

Q1.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

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Hydrocarbon

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(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.

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(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.

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(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.

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(1)

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

propene.

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(1)

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

(1)

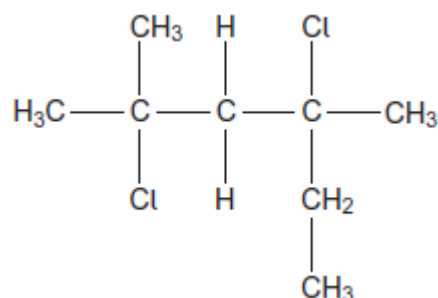
(e) There are many structural isomers with the molecular formula C_8H_{18}

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

(1)

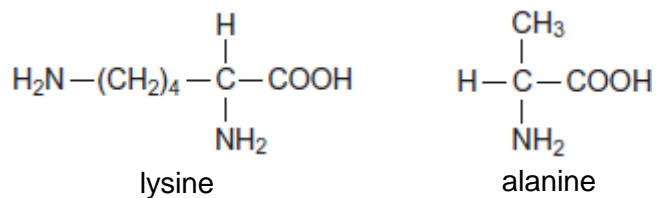
(f) A compound C_8H_{18} reacts with chlorine to give several haloalkanes.

Give the IUPAC name of the following haloalkane.



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Q2. Lysine and alanine are two amino acids.



(a) Give the IUPAC name of lysine.

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(1)

(b) Draw structures to show the product formed in each case when lysine reacts with

(i) an excess of aqueous HCl

(1)

(ii) an excess of aqueous NaOH

(1)

(iii) methanol in the presence of a small amount of concentrated H_2SO_4

(1)

- (c) The mass spectrum of alanine gives a major peak at $m/z = 44$

Write an equation for the fragmentation of the molecular ion of alanine to give an ion that produces this peak.

In your answer, draw the displayed formula for this fragment ion.

(2)

- (d) Draw a dipeptide formed from one molecule of lysine and one molecule of alanine.

(1)

- (e) The dipeptide in part (d) is hydrolysed in acid conditions and the mixture produced is analysed by column chromatography. The column is packed with a resin which acts as a polar stationary phase.

Suggest why lysine leaves the column after alanine.

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(2)

Q3.Compound **J**, known as leaf alcohol, has the structural formula $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}_2\text{OH}$ and is produced in small quantities by many green plants. The *E* isomer of **J** is responsible for the smell of freshly cut grass.

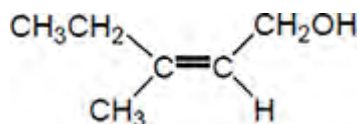
(a) Give the structure of the *E* isomer of **J**.

(1)

(b) Give the **skeletal formula** of the organic product formed when **J** is dehydrated using concentrated sulfuric acid.

(1)

(c) Another structural isomer of **J** is shown below.



Explain how the Cahn-Ingold-Prelog (CIP) priority rules can be used to deduce the full IUPAC name of this compound.

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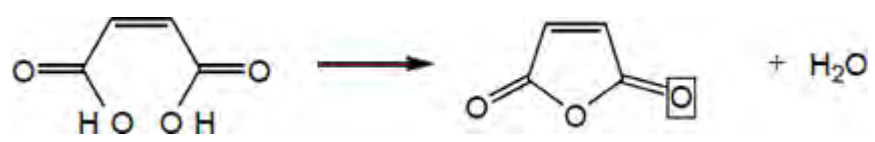
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(6)

(d) The effect of gentle heat on maleic acid is shown below.



A student predicted that the yield of this reaction would be greater than 80%.

In an experiment, 10.0 g of maleic acid were heated and 6.53 g of organic product were obtained.

Is the student correct? Justify your answer with a calculation using these data.

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(2)
(Total 10 marks)

Q4. Some oil-fired heaters use paraffin as a fuel.

One of the compounds in paraffin is the straight-chain alkane, dodecane (C₁₂H₂₆).

- (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.

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..... (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 ($\text{C}_{12}\text{H}_{26}$) can be cracked to form other compounds.

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

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(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

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(3)

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

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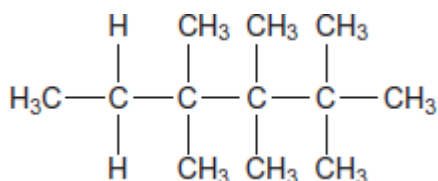
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(2)

- (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)

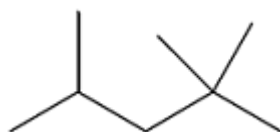
- (f) Dodecane can be converted into halododecanes.

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

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(1)
(Total 16 marks)

Q5. Isooctane (C_8H_{18}) is the common name for the branched-chain hydrocarbon that burns smoothly in car engines. The skeletal formula of isooctane is shown below.



(a) Give the IUPAC name for isooctane.

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(1)

(b) Deduce the number of peaks in the ^{13}C NMR spectrum of isooctane.

5

6

7

8

(1)

(c) Isooctane can be formed, together with propene and ethene, in a reaction in which one molecule of an alkane that contains 20 carbon atoms is cracked.

Using molecular formulas, write an equation for this reaction.

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(1)

- (d) How do the products of the reaction in part (c) show that the reaction is an example of thermal cracking?

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(1)

- (e) Deduce the number of monochloro isomers formed by isooctane.
Draw the structure of the monochloro isomer that exists as a pair of optical isomers.

Number of monochloro isomers

Structure

(2)

- (f) An isomer of isooctane reacts with chlorine to form only one monochloro compound.

Draw the **skeletal formula** of this monochloro compound.

(1)

- (g) A sample of a monochlorooctane is obtained from a comet. The chlorine in the monochlorooctane contains the isotopes ^{35}Cl and ^{37}Cl in the ratio 1.5 : 1.0
Calculate the M_r of this monochlorooctane.

$$M_r = \dots\dots\dots$$

(2)

- (h) Isooctane reacts with an excess of chlorine to form a mixture of chlorinated compounds.
One of these compounds contains 24.6% carbon and 2.56% hydrogen by mass.
Calculate the molecular formula of this compound.

Molecular formula =

(3)

(Total 12 marks)