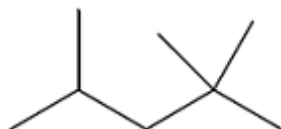


**Q10.**

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.

(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.

(1)

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

(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.

$M_r =$ _____

(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 = _____

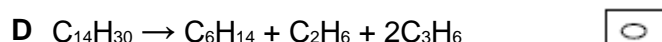
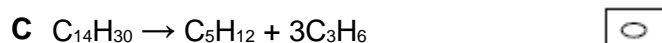
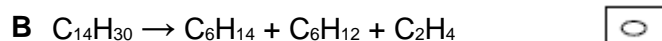
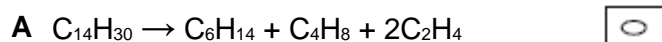
(3)

(Total 12 marks)

**Q11.**

Tetradecane ($C_{14}H_{30}$) is an alkane found in crude oil. When tetradecane is heated to a high temperature, one molecule of tetradecane decomposes to form one molecule of hexane and three more molecules.

Which of the following could represent this reaction?



(Total 1 mark)

Q12.

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

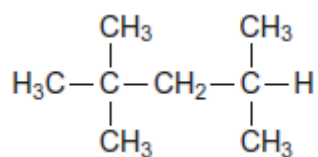
(i) Identify the homologous series to which octane belongs.

(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.

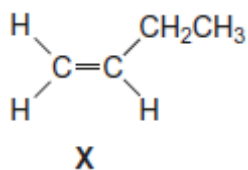


Give the IUPAC name of this isomer.

(1)



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



- (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.

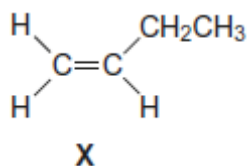
Type of cracking _____

Conditions _____

(2)



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



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)

Q13.

Central heating fuel, obtained by the fractional distillation of crude oil, contains saturated hydrocarbons with the molecular formula $\text{C}_{16}\text{H}_{34}$

- (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}

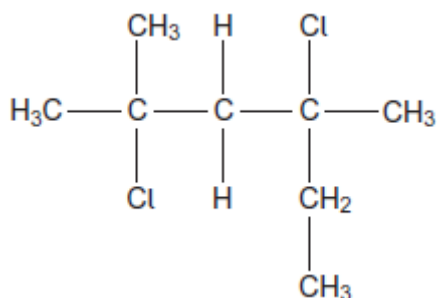
Draw the structure of 2,3,3-trimethylpentane.

(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)

Q14.

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

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

(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 _____

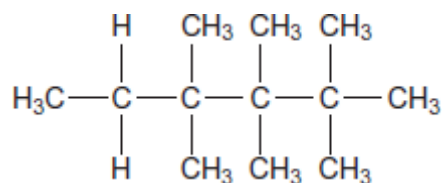
(3)

- (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)

Q15.

- (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 (C₈H₁₈) 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)

Q16.

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

	CH ₄	C ₂ H ₆	C ₃ H ₈	C ₄ H ₁₀	C ₅ H 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)

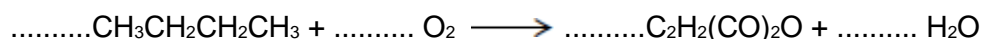
- (c) Write an equation for the complete combustion of C_4H_{10}

(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.



(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)

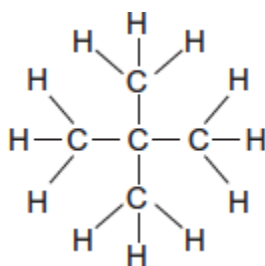


- (iii) Ethanethiol and ethanol molecules have similar shapes.

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)

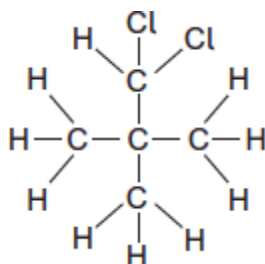
- (ii) **X** has a boiling point of 9.5 °C.

