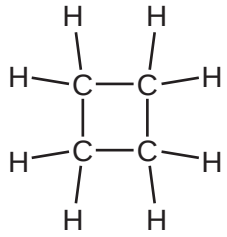
1 **(a)** A hydrocarbon has the following structural formula.



(i) State the molecular formula and the empirical formula of this hydrocarbon.

molecular formula .....

empirical formula .....

[2]

(ii) Draw the structural formula of an isomer of the above hydrocarbon.

[1]

(iii) Explain why these two hydrocarbons are isomers.

.....

..... [2]

(iv) Are these two hydrocarbons members of the same homologous series?
Give a reason for your choice.

.....

..... [1]

(b) Alkenes can be made from alkanes by cracking.

(i) Explain the term *cracking*.

.....

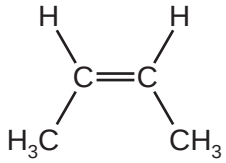
..... [2]

(ii) One mole of an alkane, when cracked, produced one mole of hexane, C_6H_{14}, and two moles of ethene.
What is the molecular formula of the original alkane?

..... [1]

(c) Alkenes are used in polymerisation reactions and addition reactions.

(i) Draw the structural formula of the product formed by the addition polymerisation of but-2-ene. Its formula is given below.



[3]

(ii) Give the name and structural formula of the addition product formed from ethene and bromine.

name .....

structural formula

[2]

[Total: 14]

2 The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) 10 cm^3 of butane is mixed with 100 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

(ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....

..... [2]

(b) The equation for a substitution reaction of butane is given below.

$$CH_3{-}CH_2{-}CH_2{-}CH_3 + Cl_2 \longrightarrow CH_3{-}CH_2{-}CH_2{-}CH_2{-}Cl + HCl$$

(i) Name the organic product.

..... [1]

(ii) This reaction does not need increased temperature or pressure.
What is the essential reaction condition?

..... [1]

(iii) Write a different equation for a substitution reaction between butane and chlorine.

..... [1]

(c) Alkenes are more reactive and industrially more useful than alkanes.
They are made by cracking alkanes.

$$\underset{\text{heptane}}{C_7H_{16}} \longrightarrow \underset{\text{propene}}{CH_3{-}CH{=}CH_2} + \underset{\text{but-1-ene}}{CH_3{-}CH_2{-}CH{=}CH_2} + H_2$$

(i) Draw the structural formula of the polymer poly(propene).

[2]

(ii) Give the structural formula and name of the alcohol formed when but-1-ene reacts with steam.

name ..... [1]

structural formula

[1]

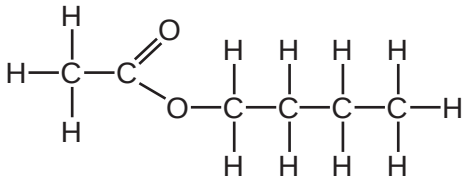
(iii) Deduce the structural formula of the product formed when propene reacts with hydrogen chloride.

[1]

[Total: 12]

3 Esters, fats and polyesters all contain the ester linkage.

(a) The structural formula of an ester is given below.



Name **two** chemicals that could be used to make this ester and draw their structural formulae. Show all bonds.

names ..... and ..... [2]

structural formulae

[2]

(b) **(i)** Draw the structural formula of a polyester such as *Terylene*.

[2]

(ii) Suggest a use for this polymer.

..... [1]

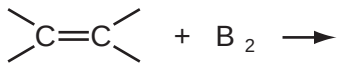
(c) Cooking products, fats and vegetable oils, are mixtures of saturated and unsaturated esters.

The degree of unsaturation can be estimated by the following experiment. 4 drops of the oil are dissolved in 5 cm^3 of ethanol. Dilute bromine water is added a drop at a time until the brown colour no longer disappears. Enough bromine has been added to the sample to react with all the double bonds.

cooking product	mass of saturated fat in 100 g of product / g	mass of unsaturated fat in 100 g of product / g	number of drops of bromine water
margarine		35	5
butter		28	4
corn oil	10	84	12
soya oil	15	70	10
lard		56	.....

(i) Complete the one blank space in the table. [1]

(ii) Complete the equation for bromine reacting with a double bond.



[2]

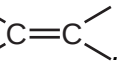
(iii) Using saturated fats in the diet is thought to be a major cause of heart disease. Which of the products is the least likely to cause heart disease?

..... [1]

(d) A better way of measuring the degree of unsaturation is to find the iodine number of the unsaturated compound. This is the mass of iodine that reacts with all the double bonds in 100 g of the fat.

Use the following information to calculate the number of double bonds in one molecule of the fat.

Mass of one mole of the fat is 884 g.

One mole of I_2 reacts with one mole 

The iodine number of the fat is 86.2 g.

Complete the following calculation.

100 g of fat reacts with 86.2 g of iodine.

884 g of fat reacts with ..... g of iodine.

One mole of fat reacts with ..... moles of iodine molecules.

Number of double bonds in one molecule of fat is ..... [3]

[Total:14]

4 The fractional distillation of crude oil usually produces large quantities of the heavier fractions. The market demand is for the lighter fractions and for the more reactive alkenes. The heavier fractions are cracked to form smaller alkanes and alkenes as in the following example.

$$\underset{\text{octane}}{C_8H_{18}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{butenes}}{C_4H_8}$$

(a) (i) Write a different equation for the cracking of octane.

$C_8H_{18} \longrightarrow$ ..... + ... [1]

(ii) The cracking of octane can produce isomers with the molecular formula C_4H_8. Draw the structural formulae of two of these isomers.

[2]

(b) (Give the essential condition for the reaction between chlorine and butane.

..... [1]

(ii) What type of reaction is this?

..... [1]

(iii) This reaction produces a mixture of products. Give the names of **two** products that contain four carbon atoms per molecule.

..... and ..... [2]

(c) Alkenes are more reactive than alkanes and are used to make a range of organic chemicals. Propene, $CH_3–CH=CH_2$, is made by cracking. Give the structural formula of the addition product when propene reacts with the following.

(i) water

[1]

(ii) bromine

[1]

(d) Propene reacts with hydrogen iodide to form 2-iodopropane.

$$CH_3–CH=CH_2 \quad + \quad HI \longrightarrow CH_3–CHI–CH_3$$

1.4 g of propene produced 4.0 g of 2-iodopropane.

Calculate the percentage yield.

moles of $CH_3–CH=CH_2$ reacted = ...

maximum moles of $CH_3–CHI–CH_3$ that could be formed = ...

mass of one mole of $CH_3–CHI–CH_3$ = 170 g

maximum mass of 2-iodopropane that could be formed = ...

percentage yield .....% [4]