

Q1. The burning of fossil fuels can produce atmospheric pollutants.

(a) The combustion of petrol in an internal combustion engine can lead to the formation of carbon monoxide, CO, and nitrogen monoxide, NO.

(i) Write an equation for the incomplete combustion of octane, C₈H₁₈, to produce CO and water only.

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(ii) State **one** essential condition for the formation of NO in an engine. Write an equation for the reaction in which NO is formed.

Condition

Equation

(3)

(b) All new petrol-engined cars must be fitted with a catalytic converter.

(i) Name **one** of the metals used as a catalyst in a catalytic converter.

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(ii) Write an equation to show how CO and NO react with each other in a catalytic converter.

.....

(2)

(c) State why sulphur dioxide gas is sometimes found in the exhaust gases of petrol-engined cars. Give **one** adverse effect of sulphur dioxide on the environment.

Reason for SO₂ in exhaust gases

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Environmental effect of SO₂

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(2)

(Total 7 marks)

Q2. (a) Butane, C_4H_{10} , is a hydrocarbon which is used as a fuel.

(i) Explain what is meant by the term *hydrocarbon*.

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(ii) Explain what is meant by the term *fuel*.

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

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(iv) Write an equation for the incomplete combustion of butane to produce carbon monoxide and water.

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(v) Under what conditions would you expect incomplete combustion to occur?

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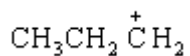
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(b) Three different carbocations are formed by breaking C – C bonds in separate molecules of butane during catalytic cracking. One of these structures is shown below. Give the structures of the other two carbocations.

Structure 1

Structure 2

Structure 3



(2)

(c) Ethane can be cracked in the presence of a catalyst to produce ethene and hydrogen.

(i) Write an equation for this reaction.

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(ii) Give a suitable catalyst for this reaction.

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(iii) State **one** reason why cracking is important.

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(3)
(Total 10 marks)

Q3. (a) Gas oil (diesel), kerosine (paraffin), mineral oil (lubricating oil) and petrol (gasoline) are four of the five fractions obtained by the fractional distillation of crude oil within the temperature range 40–400 °C.

Identify the missing fraction and state the order in which the five fractions are removed as the fractionating column is ascended. Give **two** reasons why the fractions collect at different levels in the fractionating column.

(4)

- (b) Thermal cracking of large hydrocarbon molecules is used to produce alkenes. State the type of mechanism involved in this process. Write an equation for the thermal cracking of $C_{21}H_{44}$ in which ethene and propene are produced in a 3:2 molar ratio together with one other product.

(3)

- (c) Write equations, where appropriate, to illustrate your answers to the questions below.

(i) Explain why it is desirable that none of the sulphur-containing impurities naturally found in crude oil are present in petroleum fractions.

(ii) The pollutant gas NO is found in the exhaust gases from petrol engines. Explain why NO is formed in petrol engines but is not readily formed when petrol burns in the open air.

(iii) The pollutant gas CO is also found in the exhaust gases from petrol engines. Explain how CO and NO are removed from the exhaust gases and why the removal of each of them is desirable.

(10)

(Total 17 marks)