A-Level Chemistry

Introduction to Organic Chemistry

Question Paper

Time available: 63 minutes
Marks available: 58 marks

1. This question is about the structures of some organic molecules.

(a) Draw the **skeletal** formula of 3-methylbutanal.

(1)

(b) Draw the **displayed** formula of $C_5H_{11}Br$ that is the major product of the reaction of 2-methylbut-2-ene with hydrogen bromide.

(1)

(c) Thermal cracking of hydrocarbons produces molecules that are attacked by electrophiles because they have a region of high electron density.

Draw the structure of one of these molecules that contains four carbon atoms.

(1)

(Total 3 marks)

2. (a) Octane (C_8H_{18}) is an important compound in petrol.

(i) Identify the homologous series to which octane belongs.

_____

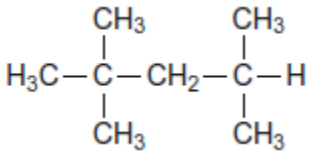
(1)

(ii) Write an equation to show the complete combustion of C_8H_{18}

_____

(1)

(iii) An isomer of octane used to improve the performance of car engines is shown.

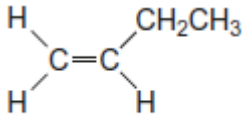


Give the IUPAC name of this isomer.

_____

(1)

(b) Compound **X** is produced when an alkane is cracked.



X

(i) Give the IUPAC name for compound **X**.

_____

(1)

(ii) One molecule of an alkane is cracked to produce one molecule of compound **X**, one molecule of octane and one molecule of ethene.

Deduce the molecular formula of this alkane.

_____

(1)

(iii) Name the type of cracking that produces a high yield of compound **X**.
Give **two** conditions required for this process.

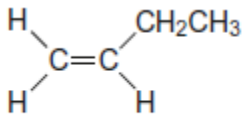
Type of cracking _____

Conditions _____

_____

(2)

(iv) Compound **X** has several isomers. The structure of **X** is repeated here.



X

Draw the displayed formula of a chain isomer, a position isomer and a functional group isomer of compound **X**.

Type of isomer	**Displayed formula of isomer of compound X**
Chain	
Position	
Functional group	

(3)

(Total 10 marks)

3. 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)

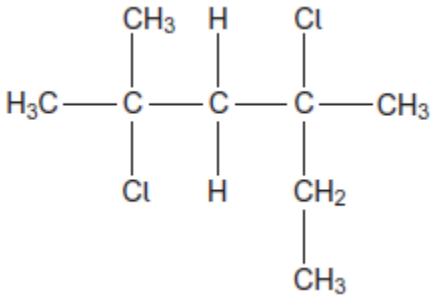
(e) There are many structural isomers with the molecular formula C_8H_{18}

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)

4. (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)

5. Pentane is a member of the alkane homologous series.

(a) Give the general formula for the homologous series of alkanes.

_____

(1)

(b) One of the structural isomers of pentane is 2,2-dimethylpropane.

Draw the displayed formula of 2,2-dimethylpropane.

State the type of structural isomerism shown.

_____

(2)

(c) A molecule of hydrocarbon **Y** can be thermally cracked to form one molecule of pentane and two molecules of ethene only.

Deduce the molecular formula of **Y**.

State why high temperatures are necessary for cracking reactions to occur.

Give **one** reason why thermal cracking reactions are carried out in industry.

_____

_____

_____

_____

_____

_____

(3)

(d) Write an equation for the incomplete combustion of pentane to form a solid pollutant.

Suggest why this solid pollutant is an environmental problem.

(2)

(e) Pentane can react with chlorine as shown in the following equation.

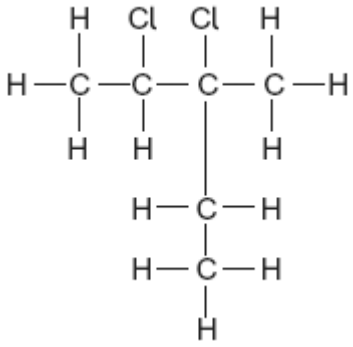
$$C_5H_{12} + Cl_2 \rightarrow C_5H_{11}Cl + HCl$$

Calculate the percentage atom economy for the formation of $C_5H_{11}Cl$

Deduce how many straight-chain isomers of $C_5H_{11}Cl$ could be formed.

(3)

(f) Consider the following compound.



Name this compound.

Deduce the empirical formula of this compound.

_____

_____

_____

_____

(2)

(Total 13 marks)

6. Hexane is a member of the homologous series of alkanes.

(a) State **two** characteristics of a *homologous series*.

Characteristic 1 _____

_____

Characteristic 2 _____

_____

(2)

(b) (i) Hexane can be converted into 2,2-dichlorohexane.

Draw the displayed formula of 2,2-dichlorohexane and deduce its empirical formula.

Displayed formula

Empirical formula _____

_____

(2)

(ii) Explain why 2,2-dichloro-3-methylpentane is a structural isomer of 2,2-dichlorohexane.

_____

_____

(2)

(c) A reaction of hexane with chlorine is shown by the equation below.

$$C_6H_{14} + 2Cl_2 \rightarrow C_6H_{12}Cl_2 + 2HCl$$

Calculate the percentage atom economy for the formation of $C_6H_{12}Cl_2$ in this reaction.

_____

_____

_____

(2)

(d) The boiling points of some straight-chain alkanes are shown below.

Alkane	C_4H_{10}	C_5H_{12}	C_6H_{14}
Boiling point / °C	– 0.5	36.3	68.7

(i) Explain the trend in these boiling points.

_____

_____

_____

(2)

(ii) Name a process which can be used to separate C_5H_{12} from C_6H_{14}

_____

(1)

(Total 11 marks)