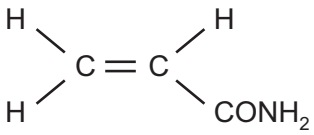
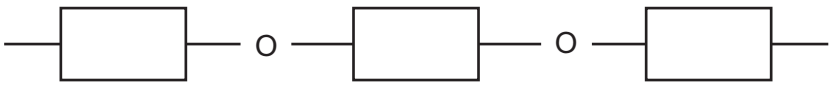
1 In 2002, Swedish scientists found high levels of acrylamide in starchy foods that had been cooked above 120 °C. Acrylamide, which is thought to be a risk to human health, has the following structure.



(a) (i) It readily polymerises to polyacrylamide. Draw the structure of this polymer.

[2]

(ii) Starch is formed by polymerisation. It has a structure of the type shown below. Name the monomer.



..... [1]

(iii) What are the differences between these two polymerisation reactions, one forming polyacrylamide and the other starch?

.....

..... [2]

(b) Acrylamide hydrolyses to form acrylic acid and ammonium ions.

(i) Describe the test for the ammonium ion.

test .....

.....

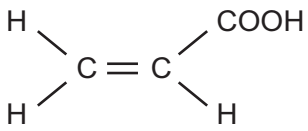
result ..... [2]

(ii) Given an aqueous solution, concentration 0.1 mol / dm^3, how could you show that acrylic acid is a weak acid.

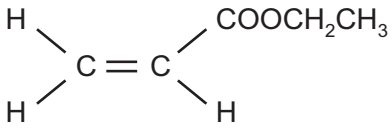
.....

..... [2]

(c) The structural formula of acrylic acid is shown below. It forms compounds called acrylates.



(i) Acrylic acid reacts with ethanol to form the following compound.



Deduce the name of this compound. What type of organic compound is it?

name .....

type of compound ..... [2]

(ii) Acrylic acid is an unsaturated compound. It will react with bromine. Describe the colour change and draw the structural formula of the product of this addition reaction.

colour change .....

structural formula of product

[2]

2 Esters occur naturally in plants and animals. They are manufactured from petroleum. Ethyl ethanoate and butyl ethanoate are industrially important as solvents.

(a) (i) Explain the term *solvent*.

.....[1]

(ii) Give the formula of ethyl ethanoate.

[1]

(iii) Ethyl ethanoate can be made from ethanol and ethanoic acid. Describe how these chemicals can be made.

ethanol from ethene

.....

.....[2]

ethanoic acid from ethanol

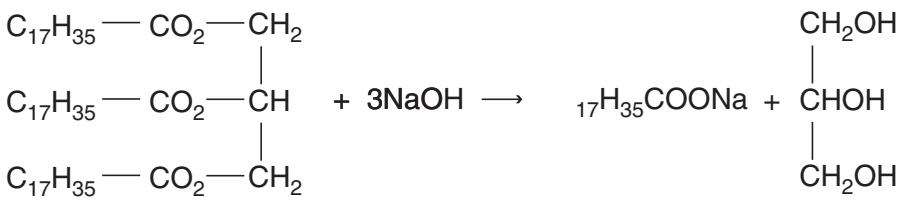
.....

.....[2]

(iv) Name **two** chemicals from which butyl ethanoate can be made.

.....[1]

(b) The following equation represents the alkaline hydrolysis of a naturally occurring ester.



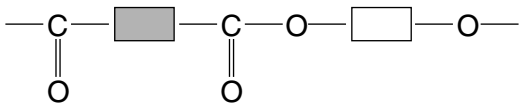
(i) Which substance in the equation is an alcohol? Underline the substance in the equation above.

[1]

(ii) What is the major use for compounds of the type $C_{17}H_{35}COONa$?

.....[1]

(c) A polymer has the structure shown below.



(i) What type of polymer is this?

.....[1]

(ii) Complete the following to give the structures of the two monomers from which the above polymer could be made.

