IGCSE 0620 : ORGANIC CHEMISTRY

Question 1

7 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) (i) 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, $CH_3COOCH_2CH_3$.

(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 CH_3COOCH_3?

..... [1]

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

$$3C_4H_{10} + ...O_2 \rightarrow 4C_2H_5COOH + ...H_2O$$

[1]

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

..... [1]

[Total: 14]

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Question 2

5 (a) Glucose, sucrose and starch are all carbohydrates. Their formulae are:

glucose, $C_6H_{12}O_6$,
sucrose, $C_{12}H_{22}O_{11}$,
starch, $(C_6H_{10}O_5)_n$.

(i) Identify **two** common features in the formulae of these carbohydrates.

.....

..... [2]

(ii) Draw the structure of a complex carbohydrate, such as starch. The formula of glucose, can be represented by

Include **three** glucose units in the structure.

[2]

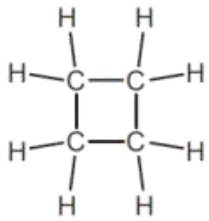
(b) Starch hydrolyses to glucose in the presence of the enzyme, amylase.
What is meant by the term *enzyme*?

..... [2]

0620/w14/qp32

Question 3

3 **(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*.

.....

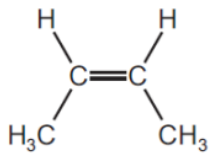
..... [2]

(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]

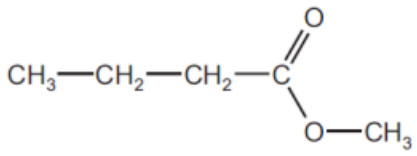
Question 4

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

(a) Esters can be made from alcohols and carboxylic acids. For example, the ester ethyl ethanoate can be made by the following reaction.

$$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$$

(i) Name the carboxylic acid and the alcohol from which the following ester could be made.



name of carboxylic acid .....

name of alcohol .....

[2]

(ii) 6.0 g of ethanoic acid, M_r = 60, was reacted with 5.5 g of ethanol, M_r = 46.
Determine which is the limiting reagent and the maximum yield of ethyl ethanoate, M_r = 88.

number of moles of ethanoic acid = ... [1]

number of moles of ethanol = ... [1]

the limiting reagent is ..... [1]

number of moles of ethyl ethanoate formed = ... [1]

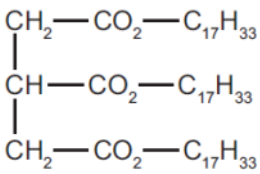
maximum yield of ethyl ethanoate = ... [1]

(b) The following two monomers can form a polyester.

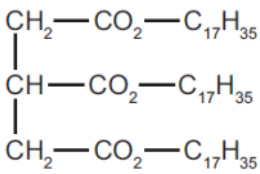
Draw the structural formula of this polyester. Include two ester linkages.

[3]

(c) Fats and vegetable oils are esters. The formulae of two examples of natural esters are given below.



ester 1



ester 2

(i) One ester is saturated, the other is unsaturated.
Describe a test to distinguish between them.

test .....

result with unsaturated ester .....

.....

result with saturated ester .....

.....

[3]

(ii) Deduce which one of the above esters is unsaturated. Give a reason for your choice.

.....

.....

..... [2]

(iii) Both esters are hydrolysed by boiling with aqueous sodium hydroxide.
What types of compound are formed?

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

[Total: 17]

Question 5

6 The alcohols form a homologous series. The first five members are given in the table below.

(a)

alcohol	formula	heat of combustion in kJ / mol
methanol	CH_3OH	730
ethanol	$CH_3–CH_2–OH$	1380
propan-1-ol		
butan-1-ol	$CH_3–CH_2–CH_2–CH_2–OH$	2680
pentan-1-ol	$CH_3–CH_2–CH_2–CH_2–CH_2–OH$	3350

(i) Complete the table. [2]

(ii) Complete the equation for the combustion of pentan-1-ol in excess oxygen.

$C_5H_{11}OH$ + ...O_2 → ..... + ... [1]

(b) State **three** characteristics of a homologous series other than the variation of physical properties down the series.

.....

.....

..... [3]

(c) The following alcohols are isomers.

$CH_3–CH_2–CH_2–CH_2–OH$ and $(CH_3)_2CH–CH_2–OH$

(i) Explain why they are isomers.

.....

.....

..... [2]

(ii) Draw the structural formula of another isomer of the above alcohols.

[1]

(d) Alcohols can be made by fermentation and from petroleum.

(i) Ethanol is made from sugars by fermentation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

The mass of one mole of glucose, $C_6H_{12}O_6$, is 180 g.
Calculate the maximum mass of ethanol which could be obtained from 72 g of glucose.

.....

.....

.....

..... [3]

(ii) Describe how ethanol is made from petroleum.

petroleum (alkanes) → ethene → ethanol

.....

.....

.....

..... [3]

[Total: 15]

Question 6

5 Domestic rubbish is disposed of in landfill sites. Rubbish could include the following items.

item of rubbish	approximate time for item to break down
newspaper	one month
cotton rag	six months
woollen glove	one year
aluminium container	up to 500 years
styrofoam cup	1000 years

(a) Explain why aluminium, a reactive metal, takes so long to corrode.

..... [1]

(b) Both paper and cotton are complex carbohydrates. They can be hydrolysed to simple sugars such as glucose.
The formula of glucose can be represented as:

Draw the structural formula of a complex carbohydrate, such as cotton.
Include at least **two** glucose units.

[2]

(c) Wool is a protein. It can be hydrolysed to a mixture of monomers by enzymes.

(i) What are enzymes?

.....

..... [2]

(ii) Name another substance which can hydrolyse proteins.

..... [1]

(iii) What type of compound are the monomers formed by the hydrolysis of proteins?

..... [1]

(iv) Which technique could be used to identify the individual monomers in the mixture?

..... [1]

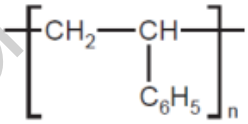
(v) Proteins contain the amide linkage. Name a synthetic macromolecule which contains the same linkage.

..... [1]

(d) **(i)** What is the scientific term used to describe polymers which do not break down in landfill sites?

..... [1]

(ii) Styrofoam is poly(phenylethene). It is an addition polymer. Its structural formula is given below. Deduce the structural formula of the monomer, phenylethene.



[1]

[Total: 11]

Question 7

7 Plants can make complex molecules from simple starting materials, such as water, carbon dioxide and nitrates. Substances produced by plants include sugars, more complex carbohydrates, esters, proteins, vegetable oils and fats.

(a) (i) Describe how you could decide from its molecular formula whether a compound is a carbohydrate.

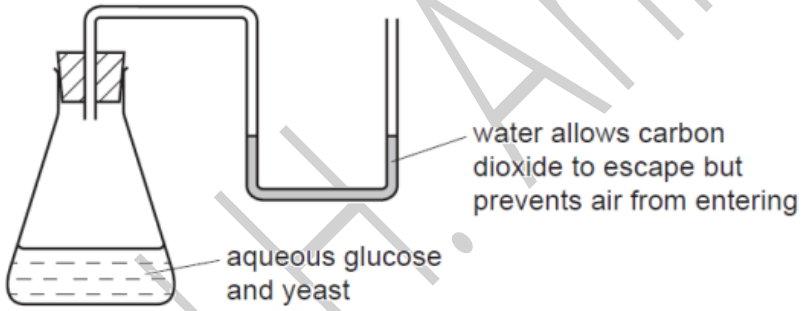
.....

..... [2]

(ii) Plants can change the sugar, glucose, into starch which is a more complex carbohydrate. What type of reaction is this?

..... [2]

(b) The fermentation of glucose can be carried out in the apparatus shown below. After a few days the reaction stops. A 12% aqueous solution of ethanol has been produced.



(i) The enzyme, zymase, catalyses the anaerobic respiration of the yeast. Explain the term *respiration*.

.....

..... [2]

(ii) Complete the equation.

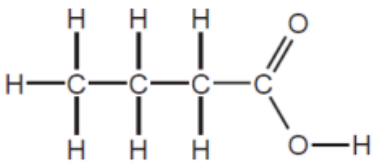
$C_6H_{12}O_6 \rightarrow$ ..... + ... [2]

glucose ethanol carbon dioxide

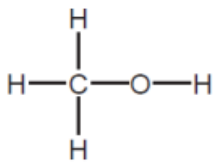
(iii) Why must air be kept out of the flask?

..... [1]

(c) The ester methyl butanoate is found in apples. It can be made from butanoic acid and methanol. Their structural formulae are given below.



butanoic acid

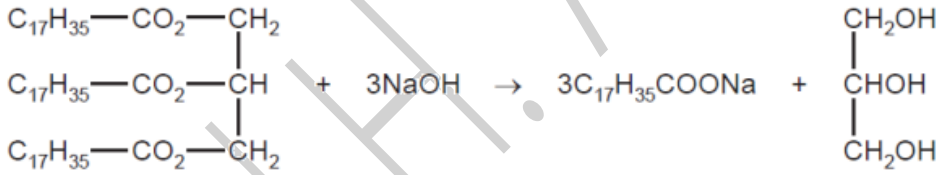


methanol

Use the information given above to deduce the structural formula of methyl butanoate showing all the bonds.

[2]

(d) The equation represents the hydrolysis of a naturally occurring ester.



(i) Which substance in the equation is an alcohol? Put a ring around this substance in the equation above. [1]

(ii) Is the alkyl group, $C_{17}H_{35}$, in this ester saturated or unsaturated? Give a reason for your choice.

..... [1]

(iii) What type of compound is represented by the formula $C_{17}H_{35}COONa$?
What is the major use for compounds of this type?

type of compound .....

use ..... [2]

(e) Proteins are natural macromolecules. Draw the structural formula of a typical protein. Include three monomer units. You may represent amino acids by formulae of the type drawn below.

[3]

[Total: 18]

Question 8

7 **(a)** The following are two examples of substitution reactions. Only the reaction involving chlorine is a photochemical reaction.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(i) Explain the phrase *substitution reaction*.

.....

..... [1]

(ii) How do photochemical reactions differ from other reactions?

.....

..... [1]

(b) Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

.....

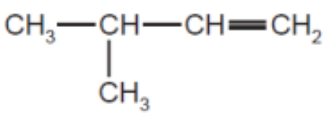
..... [2]

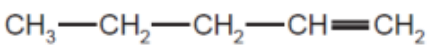
0620/w13/qp31

Question 9

5 The alkenes are unsaturated hydrocarbons. They form a homologous series, the members of which have the same chemical properties.
They undergo addition reactions and are easily oxidised.

(a) The following hydrocarbons are isomers.





(i) Explain why these two hydrocarbons are isomers.

.....

..... [2]

(ii) Give the structural formula of another hydrocarbon which is isomeric with the above.

[1]

(b) Give the structural formula and name of each of the products of the following addition reactions.

(i) ethene and bromine

structural formula of product

name of product ..... [2]

(ii) propene and hydrogen

structural formula of product

name of product ..... [2]

(iii) but-1-ene and water

structural formula of product

name of product ..... [2]

(c) Alkenes can be oxidised to carboxylic acids.

(i) For example, propene, $CH_3-CH=CH_2$, would produce ethanoic acid, CH_3-COOH, and methanoic acid, $H-COOH$. Deduce the formulae of the alkenes which would form the following carboxylic acids when oxidised.

ethanoic acid and propanoic acid

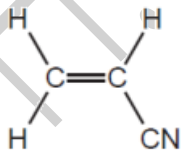
only ethanoic acid

[2]

(ii) Describe the colour change you would observe when an alkene is oxidised with acidified potassium manganate(VII).

..... [2]

(d) Alkenes polymerise to form addition polymers.
Draw the structural formula of poly(cyanoethene), include at least **two** monomer units.
The structural formula of the monomer, cyanoethene, is given below.



[3]

[Total: 16]

Question 10

(c) Hair is a natural protein. Hair absorbs arsenic from the body. Analysis of the hair provides a measurement of a person's exposure to arsenic. To release the absorbed arsenic for analysis, the protein has to be hydrolysed.

(i) What is the name of the linkage in proteins?

..... [1]

(ii) Name a reagent which can be used to hydrolyse proteins.

..... [1]

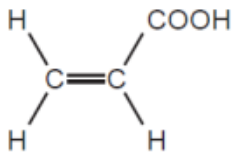
(iii) What type of compound is formed by the hydrolysis of proteins?

..... [1]

0620/w12/qp33

Question 11

5 Propenoic acid is an unsaturated carboxylic acid. The structural formula of propenoic acid is given below.



(a) **(i)** Describe how you could show that propenoic acid is an unsaturated compound.

test .....

result .....

..... [2]

(ii) Without using an indicator, describe how you could show that a compound is an acid.

test .....

result .....

..... [2]

(b) Propenoic acid reacts with ethanol to form an ester. Deduce the name of this ester. Draw its structural formula.

name of ester .....

structural formula showing all bonds

[3]

(c) An organic compound has a molecular formula $C_6H_8O_4$. It is an unsaturated carboxylic acid. One mole of the compound reacts with two moles of sodium hydroxide.

(i) Explain the phrase *molecular formula*.

.....

..... [2]

(ii) One mole of this carboxylic acid reacts with two moles of sodium hydroxide.
How many moles of –COOH groups are there in one mole of this compound?

..... [1]

(iii) What is the formula of another functional group in this compound?

..... [1]

(iv) Deduce a structural formula of this compound.

[1]

[Total: 12]

Question 12

7 The alcohols form a homologous series. The first member of this series is methanol, CH_3OH.

(a) (i) Give the general formula of the alcohols.

..... [1]

(ii) The mass of one mole of an alcohol is 116 g. What is its formula?
Show your reasoning.

.....

..... [2]

(iii) Draw a diagram showing the arrangement of the outer (valency) electrons in one molecule of methanol.

Use x to represent an electron from a carbon atom.
Use o to represent an electron from a hydrogen atom.
Use • to represent an electron from an oxygen atom.

[3]

(c) Methanol is oxidised by atmospheric oxygen. This reaction is catalysed by platinum.

(i) The products of this reaction include a carboxylic acid. Give its name and structural formula.

name .....

structural formula showing all bonds

[2]

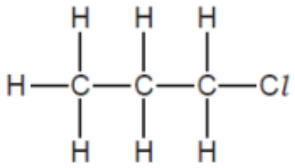
(ii) Deduce the name of the ester formed by the reaction of methanol with the carboxylic acid named in **(i)**.

..... [1]

Question 13

3 Many organic compounds which contain a halogen have chloro, bromo or iodo in their name.

(a) The following diagram shows the structure of 1-chloropropane.



(i) Draw the structure of an isomer of this compound.

[1]

(ii) Describe how 1-chloropropane could be made from propane.

.....

..... [2]

(iii) Suggest an explanation why the method you have described in **(ii)** does not produce a pure sample of 1-chloropropane.

.....

..... [2]

(b) Organic halides react with water to form an alcohol and a halide ion.

$$CH_3–CH_2–I + H_2O \rightarrow CH_3–CH_2–OH + I^-$$

(i) Describe how you could show that the reaction mixture contained an iodide ion.

.....

..... [2]

(ii) Name the alcohol formed when 1-chloropropane reacts with water.

..... [1]

(c) The speed (rate) of reaction between an organic halide and water can be measured by the following method.

A mixture of 10 cm^3 of aqueous silver nitrate and 10 cm^3 of ethanol is warmed to 60 °C. Drops of the organic halide are added and the time taken for a precipitate to form is measured.

Silver ions react with the halide ions to form a precipitate of the silver halide.

$$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$$

Typical results for four experiments, **A**, **B**, **C** and **D**, are given in the table.

experiment	organic halide	number of drops	time / min
A	bromobutane	4	6
B	bromobutane	8	3
C	chlorobutane	4	80
D	iodobutane	4	0.1

(i) Explain why it takes longer to produce a precipitate in experiment **A** than in **B**.

.....

..... [2]

(ii) How does the order of reactivity of the organic halides compare with the order of reactivity of the halogens?

.....

..... [2]

(iii) Explain why the time taken to produce a precipitate would increase if the experiments were repeated at 50 °C.

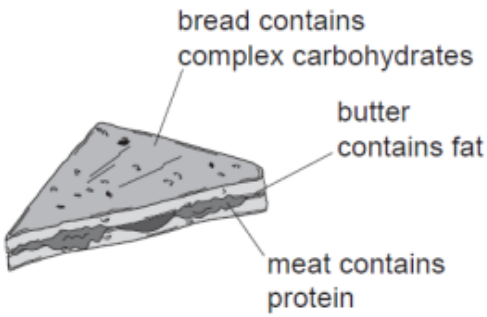
.....

.....

..... [3]

Question 14

6 A sandwich contains three of the main constituents of food.



(a) **(i)** These constituents of food can be hydrolysed by boiling with acid or alkali.
Complete the table.

constituent of food	product of hydrolysis
protein	
fat	
complex carbohydrate	

[3]

(ii) What type of synthetic polymer contains the same linkage as

fats, ...

proteins? ..... [2]

(b) An incomplete structural formula of a protein is given below.
Complete this diagram by inserting the linkages.

[2]

(c) Butter contains mainly saturated fats. Fats based on vegetable oils, such as olive oil, contain mainly unsaturated fats.

A small amount of fat was dissolved in an organic solvent.
Describe how you could determine if the fat was saturated or unsaturated.

.....

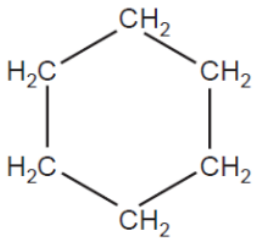
.....

..... [3]

[Total: 10]

Question 15

4 The structural formula of cyclohexane is drawn below.



(a) The name gives information about the structure of the compound.
Hex because there are six carbon atoms and **cyclo** because they are joined in a ring.
What information about the structure of this compound is given by the ending **ane**?

.....

..... [2]

(b) What are the molecular and empirical formulae of cyclohexane?

molecular formula .....

empirical formula ..... [2]

(c) Draw the structural formula of cyclobutane.

[1]

(d) **(i)** Deduce the molecular formula of hexene.

..... [1]

(ii) Explain why cyclohexane and the alkene, hexene, are isomers.

.....

.....

..... [2]

(e) Describe a test which would distinguish between cyclohexane and the unsaturated hydrocarbon hexene.

test .....

result of test with cyclohexane .....

