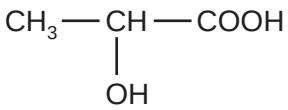
1 Lactic acid can be made from corn starch.



lactic acid

It polymerises to form the polymer, polylactic acid (PLA) which is biodegradable.

(a) Suggest **two** advantages that PLA has compared with a polymer made from petroleum.

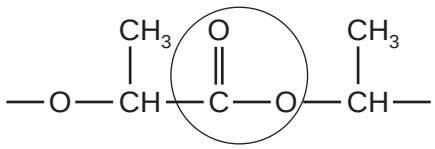
.....

.....

.....

..... [2]

(b) The structure of PLA is given below.



(i) What type of compound contains the group that is circled?

..... [1]

(ii) Complete the following sentence.

Lactic acid molecules can form this group because they contain both an

..... group and an ..... group. [2]

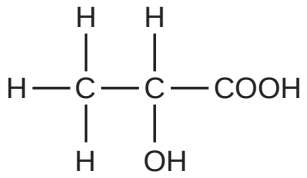
(iii) Is the formation of PLA, an addition or condensation polymerisation? Give a reason for your choice.

.....

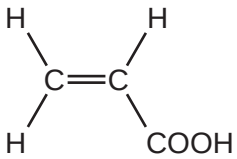
.....

..... [2]

(c) When lactic acid is heated, acrylic acid is formed.



lactic acid



acrylic acid

(i) Complete the word equation for the action of heat on lactic acid.

lactic acid → ..... + ... [1]

(ii) Describe a test that would distinguish between lactic acid and acrylic acid.

test .....

result for lactic acid .....

result for acrylic acid ..... [3]

(iii) Describe a test, other than using an indicator, which would show that both chemicals contain an acid group.

test .....

result .....

..... [2]

[Total: 13]

2 Butan-1-ol is used as a solvent for paints and varnishes, to make esters and as a fuel. Butan-1-ol can be manufactured from but-1-ene, which is made from petroleum.

Biobutanol is a fuel of the future. It can be made by the fermentation of almost any form of biomass - grain, straw, leaves etc.

(a) But-1-ene can be obtained from alkanes such as decane, $C_{10}H_{22}$, by cracking.

(i) Give the reaction conditions.

.....

..... [2]

(ii) Complete an equation for the cracking of decane, $C_{10}H_{22}$, to give but-1-ene.

$C_{10}H_{22} \rightarrow$ ..... [2]

(iii) Name the reagent that reacts with but-1-ene to form butan-1-ol.

..... [1]

(b) Balance the equation for the complete combustion of butan-1-ol.

..... C_4H_9OH + ... $O_2 \rightarrow$ ..... CO_2 + ... H_2O [2

(ii) Write a word equation for the preparation of the ester butyl methanoate.

..... [2]

(c) The fermentation of biomass by bacteria produces a mixture of products which include biobutanol, propanol, hydrogen and propanoic acid.

(i) Draw the structural formula of propanol and of propanoic acid. Show all the bonds.

propanol

propanoic acid

[2]

(ii) Why is it important to develop these fuels, such as biobutanol, as alternatives to petroleum?

.....

[1]

(d) How could you show that butanol made from petroleum and biobutanol are the same chemical?

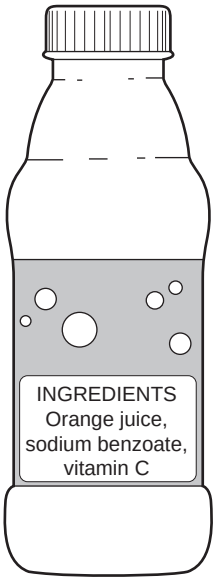
.....

.....

[1]

[Total: 13]

3 Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.



(a) Sodium benzoate is a salt, it has the formula C_6H_5COONa. It can be made by the neutralisation of benzoic acid by sodium hydroxide.

(i) Deduce the formula of benzoic acid.

..... [1]

(ii) Write a word equation for the reaction between benzoic acid and sodium hydroxide.

..... [1]

(iii) Name **two** other compounds that would react with benzoic acid to form sodium benzoate.

..... [2]

(b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

.....

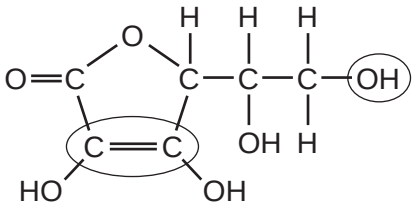
..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

(c) The structural formula of Vitamin C is drawn below.



(i) What is its molecular formula?

..... [1]

(ii) Name the two functional groups which are circled.

