

Q1. Cetane ($C_{16}H_{34}$) is a major component of diesel fuel.

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

..... (1)

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

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

(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)

(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)

(iii) Deduce an equation to show how NO_2 reacts with water and oxygen to form nitric acid (HNO_3).

..... (1)

(d) Cetane ($C_{16}H_{34}$) can be cracked to produce hexane, butene and ethene.

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

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(1)

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

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(1)

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

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(1)

(Total 10 marks)

Q2. The fractions obtained from petroleum contain saturated hydrocarbons that belong to the homologous series of alkanes.

(a) Any homologous series can be represented by a general formula.

(i) State **two** other characteristics of homologous series.

Characteristic 1

.....

Characteristic 2

.....

(ii) Name the process which is used to obtain the fractions from petroleum.

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(iii) State what is meant by the term *saturated*, as applied to hydrocarbons.

.....
.....

(4)

(b) Decane has the molecular formula $C_{10}H_{22}$.

(i) State what is meant by the term *molecular formula*.

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(ii) Give the molecular formula of the alkane which contains 14 carbon atoms.

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(iii) Write an equation for the incomplete combustion of decane, $C_{10}H_{22}$, to produce carbon and water only.

.....

(3)

(c) When petrol is burned in an internal combustion engine, some nitrogen monoxide, NO , is formed. This pollutant is removed from the exhaust gases by means of a reaction in a catalytic converter.

(i) Write an equation for the reaction between nitrogen and oxygen to form nitrogen monoxide.

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

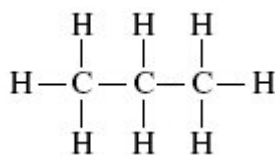
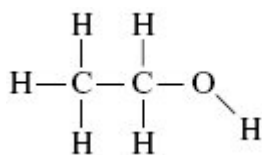
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- (iii) Write an equation to show how nitrogen monoxide is removed from the exhaust gases as they pass through a catalytic converter.

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(3)
(Total 10 marks)

- Q3.** (a) Two organic compounds with similar relative molecular masses are shown below.



Ethanol

Propane

- (i) State the type of bond present between the C and H atoms in both of these molecules. Explain how this type of bond is formed.

Type of bond

Explanation

(2)

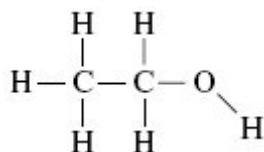
- (ii) State the strongest type of intermolecular force present in each compound.

Liquid ethanol

Liquid propane

(2)

- (b) Ethanol dissolves in water. Draw a diagram to show how one molecule of ethanol interacts with one molecule of water in the solution. Include partial charges and all lone pairs. The ethanol molecule has been drawn for you.



(3)

(c) Ethanol was the fuel used in the first mass-produced car, the Model T Ford.

(i) Write an equation which shows how ethanol burns completely in air to form carbon dioxide and water as the only products.

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(1)

(ii) Suggest **one** environmental problem caused by incomplete combustion of ethanol in a car engine.

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(1)

(iii) Suggest **one** economic problem for the car user caused by incomplete combustion of ethanol in the car engine.

.....

(1)

(d) Propane is also used as a fuel, although sometimes it can be contaminated with sulfur-containing impurities. When this propane burns, these impurities form sulfur dioxide.

(i) State how the sulfur dioxide can be removed from the waste gases produced when this propane is burned on a large scale in industry. Suggest a reason why the method you have stated may not be 100% efficient.

How removed

.....
Reason for less than 100% efficiency

(2)

- (ii) Although propane has a boiling point of $-42\text{ }^{\circ}\text{C}$, it is usually supplied as a liquid for use in camping stoves. Suggest why it is supplied as a liquid.

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(1)

(Total 13 marks)

Q4. Alkanes are saturated hydrocarbons which can be obtained from crude oil. Pentane is an example of an alkane. A molecule of pentane contains five carbon atoms.

- (a) (i) State the meaning of the term *saturated* and of the term *hydrocarbon* as applied to alkanes.

Saturated

Hydrocarbon

(2)

- (ii) Give the general formula for the alkanes.

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(1)

(b) Pentane burns completely in oxygen.

- (i) Write an equation for this reaction.

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(1)

(ii) State how the products of this reaction may affect the environment.

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(1)

(c) Give the name of a solid pollutant which may form when pentane burns incompletely in air.

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(1)

(d) One molecule of C_9H_{20} can be cracked to form one molecule of pentane and one other product.

(i) Write an equation for this cracking reaction.

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(1)

(ii) Suggest a type of compound that can be manufactured from the other product of this cracking reaction.

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(1)

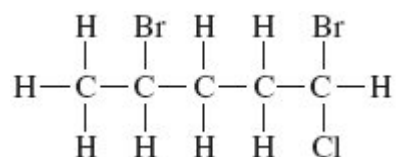
(iii) State why a high temperature is needed for cracking reactions to occur.

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(1)

(e) Pentane can react to form the following haloalkane **Q**.

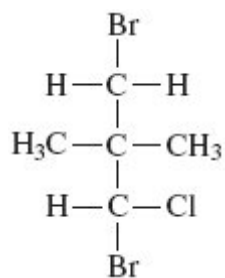


(i) Name **Q**.

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(1)

(ii) State the type of structural isomerism shown by **Q** and the haloalkane shown below.



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(1)

(Total 11 marks)

Q5. There are several oxides of nitrogen.

(a) An oxide of nitrogen contains 25.9% by mass of nitrogen. Determine the empirical formula of this oxide.

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.....

..... (3)

(b) Give **one** reason why the oxide NO is a pollutant gas.

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..... (1)

(c) The oxide NO reacts with oxygen to form nitrogen dioxide. Write an equation for this reaction.

..... (1)

(d) Explain how NO is produced in the engine of a motor vehicle.

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..... (2)

(e) Write an equation to show how NO is removed from the exhaust gases in motor vehicles using a catalytic converter.

..... (1)
(Total 8 marks)

Q6. The alkane butane is used as a fuel.

(a) (i) Write an equation for the complete combustion of butane.

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(1)

- (ii) State a condition which may cause carbon to be formed as a product in the combustion of butane.

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(1)

- (b) Butane obtained from crude oil may contain trace amounts of an impurity. When this impurity burns it produces a toxic gas that can be removed by reacting it with calcium oxide coated on a mesh.

- (i) Suggest the identity of the toxic gas.

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(1)

- (ii) Suggest why calcium oxide reacts with the toxic gas.

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(1)

- (iii) Suggest why the calcium oxide is coated on a mesh.

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(1)

(Total 5 marks)