.....

result of test with hexene .....

..... [3]

[Total: 11]

Question 16

1 Petroleum contains hydrocarbons which are separated by fractional distillation.

(a) **(i)** Complete the following definition of a hydrocarbon.

A hydrocarbon is a compound which .....

..... [2]

(ii) Explain what is meant by the term *fractional distillation*.

.....

.....

..... [2]

(b) Some of the fractions obtained from petroleum are given below.
State a use for each fraction.

bitumen .....

lubricating fraction .....

paraffin fraction .....

gasoline fraction ..... [4]

[Total: 8]

0620/s13/qp31

Question 17

8 Ethylamine, $CH_3–CH_2–NH_2$, is a base which has similar properties to ammonia.

(a) In aqueous ethylamine, there is the following equilibrium.

$$CH_3–CH_2–NH_2 + H_2O \rightleftharpoons CH_3–CH_2–NH_3^+ + OH^-$$

Explain why water is behaving as an acid in this reaction.

..... [1]

(b) Given aqueous solutions of ethylamine and sodium hydroxide, describe how you could show that ethylamine is a weak base like ammonia and not a strong base like sodium hydroxide.

.....

.....

..... [3]

(c) Ethylamine, like ammonia, reacts with acids to form salts.

$$CH_3–CH_2–NH_2 + HCl \rightarrow CH_3–CH_2–NH_3Cl$$

ethylammonium chloride

Suggest how you could displace ethylamine from the salt, ethylammonium chloride.

.....

..... [2]

(d) Explain the chemistry of the following reaction:

When aqueous ethylamine is added to aqueous iron(III) chloride, a brown precipitate is formed.

.....

..... [2]

[Total: 8]

Question 18

7 The alkenes are unsaturated hydrocarbons. They form a homologous series, the members of which have similar chemical properties:

- easily oxidised
- addition reactions
- polymerisation
- combustion.

(a) All the alkenes have the same empirical formula.

(i) State their empirical formula.

..... [1]

(ii) Why is the empirical formula the same for all alkenes?

..... [1]

(b) Alkenes can be oxidised to carboxylic acids by boiling with aqueous potassium manganate(VII).

(i) Pent-2-ene, $CH_3–CH_2–CH=CH–CH_3$, oxidises to $CH_3–CH_2–COOH$ and CH_3COOH. Name these two acids.

$CH_3–CH_2–COOH$ .....

CH_3COOH ..... [2]

(ii) Most alkenes oxidise to two carboxylic acids. Deduce the formula of an alkene which forms only one carboxylic acid.

[1]

(c) Complete the following equations for the addition reactions of propene.

(i) $CH_3–CH=CH_2 + Br_2 \rightarrow$ ..... [1]

(ii) $CH_3–CH=CH_2 + H_2O \rightarrow$ ..... [1]

(d) Draw the structural formula of poly(propene)

[2]

(e) 0.01 moles of an alkene needed 2.4 g of oxygen for complete combustion. 2.2 g of carbon dioxide were formed. Determine the following mole ratio.

moles of alkene : moles of O_2 : moles of CO_2

From this ratio determine the formula of the alkene.

..... [3]

Write an equation for the complete combustion of this alkene.

..... [1]

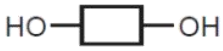
[Total: 13]

0620/s12/qp32

Question 19

5 Islay is an island off the west coast of Scotland. The main industry on the island is making ethanol from barley.

Barley contains the complex carbohydrate, starch. Enzymes catalyse the hydrolysis of starch to a solution of glucose.

(a) **(i)** Draw the structure of the starch.
Glucose can be represented by 

[2]

(ii) Enzymes can catalyse the hydrolysis of starch. Name another catalyst for this reaction.

..... [1]

(iii) Both starch and glucose are carbohydrates. Name the elements found in all carbohydrates.

.....

..... [1]

(b) Yeast cells are added to the aqueous glucose. Fermentation produces a solution containing up to 10 % of ethanol.

(i) Complete the word equation for the fermentation of glucose.

glucose → ..... + ...

[1]

(ii) Explain why is it necessary to add yeast and suggest why the amount of yeast in the mixture increases.

.....

.....

..... [2]

(iii) Fermentation is carried out at 35 °C. For many reactions a higher temperature would give a faster reaction. Why is a higher temperature not used in this process?

.....

..... [2]

(c) The organic waste, the residue of the barley and yeast, is disposed of through a pipeline into the sea. In the future this waste will be converted into biogas by the anaerobic respiration of bacteria. Biogas, which is mainly methane, will supply most of the island's energy.

(i) Anaerobic means in the absence of oxygen. Suggest an explanation why oxygen must be absent.

..... [1]

(ii) The obvious advantage of converting the waste into methane is economic. Suggest **two** other advantages.

.....

..... [2]

[Total: 12]

Question 20

7 Plastics are polymers. They are formed from their monomers by polymerisation.

(a) Two methods for the disposal of waste plastics are

- burning
- recycling.

Describe one advantage **and** one disadvantage of each method.

burning .....

.....

.....

recycling .....

.....

..... [4]

(b) **(i)** There are two types of polymerisation reaction. Give their names and explain the differences between them.

.....

.....

.....

..... [4]

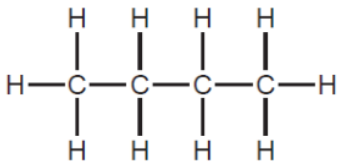
(ii) Give the structural formula of a polymer which is formed from two different monomers.

[2]

[Total: 10]

Question 21

6 Butane is an alkane. It has the following structural formula.



(a) The equation for the complete combustion of butane is given below. Insert the two missing volumes.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

.... 40 volume of gas / cm^3

[2]

(b) Butane reacts with chlorine to form two isomers of chlorobutane.

(i) What type of reaction is this?

..... [1]

(ii) Explain the term *isomer*.

.....

..... [2]

(iii) Draw the structural formulae of these two chlorobutanes.

[2]

(c) One of the chlorobutanes reacts with sodium hydroxide to form butan-1-ol. Butan-1-ol can be oxidised to a carboxylic acid.

(i) State a reagent, other than oxygen, which will oxidise butan-1-ol to a carboxylic acid.

..... [1]

(ii) Name the carboxylic acid formed.

..... [1]

(iii) Butan-1-ol reacts with ethanoic acid to form an ester. Name this ester and give its structural formula showing all the individual bonds.

name ..... [1]

structural formula

[2]

[Total: 12]

Question 22

(b) Alkanes are hydrocarbons and are generally unreactive. Their reactions include combustion, substitution and cracking.

(i) Chlorine reacts with butane in a substitution reaction.

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

Give the structural formula of another possible product of this reaction.

[1]

(ii) What is the essential condition for this reaction?

..... [1]

(iii) Explain what is meant by *cracking*. Give an example of a cracking reaction and explain why the process is used.

.....

.....

.....

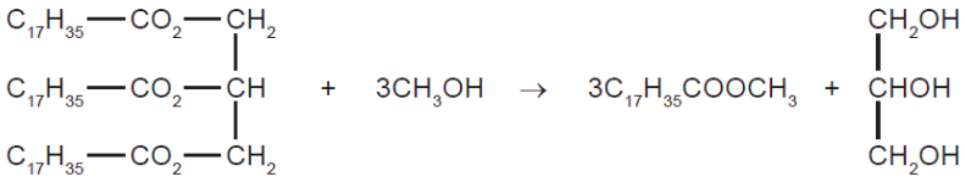
.....

..... [4]

0620/s11/qp32

Question 23

(b) Biodiesel is made from a vegetable oil by the following reaction.



vegetable oil | methanol | biodiesel | glycerol

(i) What type of compound are vegetable oil and biodiesel?

..... [1]

(ii) What other useful product is made from vegetable oil by heating it with aqueous sodium hydroxide?

..... [1]

(iii) Suggest an explanation why making and using biodiesel has a smaller effect on the percentage of carbon dioxide in the atmosphere than using petroleum-based diesel.

.....

.....

..... [2]

(c) Petroleum-based diesel is a mixture of hydrocarbons, such as octane and octene.

(i) 'Oct' means eight carbon atoms per molecule. Draw a structural formula of an octene molecule.

[1]

(ii) Describe a test which would distinguish between octane and octene.

test .....

result with octane .....

result with octene ..... [3]

[Total: 14]

Question 24

8 There are two types of polymerisation - addition and condensation.

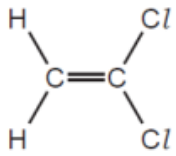
(a) Explain the difference between them.

.....

.....

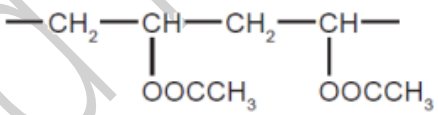
..... [2]

(b) Poly(dichloroethene) is used to package food. Draw its structure. The structural formula of dichloroethene is shown below.



[2]

(c) The polymer known as PVA is used in paints and adhesives. Its structural formula is shown below.



Deduce the structural formula of its monomer.

[1]

(d) A condensation polymer can be made from the following monomers.

$HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$

Draw the structural formula of this polymer.

[3]

[Total: 8]

0620/s11/qp31

Question 25

6 The structural formula of a butanol is given below.

$CH_3—CH_2—CH_2—CH_2—OH$

(a) Butanol can be made from petroleum and also by fermentation.

(i) Describe the chemistry of making butanol from petroleum by the following route.

petroleum → butene → butanol

.....

.....

..... [3]

(ii) Explain, in general terms, what is meant by *fermentation*.

.....

.....

.....

..... [3]

(b) Butanol can be oxidised to a carboxylic acid by heating with acidified potassium manganate(VII). Give the name and structural formula of the carboxylic acid.

name ..... [1]

structural formula

[1]

(c) Butanol reacts with ethanoic acid to form a liquid, **X**, which has the sweet smell of bananas. Its empirical formula is C_3H_6O and its M_r is 116.

(i) What type of compound is liquid **X**?

..... [1]

(ii) Give the molecular formula of liquid **X**.

..... [1]

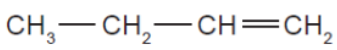
(iii) Draw the structural formula of **X**. Show all the individual bonds.

[2]

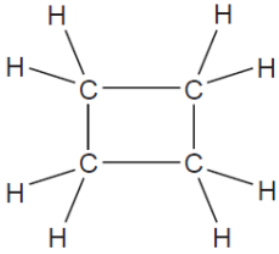
[Total: 12]

Question 26

4 But-1-ene is a typical alkene. It has the structural formula shown below.



The structural formula of cyclobutane is given below.



(a) These two hydrocarbons are isomers.

(i) Define the term *isomer*.

.....

..... [2]

(ii) Draw the structural formula of another isomer of but-1-ene.

[1]

(iii) Describe a test which would distinguish between but-1-ene and cyclobutane.

reagent .....

result with but-1-ene .....

.....

result with cyclobutane .....

..... [3]

(b) Describe how alkenes, such as but-1-ene, can be made from alkanes.

.....

..... [2]

(c) Name the product formed when but-1-ene reacts with:

bromine, ... [1]

hydrogen, ... [1]

steam. ..... [1]

[Total: 11]

Question 27

2 The hydrolysis of complex carbohydrates to simple sugars is catalysed by enzymes called carbohydrases and also by dilute acids.

(a) (i) They are both catalysts. How do enzymes differ from catalysts such as dilute acids?

..... [1]

(ii) Explain why ethanol, C_2H_6O, is not a carbohydrate but glucose, $C_6H_{12}O_6$, is a carbohydrate.

.....

..... [2]

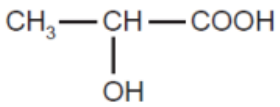
(b) Draw the structure of a complex carbohydrate, such as starch. The formula of a simple sugar can be represented by HO—□—OH.

[3]

0620/s10/qp32

Question 28

8 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.

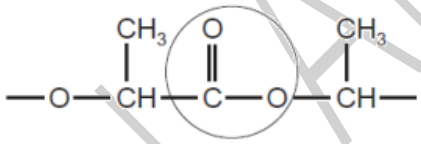
.....

.....

.....

..... [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]

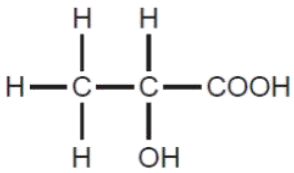
(iii) Is the formation of PLA, an addition or condensation polymerisation? Give a reason for your choice.

.....

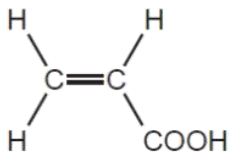
.....

..... [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]

Question 29

(b) Soya beans contain all three main food groups. Two of which are protein and carbohydrate.

(i) What is the third group?

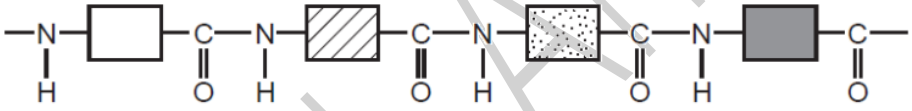
.....

[1]

(ii) Draw the structural formula of a complex carbohydrate such as starch.

[3]

(iii) Compare the structure of a protein with that of a synthetic polyamide. The structure of a typical protein is given below.



How are they similar?

.....

How are they different?

.....

.....

[3]

Question 30

(c) The fermentation of glucose is catalysed by enzymes from yeast. Yeast is added to aqueous glucose, the solution starts to bubble and becomes cloudy as more yeast cells are formed.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

The reaction is exothermic.

Eventually the fermentation stops when the concentration of ethanol is about 12%.

(i) What is an enzyme?

.....

.....

[1]

(ii) Pasteur said that fermentation was respiration in the absence of air. Suggest a definition of *respiration*.

.....

.....

.....

[2]

(iii) On a large scale, the reaction mixture is cooled. Suggest a reason why this is necessary.

.....

.....

[1]

(iv) Why does the fermentation stop? Suggest **two** reasons.

.....

.....

.....

[2]

(v) When the fermentation stops, there is a mixture of dilute aqueous ethanol and yeast. Suggest a technique which could be used to remove the cloudiness due to the yeast.

.....

.....

[1]

Name a technique which will separate the ethanol from the ethanol/water mixture.

.....

.....

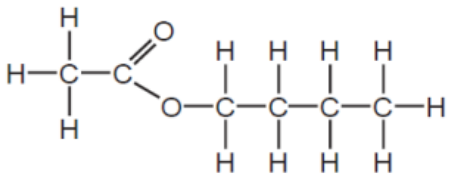
[1]

[Total: 14]

Question 31

7 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]

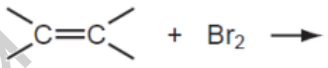
(c) Cooking products, fats and vegetable oils, are mixtures of saturated and unsaturated esters.

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	35	5
butter	45	28	4
corn oil	10	84	12
soya oil	15	70	10
lard	38	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]

Question 32

1 A major source of energy is the combustion of fossil fuels.

(a) (i) Name a solid fossil fuel.

..... [1]

(ii) Name a gaseous fossil fuel.

..... [1]

(b) Petroleum is separated into more useful fractions by fractional distillation.

(i) Name **two** liquid fuels obtained from petroleum.

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

(ii) Name **two** other useful products obtained from petroleum that are not used as fuels.

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

(iii) Give another mixture of liquids that is separated on an industrial scale by fractional distillation.

..... [1]

[Total: 7]

0620/s07/qp3

Question 33

7 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) (i) 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]

Question 34

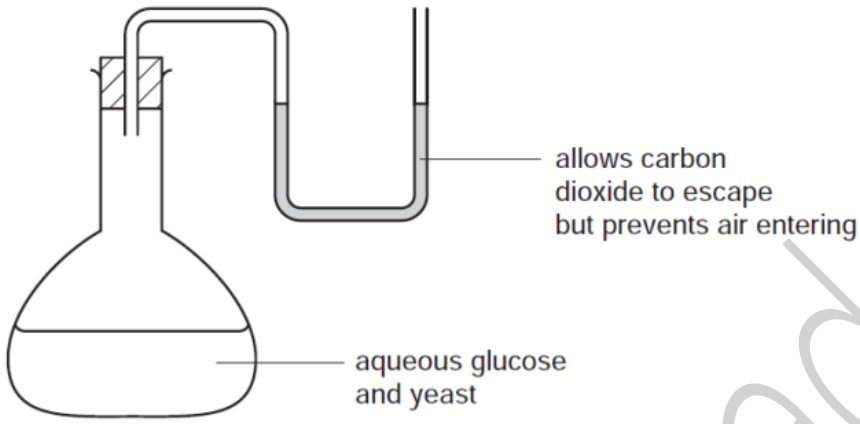
(iv) The synthetic polymer, nylon, has the same linkage as proteins. Draw the structural formula of nylon.

[3]

(b) Enzymes called carbohydrases can hydrolyse complex carbohydrates to simple sugars which can be represented as HO — [ ] — OH. Draw the structure of a complex carbohydrate.

[2]

(c) Fermentation can be carried out in the apparatus drawn below. After a few days the reaction stops. It has produced a 12% aqueous solution of ethanol.



(i) Complete the equation.

$C_6H_{12}O_6 \rightarrow$ ..... + ...

glucose ethanol carbon dioxide [2]

(ii) Zymase catalyses the anaerobic respiration of glucose. Define the term *respiration*.

.....

..... [2]

(iii) Suggest a reason why the reaction stops after a few days.

..... [1]

(iv) Why is it essential that there is no oxygen in the flask?

..... [1]

(v) What technique is used to concentrate the aqueous ethanol?

..... [1]

Question 35

3 A South Korean chemist has discovered a cure for smelly socks. Small particles of silver are attached to a polymer, poly(propene), and this is woven into the socks.

(a) (i) Give the structural formula of the monomer.

[1]

(ii) Draw the structural formula of the polymer.

[2]

(iii) Suggest which one, monomer or polymer, will react with aqueous bromine and why?

.....

..... [2]

(c) The unpleasant smell is caused by carboxylic acids. Bacteria cause the fats on the skin to be hydrolysed to these acids. Silver kills the bacteria and prevents the hydrolysis of the fats.

(i) Fats are esters. Give the name and structural formula of an ester.

name ..... [1]

structural formula

[1]

(ii) Complete the word equation.

Ester + water ⟶ carboxylic acid + ... [1]

(d) Propanoic acid is a weak acid.