..... [2]

[Total: 12]

4 The alcohols form a homologous series. The first four members are methanol, ethanol, propan-1-ol and butan-1-ol.

(a) One characteristic of a homologous series is that the physical properties vary in a predictable way. The table below gives the heats of combustion of the first three alcohols.

alcohol	formula	heat of combustion in kJ / mol
methanol	$_3$OH	
ethanol	$_3$-CH_2-OH	
propan-1-ol	$_3$-CH_2-CH_2-OH	
butan-1-ol	$_3$-CH_2-CH_2-CH_2-OH	

(i) The minus sign indicates that there is less chemical energy in the products than in the reactants. What form of energy is given out by the reaction?

.....

[1]

(ii) Is the reaction exothermic or endothermic?

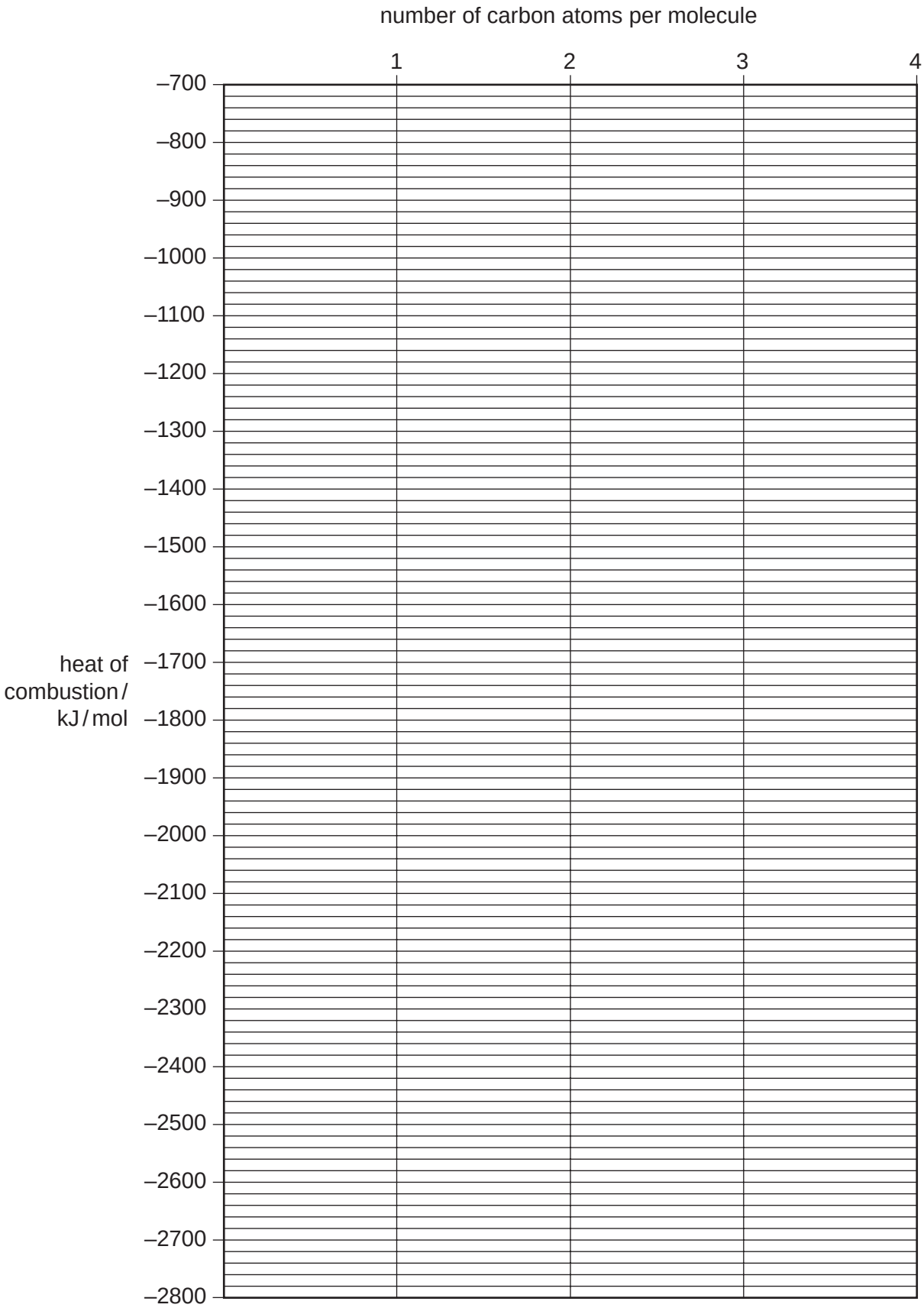
.....

[1]

(iii) Complete the equation for the complete combustion of ethanol.

C_2H_5OH + ...$O_2 \rightarrow$ ..... + ... [2]

(iv) Determine the mbustion of the first three alcohols against the number of carbon atoms per molecule.



The heat of combustion of butan-1-ol = ... kJ / mol [3]

(v) Describe **two** other characteristics of homologous series.

.....

..... [2]

(b) Give the name and structural formula of an isomer of propan-1-ol.
structural formula

name ..... [2]

(c) Methanol is made from carbon monoxide.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ the forward reaction is exothermic

(i) Describe how hydrogen is obtained from alkanes.