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)



Mark Scheme

Q10.

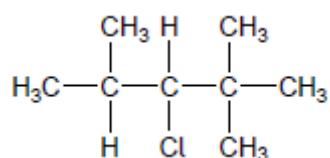
(a) 2,2,4-trimethylpentane 1

(b) 5 1

(c) $C_{20}H_{42} \longrightarrow C_8H_{18} + 2C_3H_6 + 3C_2H_4$ 1

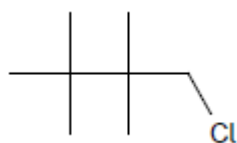
(d) Mainly alkenes formed 1

(e) 4 (monochloro isomers) 1



1

(f)



1

(g) $C_8H_{17}^{35}Cl = 96.0 + 17.0 + 35.0 = 148.0$
and $C_8H_{17}^{37}Cl = 96.0 + 17.0 + 37.0 = 150.0$

Both required

1

$$M_r \text{ of this } C_8H_{17}Cl = \frac{(1.5 \times 148.0)}{2.5} + \frac{(1.0 \times 150.0)}{2.5} = 148.8$$

1

(h) $\frac{24.6}{12} \quad \frac{2.56}{1} \quad \frac{72.8}{35.5} = 2.05 : 2.56 : 2.05$

$$\text{Simplest ratio} = \frac{2.05}{2.05} : \frac{2.56}{2.05} : \frac{2.05}{2.05}$$

$$= 1 : 1.25 : 1$$

1

$$\text{Whole number ratio } (\times 4) = 4 : 5 : 4$$

1

$$MF = C_8H_{10}Cl_8$$

1



[12]

Q11.

A

[1]

Q12.(a) (i) Alkane(s)*Ignore C_nH_{2n+2}*

1

(ii) $C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$ *Allow multiples*

1

(iii) 2, 2, 4-trimethylpentane

1

(b) (i) But-1-ene*Ignore (E or Z)*

1

(ii) $C_{14}H_{30}$

1

(iii) Thermal

If catalytic $CE = 0$

1

High pressure / 7000kPa / 70 atm

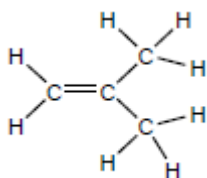
and

High temperature/temperature in range 400-1000°C (673–1273K)

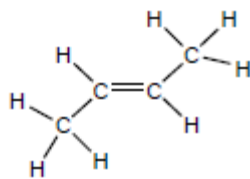
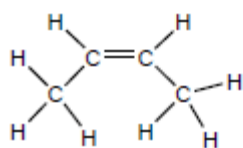
*(Allow ≥ 1000 kPa or ≥ 10 atm – no upper value)**Allow high temperature and pressure or high pressure and temperature**If no units for temperature allow 673-1000**Must show unambiguous structure**Penalise lack of displayed formula once only*

1

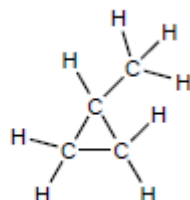
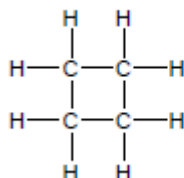
(iv)



1



1



1

[10]

Q13.

- (a) Saturated – single bonds only / no double bonds

1

Hydrocarbon – contains carbon and hydrogen (atoms) only

1

- (b) $C_{16}H_{34} + 16.5O_2 \longrightarrow 16CO + 17H_2O$

Allow multiples

1

- (c) (On combustion) SO_2 produced

Allow equation to produce SO_2 . Ignore sulfur oxides.

1

Which causes acid rain

If formula shown it must be correct

M2 is dependent on M1. But if M1 is sulfur oxides, allow M2.

For M2 allow consequence of acid rain or SO_2 .