(i) The following equation represents its reaction with ammonia.

$CH_3-CH_2-COOH + NH_3 \longrightarrow CH_3-CH_2-COO^- + NH_4^+$

Explain why propanoic acid behaves as an acid and ammonia as a base.

.....

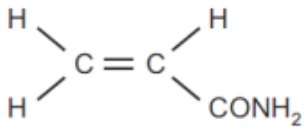
..... [3]

(ii) Explain the expression *weak acid*.

..... [1]

Question 36

6 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]

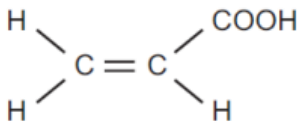
(ii) Given an aqueous solution, concentration 0.1 mol / dm^3, how could you show that acrylic acid is a weak acid.

.....

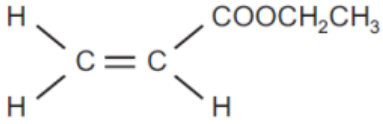
.....

[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]

Question 37

3 Alkenes are unsaturated hydrocarbons. They undergo addition reactions.

(a) Two of the methods of making alkenes are cracking and the thermal decomposition of chloroalkanes.

(i) Complete an equation for the cracking of the alkane, decane.

$C_{10}H_{22}$ → ..... + ...
decane

(ii) Propene can be made by the thermal decomposition of chloropropane.
Describe how chloropropane can be made from propane.

reagents propane and .....

conditions ..... [4]

(b) The following alkenes are isomers.

$CH_3–CH_2–CH=CH_2$ $CH_3–C(CH_3)=CH_2$

(i) Explain why they are isomers.

.....

.....

(ii) Give the name and structural formula of another hydrocarbon that is isomeric with the above.

name .....

structural formula

[4]

(c) Give the name of the product when but-1-ene reacts with each of the following.

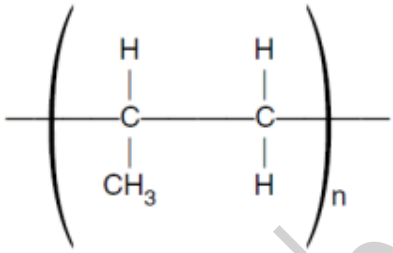
steam .....

hydrogen .....

bromine ..... [3]

(d) Alkenes can polymerise.

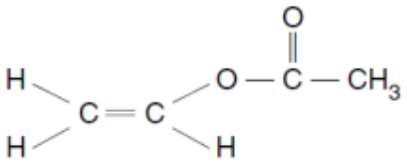
(i) Deduce the name and structural formula of the monomer from the structure of the polymer.



name of monomer .....

structural formula

(ii) Draw the structure of the polymer formed from the following monomer.



[4]

(iii) Describe the pollution problems caused by the disposal of polymers in landfill sites and by burning.

landfill sites .....

.....[2]

burning .....

.....[1]

Question 38

6 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	CH_3OH	-730
ethanol	CH_3-CH_2-OH	-1370
propan-1-ol	CH_3-CH_2-CH_2-OH	-2020
butan-1-ol	CH_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]

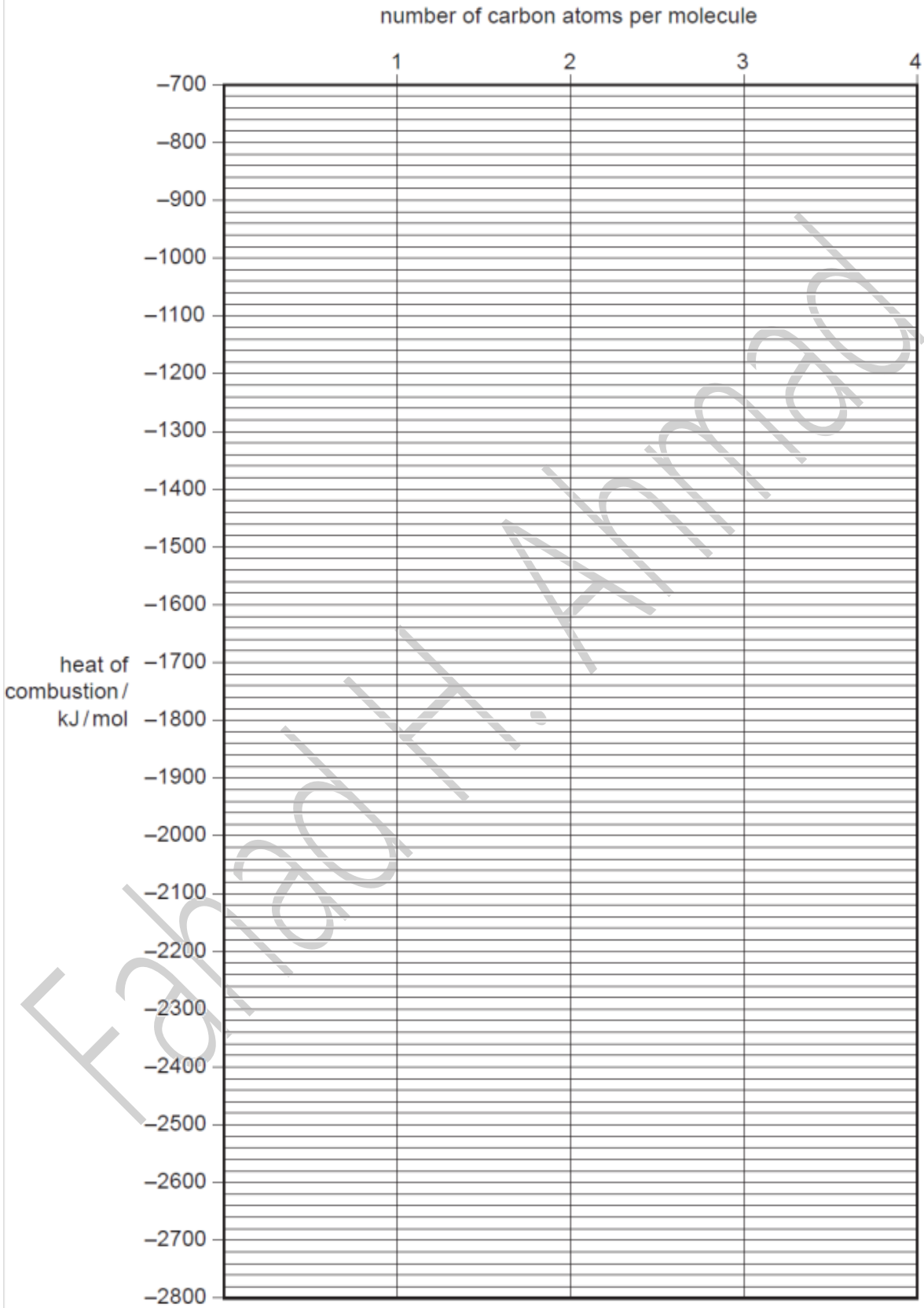
(ii) Is the reaction exothermic or endothermic?

..... [1]

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

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

(iv) Determine the heat of combustion of butan-1-ol by plotting the heats of combustion 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)

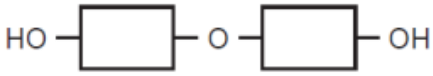
..... [1]

[Total: 20]

Question 39

8 The three types of food are carbohydrates, proteins and fats.

(a) Aqueous starch is hydrolysed to maltose by the enzyme amylase.
The formula of maltose is:



Starch is hydrolysed by dilute sulphuric acid to glucose.

(i) What is an enzyme?

.....

[1]

(ii) Draw the structure of starch.

[1]

(iii) Name the technique that would show that the products of these two hydrolyses are different.

.....

[1]

(b) Proteins have the same linkage as nylon but there is more than one monomer in the macromolecule.

(i) Draw the structure of a protein.

[2]

(ii) What class of compound is formed by the hydrolysis of proteins?

.....

[1]

(c) Fats are esters. Some fats are saturated, others are unsaturated.

(i) Write the word equation for the preparation of the ester, propyl ethanoate.

..... [2]

(ii) Deduce the structural formula of this ester showing each individual bond.

[2]

(iii) How could you distinguish between these two fats?
Fat 1 has the formula

$CH_2 - CO_2 - C_{17}H_{33}$
|
$CH - CO_2 - C_{17}H_{33}$
|
$CH_2 - CO_2 - C_{17}H_{33}$

Fat 2 has the formula

$CH_2 - CO_2 - C_{17}H_{35}$
|
$CH - CO_2 - C_{17}H_{35}$
|
$CH_2 - CO_2 - C_{17}H_{35}$

test .....

result with fat 1 .....

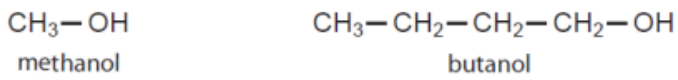
result with fat 2 ..... [3]

(iv) Both of these fats are hydrolysed by boiling with aqueous sodium hydroxide. What type of compounds are formed?

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

Question 40

4 The alcohols form a homologous series. The first member is methanol and the fourth is butanol.



(a) (i) Give **two** general characteristics of a homologous series.

.....

.....

..... [2]

(ii) Calculate the mass of one mole of the C_8 alcohol.

.....

..... [2]

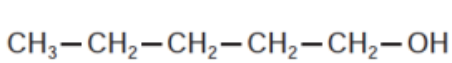
(b) Give the name and structural formula of the third member of this series.

name ..... [1]

structural formula

[1]

(c) The structural formula of the fifth member, pentan-1-ol, is drawn below.



(i) Draw the structural formula of an isomer of this alcohol.

[1]

(ii) Predict the names of the product(s) formed when pentan-1-ol

- reacts with an excess of oxygen,

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

- is dehydrated to form an alkene,

  ..... [1]

- is oxidised by acidified potassium dichromate(VI).

  ..... [1]

Question 41

(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]

Question 42

8 The alkenes are a homologous series of unsaturated hydrocarbons.

(a) The table below gives the names, formulae and boiling points of the first members of the series.

name	formula	boiling point / °C
ethene	C_2H_4	-102
propene	C_3H_6	-48
butene	C_4H_8	-7
pentene	C_5H_{10}	30
hexene		

(i) Complete the table by giving the formula of hexene and by predicting its boiling point.

[2]

(ii) Deduce the formula of the alkene which has a relative molecular mass of 168. Show your working.

[2]

(b) Describe a test that will distinguish between the two isomers, but-2-ene and cyclobutane.

test
result with but-2-ene
result with cyclobutane [3]

(c) Alkenes undergo addition reactions.

(i) What class of organic compound is formed when an alkene reacts with water?

[1]

(ii) Predict the structural formula of the compound formed when hydrogen chloride reacts with but-2-ene.

[1]

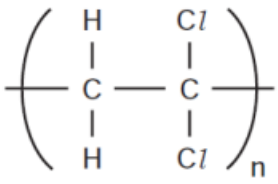
(iii) Draw the structure of the polymer formed from but-2-ene.

[2]

Question 43

6 Polymers are extensively used in food packaging. Poly(dichloroethene) is used because gases can only diffuse through it very slowly. Polyesters have a high thermal stability and food can be cooked in a polyester bag.

(a) (i) The structure of poly(dichloroethene) is given below.



Draw the structural formula of the monomer.

[1]

(ii) Explain why oxygen can diffuse faster through the polymer bag than carbon dioxide can.

.....

[2]

(b) (i) A polyester can be formed from the monomers $HO\text{-}CH_2CH_2\text{-}OH$ and $HOOC\text{-}C_6H_4\text{-}COOH$. Draw the structure of this polyester.

[2]

(ii) Name a naturally occurring class of compounds that contains the ester linkage.

[1]

(iii) Suggest what is meant by the term *thermal stability.*

.....

[1]

(c) (i) Describe **two** environmental problems caused by the disposal of plastic (polymer) waste.

.....

.....

[2]

(ii) The best way of disposing of plastic waste is recycling to form new plastics. What is another advantage of recycling plastics made from petroleum?

[1]

Question 44

(b) (i) Complete the equation for the combustion of methanol in an excess of oxygen.

$\square\ CH_3OH + \square\ O_2 \rightarrow \square + \square$ [2]

(ii) Complete the word equation.

methanol + ethanoic acid → ..... + ... [2]

(iii) Methanol can be oxidised to an acid. Name this acid.

[1]

Question 45

4 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

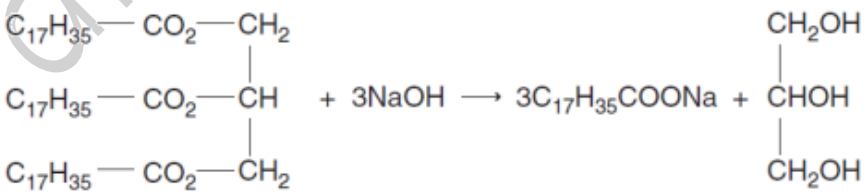
.....

.....[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.



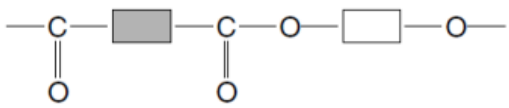
(i) Which substance in the equation is an alcohol? Underline the substance in the equation above.

[1]

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

.....[1]

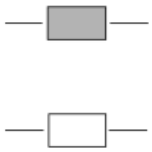
(c) A polymer has the structure shown below.



(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]

Question 46

(ii) How could you show that this reaction is photochemical?

.....

.....[1]

(c) Photosynthesis is another example of a photochemical reaction. Glucose and more complex carbohydrates are made from carbon dioxide and water.

(i) Complete the equation.

$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 +$ ..... [2]

(ii) Glucose can be represented as

Draw the structure of a more complex carbohydrate that can be formed from glucose by condensation polymerisation.

[2]

Question 47

5 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*.

.....

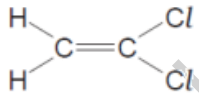
.....[2]

(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]

Question 48

8 Methanoic acid is the first member of the homologous series of carboxylic acids.

(a) Give **two** general characteristics of a homologous series.

.....

.....

..... [2]

(b) In some areas when water is boiled, the inside of kettles become coated with a layer of calcium carbonate. This can be removed by adding methanoic acid.

(i) Complete the equation.

..... $HCOOH + CaCO_3 \rightarrow Ca(HCOO)_2 +$ ..... + ...

[2]

(ii) Methanoic acid reacts with most metals above hydrogen in the reactivity series. Complete the word equation.

zinc + methanoic acid → ..... + ...

[2]

(iii) Aluminium is also above hydrogen in the reactivity series.
Why does methanoic acid not react with an aluminium kettle?

.....

..... [1]

(c) Give the name, molecular formula and empirical formula of the fourth acid in this series.

name ..... [1]

molecular formula ..... [1]

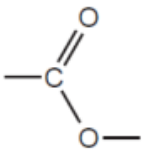
empirical formula ..... [1]

[Total: 10]

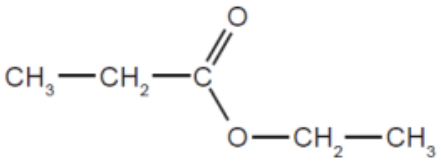
0620/s10/qp31

Question 49

4 Hydrolysis is used in chemistry to break down complex molecules into simpler ones.

(a) Compounds containing the group  or —COO— are esters.

(i) Give the names and formulae of the two compounds formed when the ester ethyl propanoate is hydrolysed.

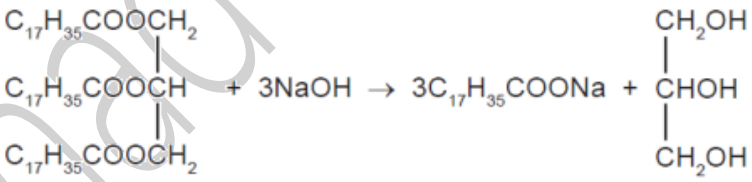


name ..... name .....

formula formula

[4]

(ii) Fats are naturally occurring esters. They can be hydrolysed by boiling with aqueous sodium hydroxide.



fat

What type of compound has the formula $C_{17}H_{35}COONa$ and what is its main use?

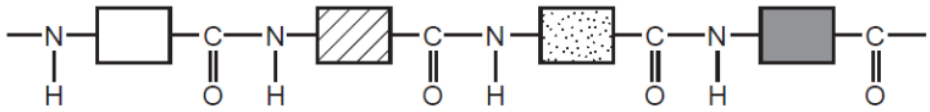
type of compound ..... [1]

use ..... [1]

(iii) Name a synthetic polyester.

..... [1]

(b) The structure of a typical protein is drawn below.



(i) What is the name of the polymer linkage?

..... [1]

(ii) Draw the structural formula of a man-made polymer with the same linkage.

[3]

(iii) A protein can be hydrolysed to a mixture of amino acids which are colourless. Individual amino acids can be identified by chromatography. The R_f value of the amino acid glycine is 0.5. Describe how you could show that glycine was present on a chromatogram.

.....

.....

..... [3]

[Total: 14]

Question 50

(iii) How can chloromethane be made from methane?

reagent .....

condition ..... [2]

Question 51

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

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

..... [1]

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

..... [1]

(b) (i) 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]

(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]

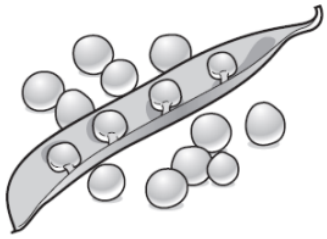
(ii) There is more than one possible substitution reaction between chlorine and propane. Suggest the structural formula of a different product.

..... [1]

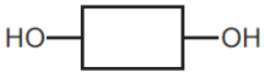
[Total: 16]

Question 52

(b) Pea seeds grow in pods on pea plants.



Freshly picked pea seeds contain a sugar. The sugar can form a polymer.
Give the structural formula of the polymer and name the other product of this polymerisation reaction.
You may represent the sugar by the formula:



structural formula of the polymer

other product ..... [3]

0620/s14/qp33

Question 53

4 Propanoic acid is a carboxylic acid. Its formula is $CH_3–CH_2–COOH$.

(a) Propanoic acid is the third member of the homologous series of carboxylic acids.

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

name .....

formula ..... [2]

(ii) Members of a homologous series have very similar chemical properties.
State **three** other characteristics of a homologous series.

.....

.....

.....

..... [3]

(b) Carboxylic acids can be made by the oxidation of alcohols.

