



- (d) Suggest why the branched chain isomer shown above has a lower boiling point than octane.

.....  
.....  
.....  
.....

(2 marks)

2 Cetane ( $C_{16}H_{34}$ ) is a major component of diesel fuel.

- (a) Write an equation to show the complete combustion of cetane.

.....  
(1 mark)

- (b) Cetane has a melting point of  $18^{\circ}C$  and a boiling point of  $287^{\circ}C$ . In polar regions vehicles that use diesel fuel may have ignition problems. Suggest **one** possible cause of this problem with the diesel fuel.

.....  
.....  
(1 mark)

- (c) The pollutant gases NO and  $NO_2$  are sometimes present in the exhaust gases of vehicles that use petrol fuel.

- (i) Write an equation to show how NO is formed and give a condition needed for its formation.

Equation .....

Condition .....

(2 marks)

- (ii) Write an equation to show how NO is removed from the exhaust gases in a catalytic converter. Identify a catalyst used in the converter.

Equation .....

Catalyst .....

(2 marks)

(iii) Deduce an equation to show how  $\text{NO}_2$  reacts with water and oxygen to form nitric acid ( $\text{HNO}_3$ ).

.....  
(1 mark)

(d) Cetane ( $\text{C}_{16}\text{H}_{34}$ ) can be cracked to produce hexane, butene and ethene.

(i) State **one** condition that is used in this cracking reaction.

.....  
(1 mark)

(ii) Write an equation to show how one molecule of cetane can be cracked to form hexane, butene and ethene.

.....  
(1 mark)

(iii) State **one** type of useful solid material that could be formed from alkenes.

.....  
(1 mark)

3 Hexane ( $\text{C}_6\text{H}_{14}$ ) is a member of the homologous series of alkanes.

(a) (i) Name the raw material from which hexane is obtained.

.....  
(1 mark)

(ii) Name the process used to obtain hexane from this raw material.

.....  
(1 mark)

(b)  $\text{C}_6\text{H}_{14}$  has structural isomers.

(i) Deduce the number of structural isomers with molecular formula  $\text{C}_6\text{H}_{14}$

Write the number in this box.

(1 mark)

(ii) State **one** type of structural isomerism shown by the isomers of C<sub>6</sub>H<sub>14</sub>

.....  
(1 mark)

(c) One molecule of an alkane **X** can be cracked to form one molecule of hexane and two molecules of propene.

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

.....  
.....  
(1 mark)

(ii) State the type of cracking that produces a high percentage of alkenes. State the conditions needed for this type of cracking.

Type of cracking .....

Conditions .....

.....  
(2 marks)

(iii) Explain the main economic reason why alkanes are cracked.

.....  
.....  
(1 mark)

(d) Hexane can react with chlorine under certain conditions as shown in the following equation.



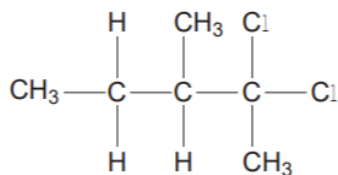
(i) Both the products are hazardous. The organic product would be labelled 'flammable'. Suggest the most suitable hazard warning for the other product.

.....  
(1 mark)

(ii) Calculate the percentage atom economy for the formation of C<sub>6</sub>H<sub>13</sub>Cl (*M<sub>r</sub>* = 120.5) in this reaction.

.....  
.....  
(1 mark)

- (e) A different chlorinated compound is shown below. Name this compound and state its empirical formula.



Name .....

Empirical formula .....  
(2 marks)

- 4 Alkanes are used as fuels. A student burned some octane ( $\text{C}_8\text{H}_{18}$ ) in air and found that the combustion was incomplete.

- (a) (i) Write an equation for the incomplete combustion of octane to produce carbon monoxide as the only carbon-containing product.

.....  
(1 mark)

- (ii) Suggest **one** reason why the combustion was incomplete.

.....  
.....  
(1 mark)

- (b) Catalytic converters are used to remove the toxic gases NO and CO that are produced when alkane fuels are burned in petrol engines.

- (i) Write an equation for a reaction between these two toxic gases that occurs in a catalytic converter when these gases are removed.

.....  
(1 mark)

- (ii) Identify a metal used as a catalyst in a catalytic converter. Suggest **one** reason, other than cost, why the catalyst is coated on a ceramic honeycomb.

Metal .....

Reason .....

.....  
(2 marks)

(c) If a sample of fuel for a power station is contaminated with an organic sulfur compound, a toxic gas is formed by complete combustion of this sulfur compound.

(i) State **one** environmental problem that can be caused by the release of this gas.

.....  
.....

(1 mark)

(ii) Identify **one** substance that could be used to remove this gas. Suggest **one** reason, other than cost, why this substance is used.

Substance .....

Reason why used .....

.....

(2 marks)

5 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 ( $\text{CH}_3\text{Cl}$ ) with chlorine to form dichloromethane ( $\text{CH}_2\text{Cl}_2$ ).

Initiation step

.....

First propagation step

.....

Second propagation step

.....

The termination step that forms a compound with empirical formula  $\text{CH}_2\text{Cl}$

.....

(4 marks)

- (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



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

.....  
(1 mark)

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

Equation 1 .....

Equation 2 .....

(2 marks)