produced when **X** reacts with chlorine.



Deduce how many **other** position isomers of **Y** can be formed.
Write the number of **other** position isomers in this box.

(1)

(h) Cracking of one molecule of an alkane **Z** produces one molecule of ethane, one molecule of propene and two molecules of ethene.

(i) Deduce the molecular formula of **Z**.

.....

(1)

(ii) State the type of cracking that produces a high proportion of ethene and propene.
Give the **two** conditions for this cracking process.

Type of cracking .....

Conditions .....

.....

(2)
(Total 17 marks)

8 The refrigerant R410A, used in air conditioners, is a mixture of two fluoroalkanes, pentafluoroethane and difluoromethane.

(a) (i) The mechanism for the reaction of fluorine with either an alkane or a fluoroalkane is similar to that for the reaction of chlorine with methane.

Name the type of mechanism for the reaction of chlorine with methane.

.....

(1)

(ii) Write equations for the following steps in the mechanism for the reaction of fluorine with fluoromethane (CH_3F) to form difluoromethane (CH_2F_2).

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step leading to the formation of 1,2-difluoroethane.

.....

(4)

(iii) Write an overall equation for the reaction of fluorine with ethane to form pentafluoroethane (CF_3CHF_2) by this mechanism.

.....

(1)

(b) The refrigerant R112A (CCl_3CF_2Cl) has been banned because of concerns about ozone depletion.

Give the IUPAC name for CCl_3CF_2Cl

.....

(1)

(c) Nitrogen monoxide (NO) catalyses the decomposition of ozone into oxygen.

(i) Write the overall equation for this decomposition.

.....

(1)

(ii) Use the overall equation to deduce Step **3** in the following mechanism that shows how nitrogen monoxide catalyses this decomposition.

Step **1** $O_3 \longrightarrow O + O_2$

Step **2** $NO + O_3 \longrightarrow NO_2 + O_2$

Step **3** .....

(1)

(Total 9 marks)