(i) Draw the structural formula of the alcohol which can be oxidised to propanoic acid.
Show all atoms and bonds.

[1]

(ii) Name a reagent, other than oxygen, which can oxidise alcohols to carboxylic acids.

..... [2]

(c) Complete the following equations for some of the reactions of propanoic acid.
The salts of this acid are called propanoates.

(i) zinc + propanoic acid → .... + hydrogen [1]

(ii) calcium oxide + propanoic acid → .... + ... [1]

(iii) $LiOH + CH_3CH_2COOH \rightarrow$ ..... + ... [1]

0620/s14/qp32

Question 54

2 **(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]

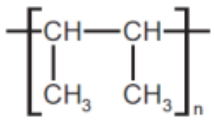
[Total: 8]

0620/s14/qp32

Question 55

8 Polymers are made by the polymerisation of simple molecules called monomers.

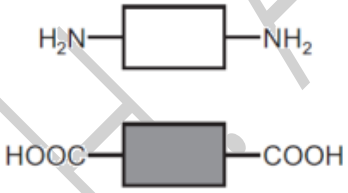
(a) (i) The structural formula of a polymer is given below.



This polymer is made by addition polymerisation. Draw the structural formula of its monomer.

[1]

(ii) The two monomers shown below form a nylon which is a condensation polymer.



Draw its structural formula showing one repeat unit of the polymer.

[3]

(iii) Name the natural macromolecule which contains the same linkage as nylon.

..... [1]

(iv) Explain the difference between addition polymerisation and condensation polymerisation.

.....

.....

..... [2]

(b) Many polymers are non-biodegradable.

(i) Explain the term *non-biodegradable*.

.....

..... [2]

(ii) State **three** problems caused by the disposal of non-biodegradable polymers.

.....

.....

..... [3]

(c) Storage tanks for cold water are now made from polymers because they are cheaper than metal tanks. Suggest **two** other advantages of making cold water tanks from polymers.

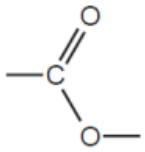
.....

..... [2]

[Total: 14]

Question 56

7 The ester linkage showing all the bonds is drawn as



or more simply it can be written as –COO–.

(a) (i) Give the structural formula of the ester ethyl ethanoate.

[1]

(ii) Deduce the name of the ester formed from methanoic acid and butanol.

..... [1]

(b) (i) Which group of naturally occurring compounds contains the ester linkage?

..... [1]

(ii) Draw the structural formula of the polyester formed from the following monomers.

$HOOCC_6H_4COOH$ and $HOCH_2CH_2OH$

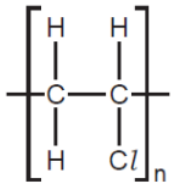
You are advised to use the simpler form of the ester linkage.

[3]

Question 57

5 Many monomer molecules react together to form one molecule of a polymer. This reaction is called polymerisation.

(a) The structural formula of the polymer, poly(chloroethene), is given below. This polymer is also known as PVC.



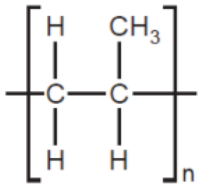
(i) A major use of PVC is insulation of electric cables. PVC is a poor conductor of electricity.
Suggest another property which makes it suitable for this use.

..... [1]

(ii) One way of disposing of waste PVC is by burning it. This method has the disadvantage that poisonous gases are formed.
Suggest **two** poisonous gases which could be formed by the combustion of PVC.

..... [2]

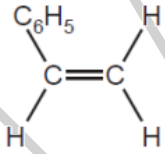
(b) (i) Deduce the structural formula of the monomer from that of the polymer.



structural formula of monomer

[1]

(ii) Deduce the structural formula of the polymer, poly(phenylethene), from the formula of its monomer, phenylethene.



structural formula of polymer

[2]

(c) The carbohydrate, glucose, polymerises to form the more complex carbohydrate starch.

If glucose is represented by

then the structural formula of starch is as drawn below.

How does the polymerisation of glucose differ from that of an alkene such as phenylethene?

.....

.....

..... [2]

[Total: 8]

0620/s13/qp32

Question 58

(b) Two other ways of producing hydrogen are cracking and electrolysis.

(i) Hydrogen can be a product of the cracking of long chain alkanes.
Complete the equation for the cracking of C_8H_{18}.

$$C_8H_{18} \rightarrow 2\text{.....} + H_2$$ [1]

(ii) There are three products of the electrolysis of concentrated aqueous sodium chloride. Hydrogen is one of them.
Write an equation for the electrode reaction which forms hydrogen.

..... [2]

0620/s13/qp32

Question 59

7 Alkanes and alkenes are both series of hydrocarbons.

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

.....

..... [1]

(ii) What is the difference between these two series of hydrocarbons?

.....

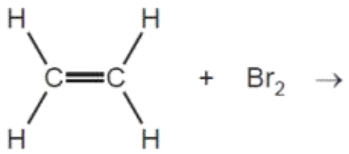
..... [2]

(b) Alkenes and simpler alkanes are made from long-chain alkanes by cracking.
Complete the following equation for the cracking of the alkane $C_{20}H_{42}$.

$$C_{20}H_{42} \rightarrow 2C_4H_8 + 2C_2H_4 + \text{.....} \quad [1]$$

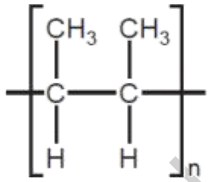
(c) Alkenes such as butene and ethene are more reactive than alkanes.
Alkenes are used in the petrochemical industry to make a range of products, which includes polymers and alcohols.

(i) Dibromoethane is used as a pesticide. Complete the equation for its preparation from ethene.



[1]

(ii) The structural formula of a poly(alkene) is given below.



Deduce the structural formula of its monomer.

[2]

(iii) How is butanol made from butene, $CH_3-CH_2-CH=CH_2$? Include an equation in your answer.

.....

..... [2]

(iv) Cracking changes alkanes into alkenes. How could an alkene be converted into an alkane? Include an equation in your answer.

.....

..... [2]

(d) 20 cm^3 of a hydrocarbon was burnt in 175 cm^3 of oxygen. After cooling, the volume of the remaining gases was 125 cm^3. The addition of aqueous sodium hydroxide removed carbon dioxide leaving 25 cm^3 of unreacted oxygen.

(i) volume of oxygen used = ... cm^3 [1]

(ii) volume of carbon dioxide formed = ... cm^3 [1]

(iii) Deduce the formula of the hydrocarbon and the balanced equation for the reaction.

.....

.....

.....

..... [2]

[Total: 15]

Question 60

6 Sulfuric acid and malonic acid are both dibasic acids. One mole of a dibasic acid can form two moles of hydrogen ions.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Dibasic acids can form salts of the type Na_2X and CaX.

(a) Malonic acid is a white crystalline solid which is soluble in water. It melts at 135 °C. The structural formula of malonic acid is given below. It forms salts called malonates.

$$CH_2(COOH)_2 \text{ or } HOOC-CH_2-COOH$$

(i) How could you determine if a sample of malonic acid is pure?

technique used .....

result if pure ..... [2]

(ii) What is the molecular formula of malonic acid?

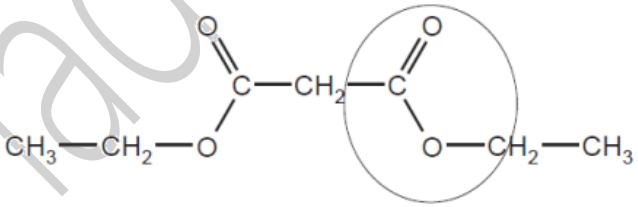
..... [1]

(iii) When malonic acid is heated there are two products, carbon dioxide and a simpler carboxylic acid. Deduce the name and molecular formula of this acid.

.....

..... [2]

(iv) Malonic acid reacts with ethanol to form a colourless liquid which has a 'fruity' smell. Its structural formula is given below.



What type of compound contains the group which is circled?

..... [1]

(b) (i) Suggest why a solution of malonic acid, concentration 0.2 mol / dm^3, has a higher pH than one of sulfuric acid of the same concentration.

..... [1]

(ii) Describe a test, other than measuring pH, which can be carried out on both acid solutions to confirm the explanation given in **(b)(i)** for the different pH values of the two acids.

.....

..... [2]

(c) Complete the following equations for reactions of these two acids.

(i) sodium hydroxide + malonic acid → ..... + ... [1]

.....

(ii) $CuO + H_2SO_4 \rightarrow$ ..... + ... [2]

(iii) $Mg + CH_2(COOH)_2 \rightarrow$ ..... + ... [2]

(iv) $K_2CO_3 + H_2SO_4 \rightarrow$ ..... + ... + ... [2]

[Total: 16]

Question 61

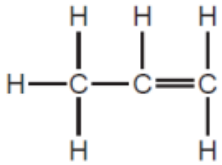
7 The alkenes are a series of unsaturated hydrocarbons. They have the general molecular formula C_nH_{2n}.

(a) Deduce the molecular formula of an alkene which has a relative molecular mass of 126. Show your working.

.....

..... [2]

(b) The structural formula of propene is drawn below.



(i) Draw a diagram showing the arrangement of the valency electrons in one molecule of this covalent compound.
Use x to represent an electron from an atom of carbon.
Use o to represent an electron from an atom of hydrogen.

[3]

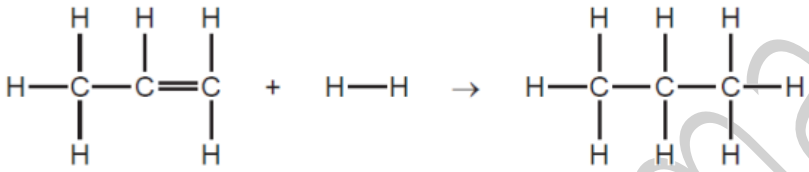
(ii) Draw the structure of the polymer formed from propene

[2]

(iii) Bond energy is the amount of energy, in kJ, which must be supplied to break one mole of the bond.

bond	bond energy in kJ / mol
H—H	+436
C=C	+610
C—C	+346
C—H	+415

Use the data in the table to show that the following reaction is exothermic.



.....

.....

..... [3]

(c) This question is concerned with some of the addition reactions of but-1-ene.

(i) Name the product formed when but-1-ene reacts with water.

..... [1]

(ii) Complete the equation.

$CH_3—CH_2—CH=CH_2 + Br_2 \rightarrow$ ..... [2]

(iii) Deduce the formula of the compound which reacts with but-1-ene to form 1-iodobutane.

..... [1]

[Total: 14]

Question 62

2 Starch, a complex carbohydrate, is a natural macromolecule or polymer.
It can be formed from its monomer by condensation polymerisation.

(a) (i) Explain the terms:

monomer .....

.....

condensation polymerisation .....

..... [2]

(ii) Draw the structural formula of starch to include three monomer units.

Glucose, the monomer, can be represented as HO—□—OH .

[3]

(b) Starch can be hydrolysed to simple sugars by heating with dilute sulfuric acid or by warming with a dilute solution of saliva. The reaction can be catalysed by H^+ ions from the acid or by the enzymes in saliva.

(i) What is an enzyme?

..... [1]

(ii) Explain why, if the saliva / starch mixture is heated above 70 °C, the hydrolysis stops.

..... [1]

(iii) The complete acid-catalysed hydrolysis of starch forms only glucose.
The partial acid-catalysed hydrolysis of starch forms a mixture of sugars which includes glucose. Describe how you could identify the different sugars in this mixture.

.....

.....

..... [3]

[Total: 10]

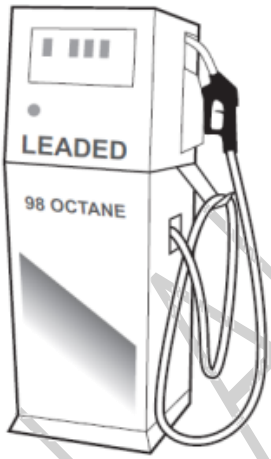
7 Petrol is a mixture of hydrocarbons and additives. The combustion of petrol in car engines is a major source of air pollution. This is reduced by catalytic converters.

(a) Petrol is obtained from the gasoline fraction, boiling point range 40 °C to 100 °C, from the distillation of petroleum. Explain the term *fraction*.

.....

..... [2]

(b) In many countries, a lead compound of the type $Pb(C_2H_5)_n$ used to be added to petrol to improve its combustion. After combustion, lead oxide was formed.



(i) Octane is a constituent of petrol. Write the equation for the complete combustion of octane.

C_8H_{18} + ...O_2 → ..... + ... [2]

(ii) Dibromoethane was added to petrol to remove the lead oxide from inside the engine. Lead bromide was formed which escaped into the environment through the exhaust. Leaded petrol cannot be used with a catalytic converter. Give another reason why leaded petrol is no longer used.

..... [1]

(iii) What does each of the following tell you about the structure of dibromoethane?

dibromo .....

eth .....

ane ..... [2]

(iv) What additional information is needed to draw the structural formula of dibromoethane?

..... [1]

Question 64

5 The alcohols form a homologous series. Two characteristics of a homologous series are that the physical properties of the members vary in a predictable way and they have similar chemical properties.

(a) Complete the table.

name	formula	mass of one mole / g	boiling point / °C
methanol	CH_3-OH	32	64
ethanol	CH_3-CH_2-OH	46	78
propan-1-ol	$CH_3-CH_2-CH_2-OH$	60	98
butan-1-ol	$CH_3-CH_2-CH_2-CH_2-OH$	74	118
pentan-1-ol			138
hexan-1-ol	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-OH$	102	

[3]

(b) Give **two** other characteristics of a homologous series.

.....

..... [2]

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound methanol.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.
Use • to represent an electron from a hydrogen atom.

[3]

(d) Alcohols can be oxidised to carboxylic acids by heating with acidic potassium manganate(VII).

(i) Draw the structural formula of the carboxylic acid formed by the oxidation of propan-1-ol. Show all the bonds.

[1]

(ii) Describe how ethanol could be oxidised to ethanoic acid by fermentation.

.....

..... [2]

(e) Propan-1-ol and ethanoic acid react together to form an ester. Give its name and structural formula.

name ..... [1]

formula

[1]

[Total: 13]

Question 65

6 Structural formulae are an essential part of Organic Chemistry.

(a) Draw the structural formula of each of the following. Show all the bonds in the structure.

(i) ethanoic acid

[1]

(ii) ethanol

[1]

(b) **(i)** Ethanoic acid and ethanol react to form an ester.
What is the name of this ester?

..... [1]

(ii) The same linkage is found in polyesters. Draw the structure of the polyester which can be formed from the monomers shown below.

$HOOC—C_6H_4—COOH$ and $HO—CH_2—CH_2—OH$

[3]

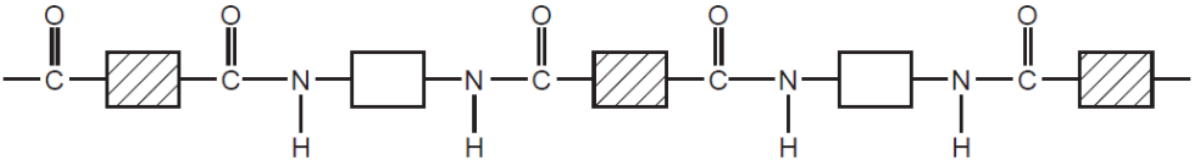
(iii) Describe the pollution problems caused by non-biodegradable polymers.

.....

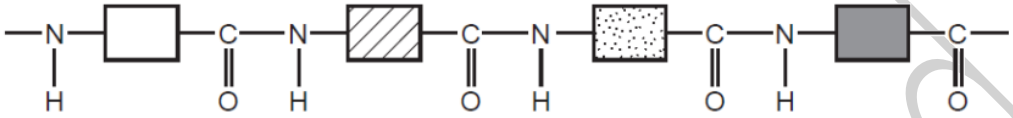
.....

..... [2]

(c) Two macromolecules have the same amide linkage.
Nylon, a synthetic polymer, has the following structure.



Protein, a natural macromolecule, has the following structure.



How are they different?

.....

.....

..... [2]

[Total: 10]

Question 66

5 Monomers polymerise to form polymers or macromolecules.

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

.....

..... [1]

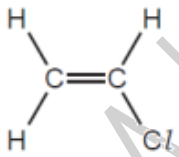
(ii) There are two types of polymerisation - addition and condensation. What is the difference between them?

.....

.....

..... [2]

(b) An important monomer is chloroethene which has the structural formula shown below.



It is made by the following method.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2 \quad \text{dichloroethane}$$

This is heated to make chloroethene.

$$C_2H_4Cl_2 \rightarrow C_2H_3Cl + HCl$$

(i) Ethene is made by cracking alkanes. Complete the equation for cracking dodecane.

$$C_{12}H_{26} \rightarrow \text{.....} + 2C_2H_4$$

[1]

Another method of making dichloroethane is from ethane.

$$C_2H_6 + 2Cl_2 \rightarrow C_2H_4Cl_2 + 2HCl$$

(ii) Suggest a reason why the method using ethene is preferred.

.....

..... [1]

(iii) Describe an industrial method of making chlorine.

.....

..... [2]

(iv) Draw the structural formula of poly(chloroethene).

Include three monomer units.

[2]

[Total: 9]

Question 67

6 The alcohols form an homologous series.

(a) Give **three** characteristics of an homologous series.

.....

.....

.....

..... [3]

(b) The following two alcohols are members of the series and they are isomers.

$CH_3—CH_2—CH_2—CH_2—OH$ and $(CH_3)_2CH—CH_2OH$

(i) Explain why they are isomers.

.....