Ignore greenhouse effect and toxic

1

- (d) (i) $C_{16}H_{34} \longrightarrow C_8H_{18} + C_2H_4 + 2C_3H_6$

Allow multiples

1

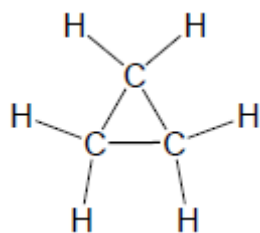
- (ii) polypropene / propan(-1 or 2-)ol / propane(-1,2-)diol / isopropanol / propanone / propanal

Accept alternative names

Ignore plastic and polymer

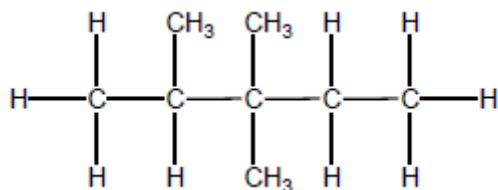
1

- (iii)



1

(e)



Allow any unambiguous representation

1

(f) 2,4-dichloro-2,4-dimethylhexane

Only but ignore punctuation

1

[10]

Q14.(a) Crude oil **OR** petroleum

Not petrol.

1

Fractional distillation / fractionation

Not distillation alone.

1

(b) $C_{12}H_{26} + 12.5O_2 \longrightarrow 12CO + 13H_2O$

Allow balanced equations that produce CO_2 in addition to CO.

Accept multiples.

1

(c) (i) M1 Nitrogen and oxygen (from air) react / combine / allow a correct equation

If nitrogen from petrol / paraffin / impurities CE = 0 / 2.

1

M2 at high temperatures

Allow temperatures above 1000 °C or spark.

Not just heat or hot.

M2 dependent on M1.

But allow 1 mark for nitrogen and oxygen together at high temperatures.

1

(ii) $2NO + O_2 \longrightarrow 2NO_2$

Allow multiples.



- (iii) $4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \longrightarrow 4\text{HNO}_3$
Allow multiples. 1
- (d) (i) $\text{C}_n\text{H}_{2n+2}$
Allow $\text{C}_x\text{H}_{2x+2}$ 1
- $\text{C}_n\text{H}_{2n+2}$
Allow $\text{C}_x\text{H}_{2x+2}$ 1
- (ii) $\text{C}_{12}\text{H}_{26} \longrightarrow \text{C}_6\text{H}_{14} + \text{C}_6\text{H}_{12}$
Only. 1
- C_3H_7
Only. 1
- Zeolite / aluminosilicate(s)
Ignore aluminium oxide. 1
- (iii) Larger molecule / longer carbon chain / more electrons / larger surface area
 1
- More / stronger van der Waals' forces between molecules
Allow dispersion forces / London forces / temporary induced dipole-dipole forces between molecules.
If breaking bonds, CE = 0 / 2. 1
- (e) 2,2,3,3,4,4-hexamethylhexane
Only.
Ignore punctuation. 1
- Chain
Ignore branch(ed). 1
- (f) Cl_2
Only.
- $\text{Cl}-\text{Cl}$
Not CL_2 or Cl2 or CL2 or Cl^2 or CL^2 .
Ignore Chlorine. 1

[16]

Q15.



- (a) (i) (Compounds with the) same molecular formula
Allow same number and type of atom for M1
Ignore same general formula. 1

But different structural formula / different displayed formula / different structures / different skeletal formula

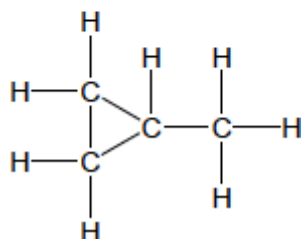
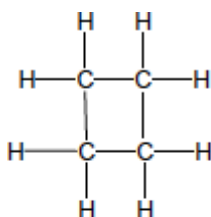
M2 dependent on M1

Not different positions of atoms / bonds in space. 1

- (ii) But-2-ene
Allow but-2-ene.
Allow but 2 ene.
Ignore punctuation. 1

- (iii) (2)-methylprop-(1)-ene
Do not allow 2-methyleprop-1-ene. 1

(iv)



Do not allow skeletal formulae.

