

1 (a) Hydrocarbons are compounds which contain hydrogen and carbon only.

- 10cm<sup>3</sup> of a gaseous hydrocarbon, C<sub>x</sub>H<sub>y</sub>, are burned in 100cm<sup>3</sup> of oxygen, which is an excess of oxygen.
- After cooling to room temperature and pressure, there is 25cm<sup>3</sup> of unreacted oxygen, 50cm<sup>3</sup> of carbon dioxide and some liquid water.

All volumes are measured under the same conditions of temperature and pressure.

(i) What is meant by an excess of oxygen?

..... [1]

(ii) What was the volume of oxygen that reacted with the hydrocarbon?

..... [1]

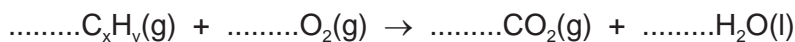
(iii) Complete the table below to express the smallest whole number ratio of

volume of hydrocarbon reacted : volume of oxygen reacted : volume of carbon dioxide produced

	volume of hydrocarbon reacted	volume of oxygen reacted	volume of carbon dioxide produced
<b>smallest</b> whole number ratio of volumes			

[1]

(iv) Use your answer to (a)(iii) to find the mole ratio in the equation below. Complete the equation and deduce the formula of the hydrocarbon.



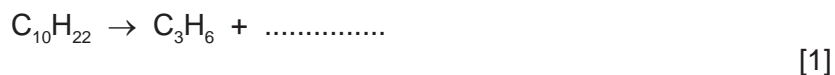
formula of hydrocarbon = .....

[2]

- (b) Cracking is used to convert long chain alkanes into shorter chain alkanes and alkenes. Alkenes are unsaturated compounds.

Decane,  $C_{10}H_{22}$ , can be cracked to give propene and one other product.

- (i) Complete the chemical equation.



- (ii) What is meant by the term *unsaturated*?

..... [1]

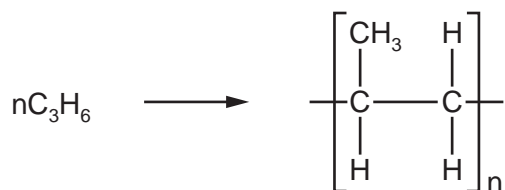
- (iii) Describe a test to show that propene is an unsaturated compound.

test .....

result .....

[2]

- (c) Propene can be polymerised. The only product is polypropene. The equation for the polymerisation is:



- (i) Name the type of polymerisation that occurs.

..... [1]

- (ii) Deduce the maximum mass of polypropene that could be produced from 1 kg of propene.

..... kg [1]

- (iii) Give the empirical formula of

propene, .....

polypropene. ....

[2]

[Total: 13]

2 Two homologous series of hydrocarbons are the alkanes and the alkenes.

(a) One general characteristic of a homologous series is that the physical properties vary in a predictable way.

State **three** other general characteristics of a homologous series.

.....  
.....  
..... [3]

(ii) How can the molecular formula of a hydrocarbon show whether it is an alkane or an alkene?

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

(iii) How do alkanes and alkenes differ in their molecular structures?

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

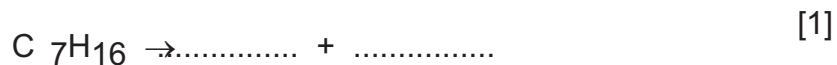
(b) Cracking is the thermal decomposition of alkanes into smaller hydrocarbons and possibly hydrogen.

(i) State **two** conditions required for the cracking of an alkane.

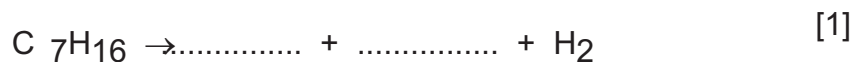
..... [2]

(ii) One type of cracking produces an alkane and an alkene.

Complete an equation for the cracking of heptane into an alkane and an alkene.



(iii) Complete an equation for the cracking of heptane into hydrogen and two other products.



(iv) Suggest **one** reason why cracking is important.