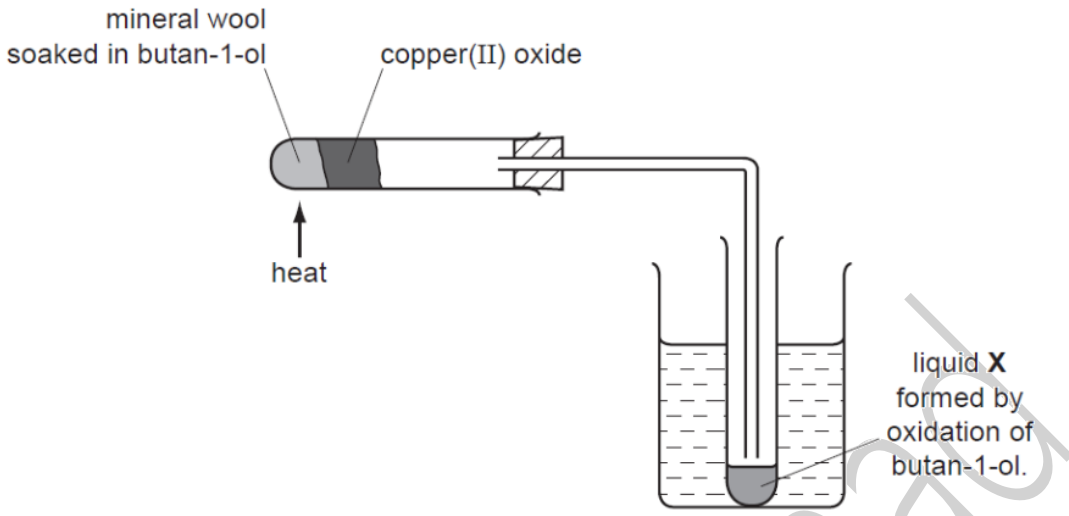
.....

..... [2]

(ii) Give the structural formula of another alcohol which is also an isomer of these alcohols.

[1]

(c) Copper(II) oxide can oxidise butan-1-ol to liquid **X** whose pH is 4.



(i) Name another reagent which can oxidise butan-1-ol.

..... [1]

(ii) What type of compound is liquid **X** and what is its formula?

type of compound ..... [1]

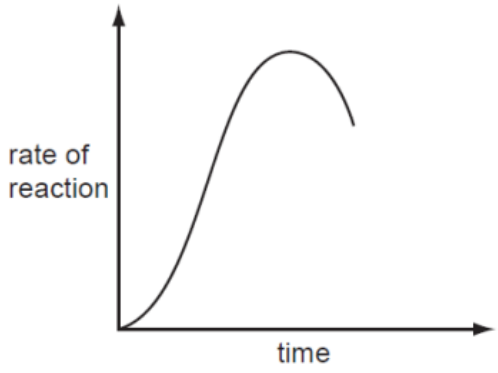
formula of liquid **X**

[1]

(d) The alcohol ethanol can be made by fermentation. Yeast is added to aqueous glucose.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Carbon dioxide is given off and the mixture becomes warm as the reaction is exothermic. The graph shows how the rate of reaction varies over several days.



(i) Suggest a method of measuring the rate of this reaction.

.....

..... [2]

(ii) Why does the rate increase initially?

.....

..... [1]

(iii) Suggest **two** reasons why the rate eventually decreases.

.....

..... [2]

(iv) Why is fermentation carried out in the absence of air?

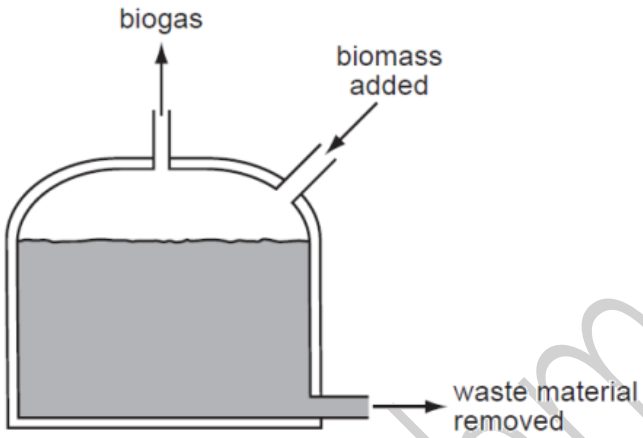
.....

..... [1]

Question 68

5 In the absence of oxygen, certain bacteria decompose carbohydrates to biogas. This is a mixture of gases mainly methane and carbon dioxide.
Biogas is becoming an increasingly important fuel around the world.

A diagram of a simple biogas generator is given below. Typically, it contains biomass - animal manure, plant material etc.



(a) (i) What is meant by the term *carbohydrate*?

.....

..... [2]

(ii) The reaction in the generator is an example of anaerobic respiration.
Anaerobic means in the absence of oxygen. What does *respiration* mean?

.....

..... [2]

(iii) The generator must produce some carbon dioxide.
Why is it impossible for it to produce only a hydrocarbon such as methane?

..... [1]

(iv) Suggest a use for the nitrogen-rich solid removed from the generator.

..... [1]

Question 69

7 Synthetic polymers are widely used in the modern world.

(a) Their use has brought considerable advantages to modern life as well as some disadvantages.

(i) Suggest **two** advantages of a plastic bucket compared to a steel bucket.

.....

..... [2]

(ii) Name **two** uses of man-made fibres, such as nylon and Terylene.

.....

..... [2]

(iii) Describe the pollution caused by synthetic polymers.

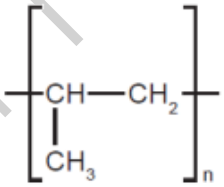
.....

.....

..... [3]

(b) One type of polymer is formed by addition polymerisation.

(i) The structural formula of an addition polymer is given below.



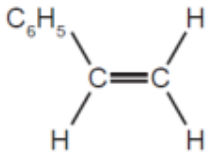
Give the name and structural formula of the monomer.

name of monomer ..... [1]

structural formula of monomer

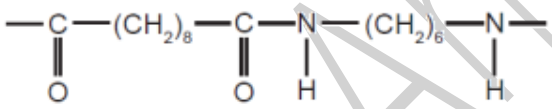
[1]

(ii) Draw the structural formula of the addition polymer formed by the polymerisation of phenylethene. The structural formula of phenylethene is given below.



[2]

(c) Nylon is made by condensation polymerisation. It has the structural formula shown below.



(i) Name the linkage in this polymer.

..... [1]

(ii) Name the natural macromolecules which have the same linkage.

..... [1]

(iii) Deduce the formulae of the two monomers which reacted to form the nylon and water.

monomer .....

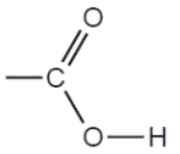
monomer .....

[2]

[Total: 15]

Question 70

5 Carboxylic acids contain the group

 or —COOH.

(a) Ethanoic acid is a typical carboxylic acid. It forms ethanoates.

(i) Complete the following equations.

Mg + ...CH_3COOH → ..... + ...

[2]

sodium hydroxide + ethanoic acid → ..... + ...
.....

[1]

(ii) Ethanoic acid reacts with ethanol to form an ester. Give the name of the ester and draw its structural formula. Show all of the bonds.

name .....

structural formula

[2]

Question 71

7 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) **(i)** 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]

Question 72

(c) Germanium forms a series of hydrides comparable to the alkanes.

(i) Draw the structural formula of the hydride which contains four germanium atoms per molecule.

[1]

(ii) Predict the products of the complete combustion of this hydride.

.....

[2]

0620/w09/qp31

Question 73

7 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]

Question 74

(b) **(i)** Why does the water supply industry use chlorine?

..... [1]

(ii) Name an important chemical that is made from hydrogen.

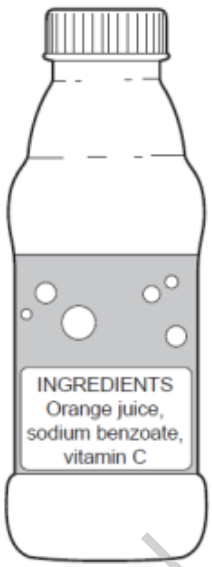
..... [1]

(iii) How is sodium hydroxide used to make soap?

..... [2]

Question 75

4 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.

.....

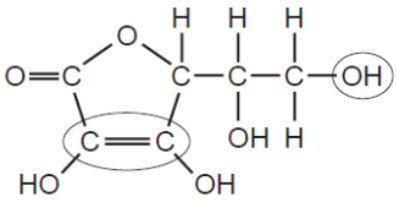
..... [2]

(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]

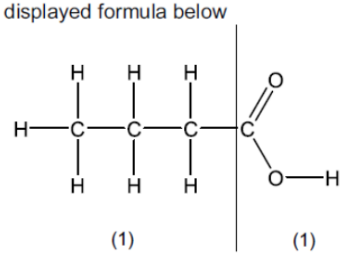
[Total: 12]

Marking Scheme : Organic (IGCSE 0620)

Question 1

7 (a) (i) butanoic acid/butyric acid [1]

displayed formula below [2]



(1) (1)

(ii) any **three** from:
same or similar chemical properties
(same) general (molecular) formula
(consecutive members) differ by CH_2
same functional group
common methods of preparation
physical properties vary in predictable manner/show trends/gradually change
or example of a physical property variation i.e. melting point/boiling point/volatility [3]

(iii) dissociates/ionises/splits up (into ions) [1]

partially/incompletely/slightly/not fully [1]

(donates) protons/(forms) H^+/H_3O^+(as the only positive ion) [1]

(b) (i) methyl propanoate [1]

$CH_3CH_2COOCH_3/CH_3CH_2CO_2CH_3/C_2H_5COOCH_3/C_2H_5CO_2CH_3$ [1]

(ii) methyl ethanoate [1]

(c) (i) $3C_4H_{10} + 5\frac{1}{2}O_2 \rightarrow 4C_2H_5COOH + 3H_2O$ [1]

(ii) propanol or propan-1-ol or propanal [1]

[Total: 14]

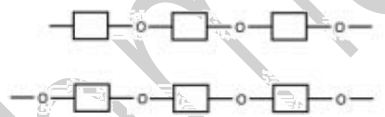
Question 2

5 (a) (i) M1 Contain carbon, hydrogen and oxygen (only) [1]

M2 hydrogen and oxygen is in a 2:1 ratio (or in the same ratio as water) [1]

(ii) M1 -O- linkage [1]

M2 3 monomer units with 3 blocks and 3 Oxygen atoms **Cond** [1]



Question 3

3 (a) (i) C_4H_8 only
CH_2 (Allow C_1H_2) [2]

(ii) Any unambiguous structural formula of methyl cyclopropane or but-1-ene or but-2-ene or methyl propene [1]

(iii) M1 same molecular formula [1]

M2 different structural formulae or different structures
or different arrangement of atoms [1]

(iv) If 'No':
one an alkane, the other an alkene
or
one is saturated / has single bonds, the other is unsaturated / has a double bond
ignore: references to the 'functional group'

If 'yes'
both alkanes **or** both saturated
ignore: references to the 'functional group' [1]

Question 4

(b) (i) M1 Action of heat or catalyst or thermal decomposition (on an alkane) [1]
Ignore steam. Ignore pressure.

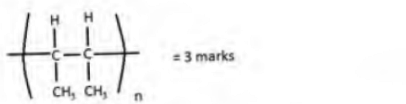
M2 Long-chained molecules or alkanes form smaller molecules (not smaller fraction) or forms smaller alkenes (or alkanes) [1]

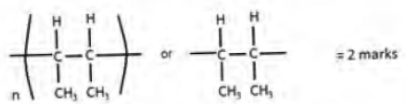
(ii) $C_{10}H_{22}$ [1]

(c) (i) M1 Correct structure of one repeat unit [1]

M2 Continuation bonds **COND** on M1 [1]

M3 use of brackets and subscript 'n' **COND** on M1 and M2 [1]


= 3 marks


or

= 2 marks


= 1 mark

(ii) dibromoethane or 1,2-dibromoethane [1]

Question 5

6 (a) (i) butanoic acid [1]
methanol [1]

(ii) number of moles of ethanoic acid = 0.1 [1]
number of moles of ethanol = 0.12(0) [1]
the limiting reagent is ethanoic acid [1]
number of moles of ethyl ethanoate formed = 0.1 [1]
maximum yield of ethyl ethanoate is 8.8 g [1]

(b) correct ester linkage [1]
two ester linkages (COND on M1) [1]
continuation (COND on M2) [1]

(c) (i) add bromine water/bromine [1]
turns colourless [1]
remains brown/orange/reddish brown/yellow [1]

ALLOW: potassium manganate(VII) (acidic or alkaline) [1]
correct colour colourless/green or brown ppt [1]
stays pink/purple [1]

(ii) ester 1 [1]
COND alkyl group is C_nH_{2n+1} which is NOT $C_{17}H_{33}$
or $C_{17}H_{35}$ is C_nH_{2n+1} **or** less hydrogen [1]

(iii) soap **or** (sodium) salt (of a carboxylic acid) **or** carboxylate [1]

alcohol [1]

[Total: 17]

Question 6

5 (a) protective / layer **and** of oxide [1]

(b) correct repeat unit [1]
continuation shown [1]

(c) (i) catalyst [1]
biological / protein [1]

(ii) hydrochloric acid / any strong acid / any strong alkali [1]

(iii) amino acids [1]

(iv) chromatography [1]

(v) nylon / kevlar [1]

(d) (i) non-biodegradable [1]

(ii) $CH_2{=}CH(C_6H_5)$ [1]

[Total: 11]

Question 7

7 (a) (i) contains only carbon, hydrogen and oxygen [1]
hydrogen (atom) to oxygen (atom) ratio is 2:1 [1]
ALLOW: C:H:O as 1:2:1 or $C_n(H_2O)_n$

(ii) condensation [1]
polymerisation [1]

(b) (i) cells / micro-organisms / plants / animals / metabolic reactions [1]
obtaining energy from food / glucose / nutrients [1]

(ii) $2C_2H_5OH + 2CO_2$ [2]
allow: C_2H_6O for C_2H_5OH
not balanced = (1) only

(iii) to prevent aerobic respiration / to get anaerobic respiration / to prevent ethanoic acid / lactic acid / carboxylic acids being formed / to prevent oxidation of ethanol [1]

(c) displayed formula of methyl butanoate [2]
NOTE: all bonds must be shown
NOTE: award (1) if error in alkyl groups but correct displayed structure of –COO–

(d) (i) alcohol, e.g. glycerol, circled [1]
ALLOW: if only part of glycerol molecule is circled as long as it involves an OH group

(ii) saturated
correct reason based on group $C_{17}H_{35}$ / all C–C bonds / no C = C bonds [1]

(iii) salt / carboxylate / alkanoate [1]
(making) soap [1]
ACCEPT: detergent / washing

(e) at least one correct amide linkage –CONH– [1]
continuation shown at both ends of chain [1]
diagram showing three (different) amino acid residues [1]

[Total: 18]

Question 8

7 (a) (i) hydrogen (atoms) replaced by (atoms) of a different element e.g. chlorine [1]
NOT: substitute

(ii) light required [1]

(b) exothermic reaction gives out energy [1]
endothermic reaction absorbs
takes in energy [1]

Question 9

5 (a) (i) have same molecular formula / both are C_5H_{12} [1]
they have different structural formulae / different structures [1]

(ii) CH_3-CH_2-CH=CH-CH_3 / any other correct isomer [1]

(b) (i) CH_2-(Br)-CH_2Br [1]
NOT: $C_2H_4Br_2$
dibromoethane [1]
NOTE: numbers not required but if given must be 1, 2

(ii) CH_3-CH_2-CH_3 [1]
NOT: C_3H_8
propane [1]

(iii) CH_3-CH_2-CH_2-CH_2-OH / CH_3-CH_2-CH(OH)-CH_3 [1]
butanol [1]
numbers not required but if given must be correct and match formula

(c) (i) CH_3-CH=CH-CH_2-CH_3 [1]
CH_3-CH=CH-CH_3 [1]

(ii) pink / purple [1]
colourless [1]
NOT: clear

(d) -CH_2-CH(CN)-CH_2-CH(CN)- [1]
correct repeat unit CH_2-CH(CN)
COND: at least 2 units in diagram [1]
continuation [1]

[Total:16]

Question 10

(c) (i) amide / peptide; [1]

(ii) named strong acid / alkali; [1]
allow: HCl / enzymes

(iii) amino acid; [1]
allow: peptides

Question 11

5 (a) (i) add bromine water / bromine / aqueous bromine; [1]
colourless; [1]

or add potassium manganate(VII) / permanganate; (ignore acid or alkali) [1]
colourless; [1]

(ii) add metal / carbonate / insoluble base / strong alkali **allow:** ammonia with an indicator / use pH meter; [1]
COND: on reagent

metal - hydrogen given off / metal dissolves / effervescence / gas given off / burning splint pops;

carbonate - carbon dioxide given off / effervescence / gas given off / limewater milky;

insoluble base - solution formed / dissolves;

alkali - use of indicator to show neutralisation / temperature increase;

pH meter - gives pH less than 7 [1]

(b) ethyl propenoate; [1]
correct SF all bonds shown;; [2]
allow: [1] for correct displayed ester linkage

(c) (i) number of atoms of each element; [1]
in one molecule; [1]

(ii) 2; [1]

(iii) C=C [1]

(iv) $HOOC(CH_3)C=C(CH_3)COOH$

[Total: 12]

Question 12

7 (a) (i) $C_nH_{2n+1}OH$ [1]

(ii) 116-17 = 99, 2n+1 = 99, n = 7
for any evidence of working out [1]
$C_7H_{15}OH$ [1]

(iii) 4bps around C; [1]
1 bp on each hydrogen; [1]
2bps and 2nbps on oxygen; [1]

(b) (i) increases yield / moves equilibrium to RHS / favours forward reaction; [1]
high pressure favours side with smaller number of (gas) molecules; [1]

(ii) any two from:
higher temperature / catalyst causes faster reaction;
comment about compromise conditions to give best rate and yield;
at 250°C (lower temp) higher yield / forward reaction favoured;
at 350°C (higher temp) lower yield / back reaction favoured; [3]

(c) (i) methanoic acid; [1]
correct SF showing all bonds; [1]
accept: -OH

(ii) methyl methanoate; [1]

[Total: 14]

Question 13

3 (a) (i) correct structure of an isomer e.g. 2-chloropropane; [1]

(ii) chlorine; [1]
light / heat / lead tetraethyl; [1]

(iii) could produce 2-chloropropane; [1]
could produce HC*l*; [1]
or
could produce dichloropropanes = [2]

(b) (i) add silver nitrate / lead nitrate; [1]
yellow precipitate; [1]
note: do not insist on presence of dilute nitric acid

(ii) propanol / propan-1-ol; [1]

(c) (i) for A;
reaction slower;
decreased collision rate;
less bromobutane present / concentration of bromobutane less / less reacting particles; [2]
any two
accept: reverse arguments for B

(ii) halogens C*l* > Br > I reactivity / reactivity decreases down group; [1]
organic halides I > Br > C*l* / reactivity increases down group; [1]
opposite without explanation = [1]