[2]

(d) Esters are frequently used as solvents in chromatography. A natural macromolecule was hydrolysed to give a mixture of amino acids. These could be identified by chromatography.

(i) What type of macromolecule was hydrolysed?

.....[1]

(ii) What type of linkage was broken by hydrolysis?

.....[1]

(iii) Explain why the chromatogram must be sprayed with a locating agent before the amino acids can be identified.

.....

.....[1]

(iv) Explain how it is possible to identify the amino acids from the chromatogram.

.....

.....[2]

3 Alkenes are unsaturated hydrocarbons. They show structural isomerism. Alkenes take part in addition reactions and form polymers.

(a) Structural isomers have the same molecular formula but different structural formulae. Give an example of structural isomerism.

molecular formula .....

two structural formulae

[3]

(b) Ethene reacts with each of the following. Give the name and structural formula of each product.

(i) steam

name of product .....

structure of product

[2]

(ii) hydrogen

name of product .....

structure of product

[2]

(c) Alkenes polymerise by addition.

(i) Explain the term *polymerise*.

.....

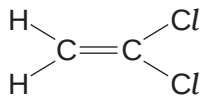
.....[2]

(ii) What is the difference between addition polymerisation and condensation polymerisation?

.....

.....[2]

(iii) Poly(dichloroethene) is used extensively to package food. Draw its structure. The structural formula of dichloroethene is drawn below.



[2]

(d) Steel may be coated with another metal, eg zinc or chromium, or with a polymer, eg poly(chloroethene), to prevent rusting.

(i) Suggest a property of poly(chloroethene) that makes it suitable for this purpose.

.....[1]

(ii) Explain why the steel will rust when the protective coating of chromium or polymer is broken.

.....[1]

(iii) When the protective layer of zinc is broken, the steel still does not rust.
Suggest an explanation.

.....

.....

.....[2]

4 Petroleum is a source of many important chemicals.

(a) Name **two** industrial processes which must take place to produce alkenes from petroleum.

.....

..... [2]

(b) Ethene, $CH_2=CH_2$, and propene, $CH_2=CHCH_3$, can both be converted into polymers.

(i) What type of polymerisation takes place when ethene forms a polymer?

..... [1]

(ii) What is the empirical formula of the polymer formed from ethene?

..... [1]

(iii) Propene has the structural formula $CH_2=CHCH_3$.

Draw **two** repeat units of the polymer made from propene.

[2]

(c) Ethene will react with steam to form ethanol.

Propene will react with steam to form two isomers, both of which are alcohols.

Suggest the structures of these alcohols.

[2]

(d) Esters are organic chemicals noted for their characteristic smells. Ethanoic acid and methanol will react to form an ester.

(i) Name the catalyst needed to form an ester from ethanoic acid and methanol.

..... [1]

(ii) Name the ester formed when ethanoic acid reacts with methanol.

..... [1]

(iii) Draw the structure of the ester formed when ethanoic acid reacts with methanol. Show all bonds.

[2]

(iv) Give the name of a polyester.

..... [1]

[Total: 13]

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

- 10 cm^3 of a gaseous hydrocarbon, C_xH_y, are burned in 100 cm^3 of oxygen, which is an excess of oxygen.
- After cooling to room temperature and pressure, there is 25 cm^3 of unreacted oxygen, 50 cm^3 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
smallest 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.

$$\text{.....}C_xH_y(g) + \text{.....}O_2(g) \rightarrow \text{.....}CO_2(g) + \text{.....}H_2O(l)$$

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.

$$C_{10}H_{22} \rightarrow C_3H_6 + \text{.....}$$

[1]

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

..... [1]

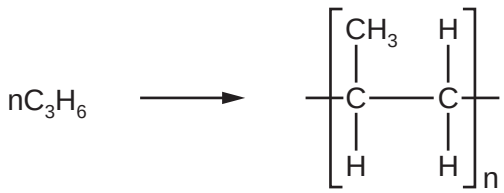
(iii) Describe a test to show that propene is an unsaturated compound.

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]