..... [1]

(c) Hydrocarbons burn in excess oxygen to form carbon dioxide and water.  $20\text{cm}^3$  of a gaseous hydrocarbon burned in an excess of oxygen,  $200\text{cm}^3$ . After cooling, the volume of the residual gas at r.t.p. was  $150\text{cm}^3$ ,  $50\text{cm}^3$  of which was oxygen.

(i) Determine the volume of the oxygen used.

..... [1]

(ii) Determine the volume of the carbon dioxide formed.

..... [1]

(iii) The hydrocarbon was an alkane.

Determine the formula of the hydrocarbon.

[1]

[Total: 15]

3 (a) Coal is a solid fossil fuel.

Name **two** other fossil fuels.

..... [2]

(b) Two of the elements present in a sample of coal are carbon and sulfur.

A sample of coal was heated in the absence of air and the products included water, ammonia and hydrocarbons.

Name **three** other elements present in this sample of coal.

..... [2]

(c) Sulfur, present in coal, is one major cause of acid rain. Sulfur burns to form sulfur dioxide which reacts with rain water to form sulfuric acid.

(i) Describe how the high temperatures in vehicle engines are another cause of acid rain.

.....  
.....  
..... [3]

(ii) Give **two** harmful effects of acid rain.

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

(d) In 2010, a large coal-burning power station in the UK was converted to burn both coal and wood.

Explain why the combustion of wood rather than coal can reduce the effect of the emissions from this power station on the level of carbon dioxide in the atmosphere.

.....  
.....  
.....  
..... [3]

[Total: 12]

4 (a) (i) Coal is a solid fossil fuel. Name another fossil fuel.

..... [1]

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

.....

..... [2]

(b) The burning of fossil fuels is largely responsible for the formation of acid rain.  
Two of the acids in acid rain are sulfuric acid and nitric acid.

(i) Explain how the combustion of coal can form sulfuric acid.

.....

.....

..... [3]

**(ii)** High temperatures generated by the combustion of fossil fuels can lead to the formation of nitric acid. Explain.

.....

.....

..... [3]

**(iii)** Nitric acid contains nitrate ions.

Describe a test for nitrate ions.

.....

..... [2]

**(iv)** Explain how you could determine which one of two samples of acid rain had the higher concentration of hydrogen ions.

.....

..... [2]

[Total: 13]



5 Butane is oxidised to a mixture of carboxylic acids by oxygen in the presence of a catalyst. The acids formed are methanoic acid, ethanoic acid and propanoic acid – the first three members of the carboxylic acid homologous series.

(a) Give the name and structural formula of the fourth member of this series.

name .....

structural formula showing all the atoms and bonds

[3]

(ii) State **three** characteristics of a homologous series.

.....  
.....  
..... [3]

(iii) All members of this series are weak acids.

What is meant by the term *weak acid*?

.....  
.....  
..... [3]

(b) Carboxylic acids react with alcohols to form esters. Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate,  $\text{CH}_3\text{COOCH}_2\text{CH}_3$ .

(i) Give the name and formula of the ester which is formed from methanol and propanoic acid.

name .....

formula .....

[2]

(ii) What is the name of the ester which has the formula  $\text{CH}_3\text{COOCH}_3$ ?

..... [1]

(c) Complete the equation for the oxidation of butane to propanoic acid.



[1]

(ii) Name **another** compound which can be oxidised to propanoic acid.

..... [1]

[Total: 14]

6 (a) Natural gas, which is mainly methane, is a fossil fuel.

(i) What is meant by the term *fuel*?

.....  
..... [1]

(ii) Name **two** other fossil fuels.

..... [2]

(iii) Name a **solid** fuel which is not a fossil fuel.

..... [1]

(b) Fossil fuels are formed by the anaerobic decomposition of organic matter. Anaerobic means in the absence of oxygen.

(i) The organic matter contains hydrogen and carbon. Suggest the products that would be formed if the decomposition occurred in the presence of oxygen.

..... [2]

(ii) What are the **two** main disadvantages in the widespread use of fossil fuels?

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

[Total: 8]