(iii) any three from:
less energy;
particles move slower;
less collisions / fewer particles have energy to react / fewer successful collisions;
slower rate; [3]

[Total: 15]

Question 14

6 (a) (i) amino acid / peptides; [1]
salt / carboxylate or soap / fatty acid or glycerine / alcohol; [1]
sugars or glucose; [1]
accept: named sugar

(ii) polyester; [1]
allow: named polyester
polyamide; [1]
allow: nylon

(b) one correct amide linkage; [1]
second amide linkage correctly orientated
– NHCO – followed by – NHCO –; [1]
note: monomers are amino acids not diamines or dicarboxylic acid

(c) bromine / bromine water / aqueous bromine; [1]
unsaturated - brown / orange to colourless **not:** clear [1]
saturated - stays brown / orange [1]

or: alkaline potassium manganate(VII);
from purple / pink to green / brown;
stays purple;
or: acidic potassium manganate(VII)
from purple / pink to colourless; **not:** clear
stays purple;

[Total: 10]

Question 15

4 (a) it is an alkane **or** hydrocarbon [1]
it is saturated **or** only C—C single bonds [1]
accept: no double bonds

(b) molecular formula C_6H_{12} [1]
empirical formula CH_2 [1]

(c) correct structural formula of cyclobutane [1]

(d) (i) C_6H_{12} [1]
accept: a correct structural formula

(ii) same molecular formula **not**: chemical formula [1]
different structural formulae / structures [1]

(e) add bromine (water) or (l) [1]

cond: (remains) brown **or** orange **or** red or yellow [1]

cond: changes from brown, etc. to colourless or decolourises [1]
not: clear

OR
potassium manganate(VII) [1]
note: oxidation state not essential but if given must be correct or [0]
accept: potassium permanganate

cond: remains pink / purple [1]

cond: changes from pink to colourless **(acidic)** [1]
not: clear

cond: change from pink to green / brown **(alkaline)**

[Total: 11]

Question 16

1 (a) (i) contains carbon and hydrogen [1]
cond: only / just [1]

(ii) (different) boiling points [1]
cond: separate [1]

(b) bitumen-making roads / roofs / water-proofing, etc. [1]

lubricating fraction – waxes / vaseline / grease, etc. or machinery example, e.g. (oil a) bike / hinges / reducing friction [1]

paraffin fraction – jet fuel / (home) heating or tractors or cooking or lighting [1]

gasoline fraction – petrol or fuel for cars / vans / trucks [1]

[Total: 8]

Question 17

8 (a) proton donor; [1]

(b) equal concentrations of both (solutions); [1]
add Universal indicator / determine pH / pH paper; [1]
ethylamine has lower pH / ORA; [1]
or
equal concentration of both (solutions); [1]
measure conductivity of aqueous ethylamine and sodium hydroxide; [1]
ethylamine will have lower conductivity / sodium hydroxide will have higher conductivity; [1]

(c) add strong(er) base / NaOH / KOH; [1]
warm / heat; [1]

(d) (ethylamine forms) hydroxide ions / OH^- (in water); [1]
hydroxide ions / OH^- reacts with iron(III) ions / Fe^{3+};
or
iron(III) hydroxide / $Fe(OH)_3$ (forms as a brown precipitate); [1]
note: balanced or unbalanced ionic equation i.e. $Fe^{3+} + (3)OH^- \rightarrow Fe(OH)_3$ scores both marks

Question 18

7 (a) (i) CH_2/H_2C [1]

(ii) same ratio of C:H (atoms) / all cancel to CH_2 / because general formula is C_nH_{2n} / same ratio of atoms or elements (in the compound) / C:H ratio is 1:2; [1]

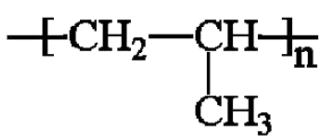
(b) (i) propanoic / propionic (acid); [1]
ethanoic / acetic (acid); [1]

(ii) formula of ethene / but-2-ene / any symmetrical alkene; [1]

(c) (i) $CH_3CH(Br)CH_2Br$ [1]

(ii) $CH_3CH(OH)CH_3$ / $CH_3CH_2CH_2OH$ / C_3H_7OH [1]

(d)



correct unit; [1]
accept: more than one repeat unit
continuation bonds at **both** ends; [1]

(e) if C_5H_{10} is given award 3 marks;;; [3]
if $C_{10}H_{20}$ is given award 2 marks;;
if 1:7.5:5 / 2:15:10 is given award 2 marks;;
in all other cases a mark can be awarded for moles of O_2 (= 2.4/32 =) 0.075 **AND** moles of CO_2 (= 2.2/44 =) 0.05;

$2C_5H_{10} + 15O_2 \rightarrow 10CO_2 + 10H_2O$ [1]
accept: multiples including fractions
allow: ecf for correct equation from any incorrect alkene

Question 19

5 (a) (i) correct -O- linkage; [1]
correct unit and continuation -O-□- (minimum); [1]

(ii) any name or correct formula of a (strong) acid / H^+; [1]

(iii) contain carbon hydrogen and oxygen /C, H and O; [1]

(b) (i) glucose → ethanol + carbon dioxide [1]

(ii) yeast is catalyst / provides enzymes / speeds up reaction / too slow without yeast; [1]
yeast cells grow / multiply / reproduce / undergo budding / breed; [1]

(iii) heat or high temperature would kill yeast (cells) / heat or high temperature denatures enzymes; [1]
not: enzyme killed / denatures yeast
reduces rate of reaction / slows reaction / (yeast or enzyme) no longer catalyses / no catalyst / stops reaction / no more product; [1]

(c) (i) would produce carbon dioxide or carboxylic or organic acids (if oxygen is present) / to prevent aerobic respiration / so products are not oxidised / anaerobic bacteria can't live with oxygen; [1]

(ii) fossil fuels have a reduced need / conserved / no need to import / will last longer / cracking hydrocarbons to make methane no longer required;
(methane) is renewable / carbon neutral;
reduce pollution of water or sea / prevents visual pollution / prevents need for waste disposal or accumulation (**accept:** any methods of waste disposal) / so that waste is recycled; **any two** [2]

Question 20

7 (a) burning
produces toxic gases / harmful to health
increases greenhouse gases / global warming
reduces visual pollution / litter
reduces risks to wildlife
shortage of landfill sites / reduces space needed in landfill sites / saves space
non-biodegradable / long time to rot / decompose / accumulates waste
burning source of energy / used to generate electricity

recycling
conserves petroleum / natural resources
difficult to recycle / expensive / takes much energy
problems over sorting
reduces need for landfill
quality of plastic is reduced each time it is recycled
four DIFFERENT valid points which are advantages or disadvantages of burning and/or recycling [4]

(b) (i) addition (polymerisation); [1]

(polymer) only product / no by-products; [1]

condensation (polymerisation); [1]

(polymer and) simple molecule / water / hydrogen chloride / one other product forms; [1]

(ii) a correct linkage (for a polyamide / polyester); [1]
two different monomers; [1]

[Total: 10]

Question 21

6 (a) $10\,cm^3$; [1]
$65\,cm^3$; [1]

(b) (i) chlorination / substitution / photochemical / exothermic / halogenation / free radical; [1]

(ii) (compounds) same molecular formula; different structural formulae; [2]

(iii) $CH_3–CH_2–CH_2–CH_2–Cl$ [1]
$CH_3–CH_2–CH(Cl)–CH_3$ [1]

(c) (i) potassium manganate(VII) / potassium dichromate(VI) / copper(II) oxide; [1]
note: do not insist on oxidation numbers but if given must be correct

(ii) butanoic acid; [1]

(iii) butyl ethanoate; [1]

correct formula all bonds shown = [2]
if alkyl groups incorrect then correct ester linkage showing bonds = [1] [2]

[Total: 12]

Question 22

(b) (i) correct structural or displayed formula of another chlorobutane / dichlorobutane / polychlorobutane [1]

(ii) light / 200 °C / lead tetraethyl [1]

(iii) cracking is the decomposition/breaking down of an alkane/hydrocarbon/petroleum [1]
heat/high temperature / Temperature between 450 °C to 800 °C
OR catalyst / named catalyst [1]
to give a simpler alkane and alkene [1]

word equation or equation as example [1]

to make polymers / to increase petrol fraction / organic chemicals/petrochemicals / hydrogen [1]
any **four**

Question 23

(b) (i) ester [1]

(ii) soap/sodium stearate or any acceptable salt/glycerol [1]

(iii) burning both fuels forms carbon [1]

growing plants to make biodiesel removes carbon dioxide from atmosphere [1]

(c) (i) correct SF of an octane [1]

(ii) add bromine (water)/bromine in an organic solvent [1]
result octane remains brown/orange/yellow/red [1]
result octane goes colourless/decolourises [1]
not clear/discolours
colour of reagent must be shown somewhere for [3] otherwise max [2]
accept equivalent test using $KMnO_4$ in acid or alkali

Question 24

8 (a) addition – polymer only product / only one product [1]
accept monomer has C=C
accept monomer and polymer have same empirical formula
accept no loss of material in polymerisation
not only one monomer

condensation – polymer and water / small molecule formed [1]

(b) $-CH_2 - CCl_2-$
repeat unit correct [1]
COND continuation [1]

(c) $CH_2=CHOOCCH_3$ [1]

(d) $-OC(CH_2)_4CONH(CH_2)_6NH-$
COND amide correct linkage [1]
correct repeat units [1]
continuation [1]
not NH_2 **or** COOH endings

Question 25

6 (a) (i) cracking / heat with catalyst [1]
to make butane [1]
butene reacts with steam/water / hydrated [1]
accept heat and catalyst for cracking but if specified: 450 to 800°C zeolites / aluminosilicates / silica / aluminium oxide/alumina / china / broken pot / porcelain / chromium oxide

(ii) glucose / sugar changed to alcohol / ethanol [2]
accept an unbalanced equation
(catalysed by) enzymes / yeast [1]

(b) butanoic acid [1]
$CH_3-CH_2-CH_2-COOH$ [1]
hydrogen atoms omitted from ends of bonds, penalise once

(c) (i) ester [1]

(ii) $C_6H_{12}O_2$
ignore $CH_3COOC_4H_9$ [1]

(iii) correct structural formula of butyl ethanoate showing all bonds [2]

Question 26

4	(a)	(i)	same molecular formula / same number of C and H atoms	[1]
			different structural formula or structure	[1]
			same compound = [1]	
		(ii)	correct **formula** of but-2-ene / methylpropene / methyl cyclopropane	[1]
		(iii)	bromine / bromine water / aqueous bromine	[1]
			brown to colourless **not** clear	[1]
			stays brown	[1]
			brom**ide** loses the first mark only	
			OR alkaline potassium manganate(VII)	[1]
			from purple/pink to green/brown	[1]
			stays purple	[1]
			OR acidic potassium manganate(VII)	[1]
			from purple/pink to colourless **not** clear	[1]
			stays purple	[1]
	(b)		heat / high temperature (temperature need not be stated, but if it is stated it must be 500ºC or above)	[1]
			catalyst (need not be named, but if they are named accept any metal oxide or zeolite / aluminosillicates / silicon dioxide)	[1]
			not nickel/platinum	
	(c)		(1,2)dibromobutane	[1]
			if numbers given must be correct	
			butane	[1]
			butanol	[1]
			accept butan-1-ol or butan-2-ol **not** but-1-ol / but-1-anol / buthanol	

Question 27

2	(a)	(i)	enzymes are proteins / come from living organisms / biological (catalysts)	[1]
			not enzymes are living or natural	
		(ii)	carbohydrates have 2H:1O ratio	[1]
			contain elements of water	[1]
			contain water = [1]	
			unless they state that carbohydrates contain water, this response scores 2 or 0	
	(b)		correct -O- linkage	[1]
			cond same correct monomer (this mark is lost if 2 different boxes are shown)	[1]
			cond continuation (i.e. bonds at **both** ends)	[1]
	(c)	(i)	(concentration or amount or mass etc.) of starch decreases (with time)	[1]
			(concentration etc.) of starch becomes zero / all starch gone	[1]
			colour (intensity) indicates how much starch is present (can be inferred)	[1]
		(ii)	enzyme denatured / destroyed	[1]
			not enzymes killed / don't work / saliva denatured	

Question 28

8 (a) biodegradable or breaks down naturally
made from a renewable source **or** does not use up petroleum

reduce visual pollution **or** reduces need for landfill sites **or** less danger to wildlife
any **TWO** [2]
ignore mention of toxic gases

(b) (i) ester [1]
accept polyester **or** fat **or** lipid **or** vegetable oil **or** carboxylic acid

(ii) acid **or** carboxylic acid **or** alkanoic acid [1]
alcohol **or** hydroxyl **or** alkanol [1]
NOT formulae **NOT** hydroxide

(iii) condensation [1]
COND because water is formed in reaction
or monomer does not have C=C bond [1]

(c) (i) lactic acid → acrylic acid + water [1]

(ii) add bromine (water) or bromine in an organic solvent [1]
remains brown/orange/yellow [1]
goes colourless **NOT** clear [1]
If mark 1 near miss e.g. bromide allow marks 2 and 3
Colour of reagent must be shown somewhere for [3] otherwise max [2]

OR acidified potassium manganate(VII)
purple/pink to colourless

OR alkaline potassium manganate(VII)
purple/pink to green
or purple/pink to brown precipitate

Question 29

(b) (i) fats **or** lipids [1]

(ii) -O- linkage, no other atoms in linkage [1]
COND same monomer [1]
COND continuation bonds at each end -A- [1]

(iii) **same** linkage **or** amide linkage **or** peptide **or** –CONH- [1]

differences
synthetic polyamide usually two monomers
protein many monomers
protein monomers are amino acids **or** proteins hydrolyse to amino acids **or** a protein monomer has one – NH_2 and one –COOH group
synthetic polyamide each monomer has 2 –NH_2 **or** 2COOH groups **or** monomers are dioic acid and diamine
accept diagrams **or** comments that are equivalent to the above
ANY **TWO** [2]

Question 30

(c) (i) biological catalyst [1]
accept protein catalyst

(ii) production of energy (from food) [1]
by living "things" **or** by cells, etc. [1]

(iii) "kill" yeast **or** denature enzymes (due to increase in temperature) [1]

(iv) all glucose used up [1]
yeast "killed" **or** denatured **or** damaged by ethanol/alcohol [1]

(v) filter **or** centrifuge [1]
fractional distillation [1]

Question 31

7 **(a)** butanol [1]
no number needed but if one is given it has to be 1

structural formula (all bonds shown) [1]
accept –OH **NOT** –HO

ethanoic acid [1]
structural formula (all bonds shown) [1]
accept –OH **NOT** –HO
no conseq marking
if all bonds are not shown (CH_3–CH_2–), penalise once

(b) **(i)** must have correct ester linkage [1]
COND continuation and a group on either side of the ester group [1]

Accept –COO–

(ii) accept any sensible suggestion
ropes, clothing, bottles, packaging, bags [1]

(c) **(i)** 8 [1]

(ii) double bond becomes single and 4 bonds per carbon atom [1]
COND a bromine atom on each carbon [1]
$C_2H_4Br_2$ ONLY [1]
accept a structural formula with hydrogen atoms

(iii) corn oil [1]

(d) 100g of fat react with 86.2g of iodine
884g of fat react with **762** g of iodine [1]
limit 762 x 2
one mole of fat reacts with 762/254 moles of iodine molecules
one mole of fat reacts with **3** moles of iodine molecules [1]

number of double bonds in one molecule of fat is **3** [1]
limit 6
consequential marking allowed provided the number of double bonds is an integer.

[Total: 14]

Question 32

1 **(a)** **(i)** coal **or** coke **or** peat [1]
NOT wood **or** charcoal

(ii) natural gas **or** methane **or** propane **or** butane **or** petroleum gases **or** calor gas **or** refinery gas [1]

(b) **(i)** petrol **or** gasoline
paraffin **or** kerosene
diesel
aviation fuel **or** jet fuel
fuel oil
heavy fuel oil
heating oil
Any **TWO** [2]
NOT a named alkane e.g. octane

(ii) waxes **or** grease **or** lubricants **or** polishes **or** bitumen (tar, asphalt) **or** naphtha [2]
Any **TWO** from the primary or secondary distillation of petroleum

(iii) (liquid) air **or** ethanol and water **or** alkenes (made by cracking) **or** Noble Gases [1]

[Total: 7]

Question 33

7 **(a)** **(i)** any correct equation **[1]**

(ii) structural formulae from but-1-ene, but-2-ene, methylpropene **or** cyclobutane Any **TWO** **[2]**

(b) **(i)** light **or** 200°C **or** lead tetraethyl **[1]**

(ii) substitution **or** photochemical **or** chlorination **or** free radical or halogenation **[1]**

(iii) 1-chlorobutane, 2-chlorobutane, dichlorobutane etc. Any **TWO** **[2]**

(c) **(i)** $CH_3CH_2CH_2OH$ **or** $CH_3CH(OH)CH_3$ **[1]**

(ii) $CH_3CH(Br)CH_2Br$ **[1]**
NOT 1,3-dibromopropane

(d) moles of CH_3-CH = CH_2 reacted = 1.4/42 = 0.033 **[1]**
conseq
maximum moles of CH_3-CH(I)-CH_3 that could be formed = 0.033 **[1]**
conseq
maximum mass of 2-iodopropane that could be formed = 5.61 g **[1]**
accept 170 x 0.033 = 5.61 and 170 x 0.033333 = 5.67
conseq unless greater than 100%
percentage yield 4.0/5.67 x 100 = 70.5% **[1]**
Do not mark consequently to a series of small integers. There has to be a serious attempt to answer the question, then consequential marking is appropriate.