.....

..... [2]

(ii) Suggest a method of making carbon monoxide from methane.

..... [2]

(iii) Which condition, high or low pressure, would give the maximum yield of methanol? Give a reason for your choice.

pressure .....

reason ..... [2]

(d) For each of the following predict the name of the organic product.

(i) reaction between methanol and ethanoic acid

..... [1]

(ii) oxidation of propan-1-ol by potassium dichromate(VI)

..... [1]

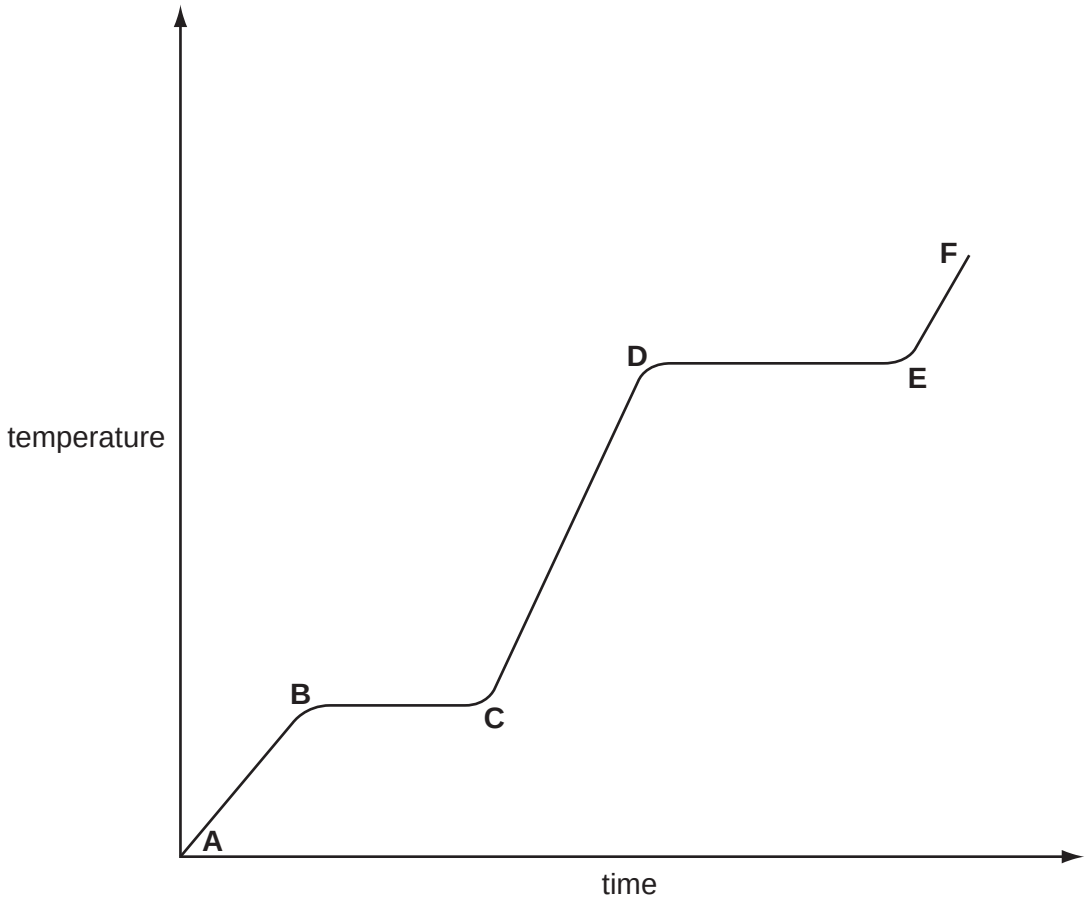
(iii) removal of H_2O from ethanol (dehydration)

..... [1]

[Total: 20]

5 Ethanoic acid is a colourless liquid at room temperature. It has the typical acid properties and forms compounds called ethanoates.

(a) A pure sample of ethanoic acid is slowly heated from 0°C to 150°C and its temperature is measured every minute. The results are represented on the graph below.



(i) Name the change that occurs in the region **D** to **E**.

..... [1]

(ii) What would be the difference in the region **B** to **C** if an impure sample had been used?

..... [1]

(iii) Sketch on the graph how the line would continue if the acid was heated to a higher temperature. [1]

(iv) Complete the following table that compares the separation and movement of the molecules in regions **C** to **D** with those in **E** to **F**.

	C to **D**	**E** to **F**
separation (distance between particles)	.....	.....
movement of particles	random and slow	....
Can particles move apart to fill any volume?	.....	.....

[5]

(b) Complete the word equations for the reactions of ethanoic acid.

calcium + ethanoic acid → .....

\+ .....

..... + ethanoic acid → zinc ethanoate + water [2]

(c) Write the symbol equation for the reaction between ethanoic acid and sodium hydroxide.

..... [2]