Penalise missing H and missing C 1

- (b) (i) $C_4H_8 + 2O_2 \rightarrow 4C + 4H_2O$
Accept multiples. 1

- (ii) Exacerbates asthma / breathing problems / damages lungs / smog / smoke / global dimming
Ignore toxic / pollutant / soot / carcinogen.
Do not allow greenhouse effect / global warming / acid rain / ozone. 1

- (c) (i) $C_{16}H_{34}$



Allow $H_{34}C_{16}$

C and H must be upper case.

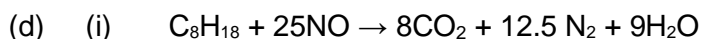
1

- (ii) Jet fuel / diesel / (motor) fuel / lubricant / petrochemicals / kerosene / paraffin / central heating fuel / fuel oil

Ignore oil alone.

Not petrol / bitumen / wax / LPG / camping fuel.

1



Accept multiples.

1

- (ii) Ir / iridium

OR

Pt / platinum

OR

Pd / palladium

OR

Rh / rhodium

1

[11]

Q16.

- (a) Fractional distillation / fractionation / GLC / gas liquid chromatography

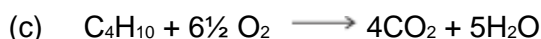
1

- (b) C_4H_{10}

*Need C_4H_{10} **and** the reason for the mark*

Because it has a higher bp / has stronger IMF / larger molecule / longer chain / larger surface (area)

1



Accept multiples

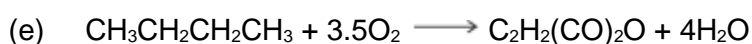
Ignore state symbols

1

- (d) CO_2 or H_2O evolved is a greenhouse gas / CO_2 or H_2O evolved contribute to global warming / the products are greenhouse gases

Ignore climate change

1



Accept multiples

Allow with or without a number 1 before the organic molecules



- 1
- (f) (i) $\text{C}_2\text{H}_5\text{SH} + 4.5\text{O}_2 \longrightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} + \text{SO}_2$
Accept multiples 1
- (ii) Calcium oxide / calcium carbonate
Allow any base or alkali
Allow correct formulae 1
- Neutralises the SO_2 / acid base reaction / it is a base
Can only score M2 if base or alkali used in M1
Allow M2 if blank in M1 1
- (iii) Ethanol contains hydrogen bonding
Breaking covalent bonds CE = 0 / 2
- Which is stronger than IMF (VDW / dipole-dipole forces) in ethanethiol / (H bonding) is the strongest IMF
Only award M2 if M1 given, but allow IMF in ethanol are stronger than in ethanethiol for maximum 1 mark 1
- (g) (i) (2,2-)dimethylpropane
Ignore punctuation 1
- (ii) Because molecule is smaller / less polarisable / has less surface (area) / is more spherical / molecules can't get as close to one another (to feel the vdW forces)
Allow converse answers referring to straight chain isomers CE = 0 / 2 if breaking bonds 1
- vdW intermolecular forces or vdW force between molecules are weaker or fewer
Need vdW rather than just IMF 1
- (iii) 1 or one 1
- (h) (i) C_9H_{20}
 H_{20}C_9 1
- (ii) Thermal (cracking)
If not thermal cracking CE = 0 / 2 1
- High pressure AND high temperature
If blank mark on
Allow high P and T



1

ORPressure of $\geq 10 \text{ atm}$, $\geq 1 \text{ MPa}$ $\geq 1000 \text{ kPa}$ AND temp of $400 \text{ }^\circ\text{C} \leq T \leq 1000 \text{ }^\circ\text{C}$ or $650 \text{ K} \leq T \leq 1300 \text{ K}$ *Do not allow high heat**If no units for T, then range must be 650 – 1000*

1

[17]