[TOTAL = 13]

Question 34

(iv) amide linkage **[1]**
COND different monomers **[1]**
continuation **[1]**
Accept hydrocarbon part of chain as boxes
If nylon 6 then only one monomer [1] **NOT** different monomers

(b) correct structure as syllabus (box representation) **[1]**
correct linkage --O-- **[1]**
continuation

(c) **(i)** $C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2$ **[2]**
not balanced [1]
Accept C_2H_6O

(ii) gives out energy **or** equivalent **[1]**
NOT heat
N.B. a total of [1] not [2]

(iii) glucose used up **or** yeast 'killed' by ethanol **[1]**
NOT yeast used up **NOT** reactant used up

(iv) oxidise alcohol to acid **or** to ethanoic acid **[1]**
or to carbon dioxide and water
or if oxygen present aerobic respiration
or cannot have anaerobic respiration in presence of oxygen
NOT it is anaerobic respiration, must be additional comment

(v) fractional distillation **[1]**

Question 35

3	(a)	(i)	CH_3-CH==CH_2	[1]
		(ii)	**conseq** to **(i)** correct repeat unit **COND** evidence of continuation	 [1] [1]
		(iii)	monomer **COND** because it has a double bond **or** unsaturated **or** alkene **NOT** addition	[1] [1]
	(b)	(i)	to remove fibres **or** remove solid **NOT** precipitate, **NOT** impurities, **NOT** to obtain a filtrate	[1]
		(ii)	because silver atoms have lost electrons **OR** oxidation number increased	[1]
		(iii)	silver chloride	[1]
	(c)	(i)	name of an ester formula of an ester if they do not correspond MAX [1] **Accept** name - terylene for formula ester linkage and continuation If a 'fat' complete structure must be correct e.g. $C_{17}H_{35}$ etc. Mark for formula only - [1]	[1] [1]
		(ii)	alcohol **or** alkanol **NOT** a named alcohol	[1]
	(d)	(i)	acid loses a proton base accepts a proton **OR** same explanation but acid loses a hydrogen ion (1) and base gains hydrogen ion (1)	[2] [1]
		(ii)	only partially ionised **or** poor hydrogen ion donor **or** poor proton donor **NOT** does not form many hydrogen ions in water **or** low concentration of hydrogen ions **NOT** pH	[1]

Question 36

6.	(a)	(i)	correct repeat unit **COND** evidence of polymer chain	[1] [1]
		(ii)	glucose **or** maltose	[1]
		(iii)	addition (polymerisation) **or** no other product except polymer condensation (polymerisation) **or** polymer and water	[1] [1]
	(b)	(i)	sodium hydroxide **COND** ammonia **or** alkaline gas **or** litmus red to blue If aluminium added wc =0	[1] [1]
		(ii)	measure pH more than 1 and less than 7 **or** correct colour eg orange **or** yellow **NOT** red **NOT** green **OR** add magnesium **or** calcium carbonate weak acid reacts slowly	[1] [1] [1]
	(c)	(i)	ethyl acrylate ester **or** alkene	[1] [1]
		(ii)	brown to colourless (**NOT** clear) correct formula for acid **NOT** ester	[1] [1]

Question 37

3	(a)	(i)	Correct equation For giving correct formula of alkane and alkene [1] only Accept alkene and hydrogen	[2]
		(ii)	chlorine **COND** light **or** 200°C **or** heat **or** lead tetraethyl **or** high temperature MAX 1000°C ignore comment 'catalyst'	[1] [1]
	(b)	(i)	same molecular formula different structures **or** structural formulae	[1] [1]
		(ii)	but-2-ene or cyclobutane corresponding structural formula NOT 2-butene	[1] [1]
	(c)		butanol ignore numbers butane ignore numbers dibromobutane ignore numbers	[1] [1] [1]
	(d)	(i)	propene	[1]
			CH_3—CH==CH_2	[1]
		(ii)	Correct structure of repeat unit ignore point of attachment of ester group COND upon repeat unit shows continuation If chain through ester group [0] out of [2]	[1] [1]
		(iii)	do not decay or non-biodegradable shortage of sites or amount of waste per year visual pollution forms methane Any TWO	[2]
		(iv)	form poisonous **or** toxic gases **or** named gas CO, HCl HCN NOT carbon dioxide, harmful, sulphur dioxide	[1]

Question 38

6	(a)	(i)	heat (energy)	[1]
		(ii)	exothermic	[1]
		(iii)	$C_2H_5OH + 3O_2 = 2CO_2 + 3H_2O$ For $CO_2 + H_2O$ **ONLY** [1]	[2]
		(iv)	plotting points correctly straight line between –2640 and –2700kJ/mol **NOTE** minus sign needed	[1] [1] [1]
		(v)	general (molecular) formula same functional group consecutive members differ by CH_2 similar chemical properties **or** react same way **NOT** a comment about physical properties **ANY TWO**	[2]
	(b)		CH_3- CH(OH)-CH_3 **NOT** C_3H_7OH propan-2-ol "2" is needed **NOTE** the name and the formula must correspond for both marks accept full structural formula – all bonds shown correctly accept formulae of the ether **NOT** CH_3- CH(HO)-CH_3	[1] [1]

(c) (i) cracking
heat (alkane) **or** (alkane) and catalyst
NOTE thermal cracking or catalytic cracking [2]
alkane = alkene + hydrogen
ANY TWO [2]

OR steam reforming
$CH_4 + H_2O = CO + 3H_2$ [2]
or water/steam [1]
catalyst **or** heat [1]

(ii) combustion **or** burning [1]
incomplete **or** insufficient oxygen/air [1]
OR ACCEPT steam reforming as above [2]

(iii) high pressure [1]
COND forward reaction volume decrease
or volume of reactants greater than that of products
or fewer moles of gas on the right
or fewer gas molecules on right [1]
NOTE accept correct arguments about either reactants **or** products

(d) (i) methyl ethanoate [1]

(ii) propanoic acid **or** propanal [1]

(iii) ethene [1]

[Total: 20]

Question 39

8 (a) (i) biological catalyst [1]

(ii) linkage ----O----
same unit as in glucose as on question paper that is rectangles [1]

(iii) chromatography [1]

(b) (i) --NHCO—linkage
different units
-NH and -CO on same monomer unit
All three [2] two points [1] [2]

(ii) amino acids [1]

(c) (i) propanol + ethanoic acid = propyl ethanoate + water [2]
reactants [1] products [1]

(ii) ester linkage correct [1]
rest of molecule correct [1]

(iii) bromine water [1]
fat 1 orange **or** yellow **or** brown to colourless [1]
fat 2 remains orange **or** yellow **or** brown [1]
Accept Potassium Manganate(VII) with corresponding colour changes

(iv) soap or sodium salts (of carboxylic acids)/sodium stearate [1]
alcohol/glycerol [1]

[TOTAL = 15]

Question 40

Question 4

(a)(i) general molecular formula
same functional group
physical properties show trend — bp increase with n
same chemical properties
common methods of preparation
any **TWO** **[2]**

(ii) $C_8H_{17}OH$ Mass of one mole = 130 (g) **[2]**
if formula correct but mass wrong **[1]**

(b) propan-1-ol **or** propan-2-ol **[1]**
corresponding structural formula **[1]**
name and formula must correspond for **[2]** if not **ONLY [1]**

(c)(i) structural formula of isomer **[1]**

(ii) carbon dioxide and water **[1]**
pentene **[1]**
pentanoic acid **[1]**

TOTAL = 10

Question 41

(b)(i) calcium ethanoate + hydrogen **[1]**

(ii) zinc oxide **or** hydroxide **[1]**

(c) $CH_3COOH + NaOH \rightleftharpoons CH_3COONa + H_2O$ **[2]**
reactants **[1]** products **[1]**

Question 42

8 (a) (i) C_6H_{12} **[1]**
between 60 to 65°C **[1]**

(ii) $C_{12}H_{24}$ **[1]**
COND giving some indication of the method **[1]**

(b) add bromine water **or** potassium manganate(VII) **[1]**
butene it goes from brown/orange/yellow to colourless
or manganate (VII) from pink to colourless **[1]**
NOT clear
Cyclobutane it remains brown/orange/yellow **or** manganate (VII) stays pink
or no colour change **[1]**
Accept does not react
Provided colour of reagent somewhere in the answer [3] is possible

(c) (i) alcohol **[1]**

(ii) CH_3-CH_2-CHC*l*-CH_3 **[1]**

(iii) -$CH(CH_3)$-$CH(CH_3)$- **[2]**
or any equivalent diagram
[1] for repeat unit and [1] for continuation

TOTAL = 11

Question 43

6	(a) (i)	correct structure $CH_2=CCl_2$	[1]
	(ii)	because it has a lower M_r **or** density **or** its molecules move faster it is lighter ONLY [1] only comment - smaller molecules [0] answer implies or states sieve idea then [0]	[2]
	(b) (i)	ester linkage	[1]
		COND polymer chain showing different monomers and continuation $-OOC-C_6H_4-COOCH_2CH_2O-$	[1]
	(ii)	fats **or** lipids	[1]
	(iii)	does not decompose easily when heated accept similar statements	[1]
	(c) (i)	does not decompose **or** non-biodegradable shortage of landfill sites **or** of space visual pollution poisonous/toxic/harmful gases when burnt **NOT** carbon monoxide, sulphur dioxide. If gas named has to be a correct one eg HCl, HCN dangerous to animals Any **TWO**	[2]
	(ii)	conserve petroleum or save energy **NOT** cheaper	[1]
			TOTAL = 10

Question 44

	(b) (i)	CO_2 and H_2O	[1]
		balanced $2CH_3OH + 3O_2 = 2CO_2 + 4H_2O$	[1]
	(ii)	methyl ethanoate	[1]
		water	[1]
	(iii)	Methanoic (acid) accept formic acid	[1]

Question 45

4	(a) (i)	in which something dissolves	[1]
	(ii)	correct formula $CH_3COOC_2H_5$ **or** full structural formula	[1]

NOT $C_4H_8O_2$

(iii) steam **or** water **or** hydration [1]
heat **or** catalyst [1]

OR bubble into (concentrated) sulphuric acid [1]
add water [1]

oxidised [1]
by air **or** dichromate **or** manganate(VII) [1]

(iv) ethanoic acid and butanol [1]

(b) (i) CH_2OH [1]
CHOH
CH_2OH

(ii) soap **or** detergent [1]

(c) (i) polyester **or** condensation polymer **NOT** terylene [1]

(ii) HOOC – [ ] – COOH [1]

HO – [ ] – OH [1]

If wrong way around [1] Point of attachment of functional group to "box" not important

(d) (i) protein **or** poly peptide **or** polyamide [1]
(ii) peptide **or** amide [1]
(iii) amino acids are colourless **or** become visible/coloured **or** to develop it [1]
(iv) using colour **or** from position **ONLY** [1]
OR discussion of Rf [2]
OR compare with known amino acids [2]

TOTAL = 17

Question 46

(ii) measure rate in different light levels and comment [1]
accept if dark no reaction

(c) (i) $+6O_2$ [2]
not balanced that is just O_2 **ONLY** [1]
(ii) linkage ---O---- [1]
chain [1]
minimum to be accepted

Question 47

5 (a) molecular formula [1]
Must be able to give isomers, need not be alkenes
two corresponding isomers [2]
If do not correspond then MAX [2] out of [3]

(b) (i) ethanol [1]
structure [1]

(ii) ethane [1]
structure [1]

(c) (i) many simple molecules **or** monomers [1]
form one large one **or** macromolecule or chain [1]

(ii) addition polymer only one product- the polymer [1]
condensation - polymer and water etc [1]

(iii) correct unit [1]
COND evidence of polymer in structure eg shows continuation such as terminal bonds [1]

(d) (i) water proof **or** impervious **or** flexible **or** good adhesion **or** non-biodegradable **or** unreactive [1]

(ii) steel in contact with water **or** air [1]

(iii) zinc more reactive
oxygen /water reacts with zinc not iron
sacrificial protection
zinc anodic
steel receives electrons from zinc
zinc forms cations
cell
TWO valid points [3]

TOTAL = 17

Question 48

8 **(a)** same general formula
same chemical properties
same functional group
physical properties vary in predictable way
common methods of preparation
consecutive members differ by CH_2
any **two** [2]
mark first two
ignore others unless it contradicts a point which has been awarded a mark

(b) **(i)** $2HCOOH + CaCO_3 \rightarrow Ca(HCOO)_2 + CO_2 + H_2O$ [2]
not balanced = [1]

(ii) zinc + methanoic acid → zinc methanoate + hydrogen [2]
[1] for each product

(iii) protected by oxide layer [1]

(c) butanoic acid [1]
$CH_3\text{-}CH_2\text{-}CH_2\text{-}COOH$ / $C_4H_8O_2$ / C_3H_7COOH / C_4H_7OOH [1]
C_2H_4O [1]
mark **ecf** to molecular formula

Question 49

4 (a) (i) ethanol [1]
CH_3-CH_2-OH [1]

propanoic acid [1]
CH_3-CH_2-COOH [1]
independent marking, no ecf
accept C_2H_5
not – HO

(ii) type of compound – salt / sodium carboxylate / alkanoate [1]
not soap / sodium stearate etc
use – soap / cleaning / detergent [1]

(iii) terylene / PET / Dacron / diolen / mylar / crimplene [1]

(b) (i) polyamide / amide / peptide / polypeptide [1]

(ii) correct amide linkage NHCO then CONH [1]
cond to mark 1, 2 monomers (different shading in box) [1]
cond continuation (to **ONE** correct linkage) [1]

OR nylon 6
only one linkage – NHCO [1]
cond only one monomer [1]
cond continuation (to correct linkage) [1]

(iii) use locating agent [1]
measure distance travelled by sample / travelled by solvent front [1]
cond this is $R_f = 0.5$ [1]
for mark 3, either mark 1 or mark 2 must be awarded

accept run a chromatogram of glycine [1]
compare with sample
same position [1] max [2]

Question 50

(iii) chlorine [1]
not chlorine water
cond light / UV / heat / high temperature if numerical value given about 200°C / lead tetraethyl [1]
not warm

Question 51

6 (a) (i) C and H only (1) [1]

(ii) only single bonds (1) [1]

(b) (i) C_nH_{2n+2} (1) [1]

(ii) $C_{14}H_{30}$ (1)
$(14 \times 12) + 30 = 198$ (g) (1) [2]

(c) (i) $C_9H_{20} + 14\ O_2 \rightarrow 9CO_2 + 10H_2O$ (2) [2]

(ii) Volume ratio

$C_xH_y(g)$	+ $O_2(g)$	→ $CO_2(g)$	+ $H_2O(l)$	
20	160	100		all in cm^3
1	8	5		mole ratio

$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$
For evidence of method (1)
for equation as above (2) [3]

(d) (i) alkanes in petrol / fuel / solvent (1)
alkenes to make alcohols / plastics / polymers / solvents (1)
hydrogen to make ammonia / fuel / fuel cells, etc. (1) [3]

(ii) a correct equation for example:
$C_{10}H_{22} \rightarrow C_8H_{16} + C_2H_4 + H_2$ (1) [1]

(e) (i) light **or** lead tetraethyl / catalyst / high temperature (1) [1]

(ii) CH_3–CHCl–CH_3 (1) [1]

[Total: 16]

Question 52

(b) correct linkage (1)
rest of molecule correct **and** continuation shown (1)
(other product is) water (1) [3]

Question 53

4 (a) (i) butanoic/butyric acid (1)

$CH_3CH_2CH_2COOH / C_2H_5CH_2COOH$ (1) [2]

(ii) any **three** from:

(same) general formula (1)

(consecutive members) differ by CH_2 (1)

same functional group (1)

common methods of preparation (1)

physical properties vary in predictable manner/show trends/gradually change
or example of a physical property variation i.e. melting point/boiling point/volatility (1) [3]

(b) (i) displayed formula of propan-1-ol, all bonds shown separately (1) [1]

(ii) acidified (1)

potassium manganate(VII)/potassium permanganate/$KMnO_4$ **or** potassium dichromate(VI)/$K_2Cr_2O_7$/potassium dichromate (1) [2]

(c) (i) zinc + propanoic acid → zinc propanoate (+ hydrogen) (1) [1]

(ii) calcium oxide + propanoic acid → calcium propanoate + water (1) [1]

(iii) $LiOH + CH_3CH_2COOH \rightarrow CH_3CH_2COOLi + H_2O$ (1) [1]

(d) (i) concentration (of acid in C) is less/halved **or** concentration of A is more/doubled. (1)

less collisions **or** more collisions in A (than in C) (1) [2]

(ii) (higher temperature in B particles/molecules/atoms) move faster/have more energy/more have E_a **or** (particles/molecules/atoms) in A move slower/have less energy/less have E_a (1)

more collisions **or** less collisions in A (than in B) (1) [2]

(iii) It (D) has strong (acid) **and** A has weak acid/(D) stronger/(D) ionises more/(D) dissociates more **or** A is weaker/A ionises less/A dissociates less (1)

It (D) has higher concentration of hydrogen ions **or** A has a lower concentration of hydrogen ions (1)

more collisions (in D) **or** fewer collisions in A (1) [3]

[Total: 18]

Question 54

2 (a) (i) substance/material/compound/element/mixture (burnt) to produce/release energy **or** heat (1) [1]

(ii) Any **two** from:
coal
coke
peat
petroleum/ crude oil
refinery gas/LPG
gasoline/petrol
naptha
kerosene/paraffin
diesel (oil)/gas oil
fuel oil
propane
butane [2]

(iii) wood/charcoal/animal dung/biomass/Uranium/U/plutonium/Pu (1) [1]

(b) (i) any **two** from:
water/steam/water vapour/H_2O (1)
carbon dioxide/CO_2 (1)
carbon monoxide/CO (1) [2]

(ii) any **two** from:

limited or finite resource/non-renewable/will run out/depleted (1)

greenhouse effect/gas(es)/climate change/(cause) global warming (1)

acid rain (1)

production of poisonous/toxic gases (1) [2]

[Total: 8]

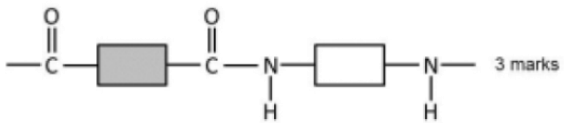
Question 55

8 (a) (i) $CH_3–CH=CH–CH_3$ (1) [1]

(ii) one correct amide linkage between two rectangles (1)

correct sequencing of a second amide link and monomers (1)

two correct amide links **and** rest of structure correct (including additional monomers if seen) **and** correct continuation bonds (1) [3]



3 marks

(iii) protein **or** polypeptide **or** named protein (1) [1]

(iv) addition: **only** the polymer **or** one product is formed (1)

condensation: the polymer **and** a small molecule / water / HC*l* is formed (1) [2]

(b) (i) does not break down **or** rot **or** decompose (1)

by microbes **or** fungi **or** bacteria **or** by living organisms (1) [2]

