

**Q1.** (a) Hexane (C<sub>6</sub>H<sub>14</sub>) is a hydrocarbon which is a component of LPG (liquid petroleum gas), used as a fuel for heating. When burning fuels in boilers it is important to ensure complete combustion.

(i) Give two reasons why boilers are designed to ensure complete combustion.

Reason 1 .....

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Reason 2 .....

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(ii) Write an equation for the incomplete combustion of hexane.

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(iii) Suggest how an engineer or a chemist could demonstrate that the combustion of hexane in a faulty boiler was incomplete.

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**(5)**

(b) Branched chain alkanes are often preferred as fuels. Draw the structure of two branched chain isomers of hexane and name the first isomer.

Isomer 1

Isomer 2

Name of isomer 1 .....

**(3)**

(c) Hexane can be cracked in the presence of a catalyst to produce another

hydrocarbon, Z, and methane.

(i) Draw a possible structure for Z.

(ii) Give a suitable catalyst for this reaction.

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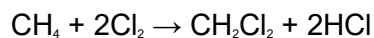
(iii) Suggest why the product Z has more commercial value than hexane.

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(3)

(d) The overall equation for the production of dichloromethane from methane and chlorine is shown below.



(i) Calculate the % atom economy for the formation of  $\text{CH}_2\text{Cl}_2$  in this reaction.

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(ii) Give one reason why this atom economy of less than 100% is an important consideration for the commercial success of this process and predict how a chemical company would maximise profits from this process.

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(3)

- Q2.** (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)

**Q3.** (a) Crude oil is separated into fractions by fractional distillation. Outline how different fractions are obtained by this process.

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(3)

(b) The table below gives details of the supply of, and demand for, some crude oil fractions.

Fractions	Approximate %	
	Typical supply from crude oil	Global demand
Gases	2	4
Petrol and naphtha	16	27
Kerosine	13	8
Gas oil	19	23
Fuel oil and bitumen	50	38

(i) Use the data given above to explain why catalytic cracking of crude oil fractions is commercially important.

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(ii) Give the two main types of product obtained by catalytic cracking.

Type 1 .....

Type 2 .....

(4)

(c) Name a catalyst used in catalytic cracking. State the type of mechanism involved and outline the industrial conditions used in the process.

Catalyst .....

Conditions .....

(4)

(Total 11 marks)

**Q4.** (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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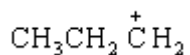
(5)

- (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)**