1 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]

2 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]

3 Three common pollutants in the air are carbon monoxide, the oxides of nitrogen, NO and NO_2, and unburnt hydrocarbons. They are all emitted by motor vehicles.

(a) Describe how the oxides of nitrogen are formed.

.....

..... [2]

(b) Describe how a catalytic converter reduces the emission of these three pollutants.

.....

.....

.....

.....

..... [4]

(c) Other atmospheric pollutants are lead compounds from leaded petrol.
Explain why lead compounds are harmful.

.....

..... [1]

[Total: 7]

4 The alkanes are a family of saturated hydrocarbons. Their reactions include combustion, cracking and substitution.

(a) What is meant by the term *hydrocarbon*?

..... [1]

(ii) What is meant by the term *saturated*?

..... [1]

(b) What is the general formula for the homologous series of alkanes?

..... [1]

(ii) Calculate the mass of one mole of an alkane with 14 carbon atoms.

.....

..... [2]

(c) The complete combustion of hydrocarbons produces carbon dioxide and water only.

(i) Write the equation for the complete combustion of nonane, C_9H_{20}.

..... [2]

(ii) 20 cm^3 of a gaseous hydrocarbon was mixed with an excess of oxygen, 200 cm^3. The mixture was ignited. After cooling, 40 cm^3 of oxygen and 100 cm^3 of carbon dioxide remained. Deduce the formula of the hydrocarbon and the equation for its combustion. All volumes were measured at r.t.p..

.....

.....

.....

.....

..... [3]

(d) Cracking is used to obtain short-chain alkanes, alkenes and hydrogen from long-chain alkanes.

(i) Give a use for each of the three products listed above.

short-chain alkanes .....

alkenes .....

hydrogen ..... [3]

(ii) Write an equation for the cracking of decane, $C_{10}H_{22}$, which produces two different alkenes and hydrogen as the only products.

..... [1]

(e) Chlorine reacts with propane in a substitution reaction to form 1-chloropropane.

$$CH_3-CH_2-CH_3 + Cl_2 \rightarrow CH_3-CH_2-CH_2-Cl + HCl$$

(i) What is the essential condition for the above reaction?

..... [1]

(ii) There is more than one possible substitution reaction between chlorine and propane. Suggest the structural formula of a different product.

..... [1]

[Total: 16]