(ii) Any **three** from: [3]
visual pollution (1)

(shortage of) landfill sites (1)

danger to wildlife / animals (including at sea) (1)

toxic gases when burnt **or** greenhouse gases produced when burned (1)

(c) Any **two** from: [2]
resistant to corrosion / unreactive to water / more durable (1)

lighter / less dense (1)

easier to manufacture / can be moulded (1)

good insulator / keeps the water cold (1)

[Total: 14]

Question 56

7 (a) (i) $CH_3COOCH_2CH_3$ / $CH_3CO_2CH_2CH_3$ / $CH_3COOC_2H_5$ / $CH_3CO_2C_2H_5$ / $C_2H_5OOCCH_3$ / $CH_3CH_2OOCCH_3$ **not:** –OCO– linkage [1]
note: formulae can be displayed or semi-displayed
note: penalise sticks (i.e. any missing atoms)

(ii) butyl methanoate [1]

(b) (i) fats / vegetable oils / triglycerides / lipids [1]

(ii) two correct ester linkages, e.g. –OOC / $–O_2C$ and –COO / $–CO_2$ [1]

contents of the 'boxes' being C_6H_4 and C_2H_4 or CH_2CH_2 [1]
continuation bonds at **both** ends [1]

Question 57

5 (a) (i) does not decay **or** non-biodegradable **or** flexible **or** bendable **or** easily moulded **or** low density / light / lightweight **or** waterproof / insoluble in water **or** does not corrode **or** durable [1]

(ii) any two from: [2]
chlorine
hydrogen chloride
carbon monoxide

(b) (i) $CH_3—CH = CH_2$ [1]
note: can be fully or semi-displayed, C = C must be shown

(ii) correct repeat unit [1]
$–CH(C_6H_5)–CH_2–$

continuation shown [1]

(c) glucose two products (polymer and water) / condensation (polymerisation) / (small) molecules removed [1]

phenylethene one product (polymer) / addition (polymerisation) [1]

Question 58

(b) (i) $C_8H_{18} \rightarrow 2C_4H_8 + H_2$ [1]

(ii) $2H^+ + 2e \rightarrow H_2$ [2]

or $2H_3O^+ + 2e \rightarrow H_2 + 2H_2O$
accept: –2e on right hand side accept: e^-
note: not balanced = 1

Question 59

7 (a) (i) a compound which contains carbon and hydrogen **only** [1]

(ii) alkanes contain **only** C-C single bonds
or they are saturated (hydrocarbons)
or have the general formula C_nH_{2n+2} [1]

alkenes contain at least one C=C double bond
or they are unsaturated (hydrocarbons)
or have the general formula C_nH_{2n} [1]

(b) $C_{20}H_{42} \rightarrow 2C_4H_8 + 2C_2H_4 + \mathbf{C_8H_{18}}$ [1]

(c) (i) any unambiguous structure of $BrCH_2CH_2Br$ [1]
NOT just $C_2H_4Br_2$

(ii) $CH_3\text{-}CH{=}CH\text{-}CH_3$ [2]
For any butene [1] only

(iii) $(CH_3\text{-}CH_2\text{-}CH{=}CH_2) + H_2O$ [1] $\rightarrow CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2OH$ [1] [2]
ALLOW $CH_3\text{-}CHOH\text{-}CH_2\text{-}CH_3$
butene reacts with **water/steam** (to form butanol) **ONLY [1]**

(iv) $C_6H_{12} + H_2 \rightarrow C_6H_{14}$ [2]
alkenes react with **hydrogen** [1] **ONLY**

(d) volume of oxygen used = 150 cm^3 [1]

volume of carbon dioxide formed = 100 cm^3 [1]
any equation of the combustion of an alkene
e.g. $2C_5H_{10} + 15O_2 \rightarrow 10CO_2 + 10H_2O$
formulae [1]
COND balancing [1]

Question 60

6 (a) (i) measure melting point **NOT** just heating [1]
pure sample would melt at 135 °C [1]
OR impure would melt lower than 135 °C

(ii) $C_3H_4O_4$ [1]

(iii) $C_2H_4O_2$ **OR** CH_3COOH [1]
ethanoic **OR** acetic acid [1]
both marks are independent of each other

(iv) ester **NOT** organic, covalent [1]

(b) (i) malonic is a weaker acid/less dissociated
OR sulfuric acid is a stronger acid/more dissociated [1]
NOT sulfuric acid is a strong acid

(ii) add piece of suitable metal, e.g. Mg **ALLOW** Al, Ca **NOT** K, Na, Cu [1]

sulfuric acid reacts fast**er** **OR** malonic reacts slow**er** [1]

OR
as above add a piece of $CaCO_3$, if soluble carbonate then [1] only

OR measure electrical conductivity [1]
sulfuric acid is the bett**er** conductor
OR malonic acid poor**er** conductor [1]
NOT sulfuric acid is a good conductor

(c) (i) sodium malonate **and** water [1]

(ii) $CuSO_4$
H_2O [2]

(iii) $CH_2(COO)_2Mg$
H_2 [2]

(iv) K_2SO_4
CO_2 **and** H_2O **NOT** H_2CO_3 [2]

[Total: 16]

Question 61

7 **(a)** correct method shown
i.e. 126/14 (= 9) **or** 14x = 126 **or** x = 9 **or** (12 × 9) + 18 = 126 [1]
C_9H_{18}
note: correct formula only = 1 [1]

(b) **(i)** all hydrogen atoms 1bp [1]
C—C bond atoms 1bp [1]
C=C 2 bp [1]

(ii) correct repeat unit [1]
continuation [1]

(iii) bonds broken
H-H +436 (kJ/mol) C=C +610 = +1046 (kJ/mol) [1]
bonds formed
2C-H −415 × 2 kJ/mol C-C −346 = −1176 (kJ/mol) [1]
−130 kJ/mol / more energy released than absorbed [1]
or:
bonds broken
3882 (kJ/mol) [1]
bonds formed
4012 (kJ/mol) [1]
−130 kJ/mol / more energy released than absorbed [1]
allow: ecf for final mark as long as the answer is not positive
note: units not necessary

(c) **(i)** butan-1-ol or butan-2-ol or butanol [1]

(ii) CH_3-CH_2-CH(Br)-CH_2Br [2]
$C_4H_8Br_2$ = 1
note: any other dibromobutane = 0

(iii) HI [1]

Question 62

2 **(a)** **(i)** molecule / unit / simple compound / building block **and** used to make a polymer / big molecule / long chain / macromolecule [1]

formation of a polymer / big molecule / long chain / macromolecule **or** joining of monomers **and** elimination / removal / formation of a simple or small molecule / H_2O / HCl [1]
note: two points needed for 1 mark in both parts

(ii) -O- linkage [1]
three correct monomer units [1]
continuation [1]

(b) **(i)** catalyst **and** from living organism [1]
accept: biological catalyst / protein catalyst

(ii) enzyme denatured / destroyed [1]

(iii) chromatography [1]
locating agent / description of locating agent [1]
measure R_f / compare with standards [1]

Question 63

7 **(a)** fraction is the distillate collected [1]
between 40–100 °C / in the stated range [1]

(b) **(i)** $C_8H_{18} + 25/2O_2 \rightarrow 8CO_2 + 9H_2O$ [2]
accept: double the above / 12.5 in front of oxygen

(ii) poisonous / toxic / damages health / brain / kidneys [1]
note: must relate to people
not: just harmful

(iii) dibromo 2 bromine atoms (per molecule)
not: Br_2
accept: 2 bromide groups
eth 2 carbon atoms (per molecule)
ane a C-C single bond / no C=C / group C_nH_{2n+1} / saturated
ignore: any reference to alkanes
all three correct [2] two correct only [1] [2]

(iv) position of bromine atom(s) [1]

(c) 0.104/0.026 [1]
n = 4 [1]

(d) (oxides of nitrogen) change carbon monoxide into carbon dioxide [1]
oxides of nitrogen then become nitrogen [1]
(oxides of nitrogen) change hydrocarbons into carbon dioxide and water [1]
accept: balanced equations for first two marks
$2NO + 2CO \rightarrow N_2 + 2CO_2$ **and** $2NO \rightarrow N_2 + O_2$ [2]
oxygen changes hydrocarbons into carbon dioxide and water [1]

Question 64

5 **(a)** CH_3-CH_2-CH_2-CH_2-OH [1]
88 [1]
156 to159 °C [1]

(b) any two from:
(same) general (molecular) formula
same functional group
consecutive members differ by $-CH_2$
common methods of preparation

(c) correct structure **and** 4bp around carbon [1]
2bp and 2nbp around oxygen [1]
1bp on hydrogens [1]

(d) **(i)** correct structural formula for propanoic acid [1]
allow: OH but all other bonds to be shown

(ii) air / oxygen [1]
bacteria / microbes / micro-organisms [1]
accept: mother of vinegar
not: yeast

(e) propyl ethanoate [1]
allow: $CH_3COOC_3H_7$ **not:** $C_5H_{10}O_2$ [1]

Question 65

6 (a) (i) correct structural formula of ethanoic acid [1]
allow: –OH **not:** –COOH

(ii) correct structural formula of ethanol [1]
allow: –OH

(b) (i) ethyl ethanoate [1]

(ii) $-OC_6H_4COOCH_2CH_2O-$
correct ester linkage [1]
correct repeat units [1]
continuation [1]
accept: boxes if it is clear what the box represents

(iii) any **two** from:
long time to decay
landfill sites
visual pollution / litter
danger to animals
poisonous gases when burnt [2]
accept: any correct suggestion

(c) synthetic – only two monomers [1]
protein – many different monomers [1]
or:
protein has 1 C=O and 1N–H [1]
nylon has 2 C=O / 2N–H [1]
or:
synthetic – one monomer is a dicarboxylic acid and the other is a diamine [1]
protein all monomers are amino acids [1]

Question 66

5 (a) (i) many (simple) molecules form one (large) molecule / monomer molecules form one polymer molecule [1]

(ii) addition - polymer is the only product [1]
accept - nX → Xn
condensation polymer and simpler molecules formed [1]
accept nX → Xn + nHC*l* / H_2O

(b) (i) $C_{12}H_{26} \rightarrow C_8H_{18} + 2C_2H_4$ [1]
/ any other correct version

(ii) ethane and chlorine give range of products [1]
/ ethene more readily available than ethane
/ waste half chlorine as hydrogen chloride
/ ethene more reactive than ethane

(iii) electrolysis [1]
aqueous sodium chloride [1]

(iv) must have **three** correct units [1]
cond continuation [1]
accept –(CH2–CH(C*l*))n–

[Total: 9]

Question 67

6 (a) same general formula
consecutive members differ by CH_2
same chemical properties
same functional group
physical properties vary in predictable way / give trend – mp increases with n etc.
common methods of preparation
any **THREE** [3]

(b) (i) they have the same molecular formula [1]
not general formula
different structures / structural formulae [1]

(ii) CH_3-CH_2-CH(OH)-CH_3 / $(CH_3)_3C$-OH [1]
not ether-type structures
NOTE butan-2-ol and 2-methylpropan-2-ol acceptable

(c) (i) air/oxygen / (acidified) potassium chromate(VI) /
(acidified) potassium manganate(VII) [1]
must have oxidation states

(ii) carboxylic acid / alkanoic acid [1]
CH_3-CH_2-CH_2-COOH / C_3H_7COOH / $C_4H_8O_2$ [1]
accept C_4H_7OOH

(d) (i) measure volume of carbon dioxide [1]
time [1]
accept day / hour for time mark

(ii) increase in temperature / more yeast present / yeast multiplies [1]

(iii) glucose used up [1]
accept sugar **not** reagent / reactant

concentration of ethanol high enough to kill/poison yeast / denature enzymes [1]
not kill enzymes

(iv) to prevent aerobic respiration [1]
/ ethanol would be oxidised / ethanoic acid/ acid formed / lactic acid formed / carbon dioxide and water formed

[Total: 15]

Question 68

5 (a) (i) contains carbon, hydrogen and oxygen [1]
accept example
ratio 2H : 1O [1]
not contains water
ignore comments about carbon

(ii) living organism / plants and animals / cells [1]
obtain energy from food [1]
not burn negates energy mark

(iii) carbohydrates contain oxygen [1]

(iv) as a fertiliser / manure [1]

(b) (i) 80 cm^3 of oxygen therefore 40 cm^3 of methane [1]
40/60 × 100 = 66.7 % [1]
accept 66 % and 67 %
no ecf

(ii) add sodium hydroxide(aq) / alkali [1]
carbon dioxide dissolves, leaving methane [1]

[Total: 10]

Question 69

7 (a) (i) lighter / light / lightweight / lower density [1]
does not corrode / rust / oxidised [1]
ignore cheaper / easier to mould

(ii) credit any two sensible suggestions e.g. rope / clothing / netting / string / carpets / fishing line / fishing nets / parachutes / tyres / tents / bottles / thread / umbrellas / curtains / toothbrushes / cassettes / video tapes [2]

(iii) non-biodegradeable / do not rot / do not decompose / persist for years / accumulate
landfill sites limited / getting filled up
visual pollution
danger to fish / animals
(burn to form) toxic gases / harmful gases / pollutant gases / acidic gases / CO / HC*l* / HF / HCN
not oxides of nitrogen / sulfur
any three [3]

(b) (i) propene / propylene [1]
accept prop-1-ene
not prop-2-ene
CH_3-CH=CH_2 [1]
double bond must be shown

(ii) correct repeat unit (one or more **whole** repeat units must be given) [1]
cond continuation [1]

(c) (i) amide / peptide / polypeptide [1]

(ii) protein / polypeptide [1]

(iii) $H_2N(CH_2)_6NH_2$ [1]
$HOOC(CH_2)_8COOH$

[Total: 15]

Question 70

5 (a) (i) $Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$ [1]
correct formula of magnesium ethanoate [1]
ignore charges

sodium ethanoate + water [1]

(ii) ethyl ethanoate [1]
displayed formula [1]

(b) (i) add up to 5.8 g [1]

(ii) moles of C atoms = 2.4/12 = 0.2
moles of H atoms = 0.2/1 = 0.2
moles of O atoms = 3.2/16 = 0.2
all three correct = 2 [2]
two correct = 1
empirical formula CHO [1]

(iii) 116/29 = 4 [1]
$C_4H_4O_4$ [1]
correct formula with no working scores both marks.

(iv) HOOCCH=CHCOOH / CH_2=C(COOH)$_2$ [2]

[Total: 13]

Question 71

7	(a)	(i)	heat catalyst	[1] [1]
		(ii)	an equation that gives: alkene + alkane **or** alkene + alkene + hydrogen	[1]
			a correct and balanced equation for the cracking of decane, $C_{10}H_{22}$ but not but-1-ene	[1]
		(iii)	water **or** steam	[1]
	(b)	(i)	$C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$ If only error is balancing the oxygen atoms	[2] [1]
		(ii)	butanol + methanoic acid → butyl methanoate + water correct products **or** reactants ONLY	[2] [1]
	(c)	(i)	correct structural formulae [1] each accept either propanol and –OH in alcohol and acid penalise once for CH_3 type diagrams For either C_3H_8O **or** $C_3H_6O_2$ [0]	[2]
		(ii)	to conserve petroleum **or** reduce greenhouse effect	[1]
	(d)		have same boiling point	[1]
				[Total: 13]

Question 72

	(c)	(i)	structural formula of Ge_4H_{10} all bonds shown	[1]
		(ii)	germanium(IV) oxide water	[1] [1]

Question 73

7	(a)	(i)	$35\,cm^3$ $40\,cm^3$	[1] [1]
		(ii)	forms carbon monoxide	[1]
			poisonous **or** toxic **or** lethal **or** prevents blood carrying oxygen **or** effect on haemoglobin **NOT** just harmful	[1]
	(b)	(i)	chlorobutane **or** butyl chloride number not required but if given must be 1, it must be in correct position	[1]
		(ii)	light **or** UV**or** 200°C **or** lead tetraethyl	[1]
		(iii)	any correct equation for example 2-chlorobutane **or** dichlorobutane	[1]
	(c)	(i)	correct repeat unit **COND** continuation $-(CH(CH_3)-CH_2)-$	[1] [1]
		(ii)	butan-1-ol **or** butan-2-ol **or** butanol if number given then formula must correspond for second mark and number must be in correct position	[1]
			structural formula of above $CH_3-CH_2-CH_2-CH_2OH$ **or** $CH_3-CH(OH)-CH_2-CH_3$ **NOT** C_4H_9OH if first mark not awarded then either formula will gain mark [1] **ACCEPT** either formula for "butanol"	[1]
		(iii)	$CH_3-CH(Cl)-CH_3$ **or** $CH_3-CH_2-CH_2-Cl$ **NOT** C_3H_7Cl response must not include HCl if equation given look at RHS only	[1]
				[Total: 12]

Question 74

(b)	(i)	sterilise/disinfect water **or** kill microbes/germs bacteria, etc. **NOT just** to make it safe to drink **or** purify it **or** clean it treat above as neutral they do not negate a correct response	[1]
	(ii)	ammonia **or** methanol **or** hydrogen chloride **or** margarine **NOT** nylon	[1]
	(iii)	fat **or** lipid **or** triester **or** named fat **or** glyceryl stearate **or** vegetable oil	[1]
		heat	[1]

Question 75

4 (a)	(i)	C_6H_5COOH **or** $C_6H_5CO_2H$ **NOT** $C_7H_6O_2$ /C_6H_6COO	[1]
	(ii)	sodium hydroxide + benzoic acid = sodium benzoate + water correct spelling needed **NOT** benzenoate **ACCEPT** correct symbol equation	[1]
	(iii)	sodium carbonate **or** oxide **or** hydrogencarbonate any **TWO** **NOT** Na	[2]
(b)	(i)	7.7%	[1]
	(ii)	for any number: equal number ratio for example 1:1 **or** 6:6	[2]
	(iii)	empirical formula is CH molecular formula is C_6H_6 no e.c.f., award of marks not dependent on **(ii)**	[1] [1]
(c)	(i)	$C_6H_8O_6$	[1]
	(ii)	carbon – carbon double bond **or** alkene alcohol **or** hydroxyl **or** hydroxy **NOT** hydroxide hydroxide and alcohol = 0	[1] [1]
			[Total: 12]