

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, $\text{CH}_3\text{COOCH}_2\text{CH}_3$.

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

name

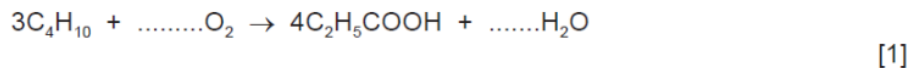
formula

[2]

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

..... [1]

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



(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, $\text{C}_6\text{H}_{12}\text{O}_6$,
sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$,
starch, $(\text{C}_6\text{H}_{10}\text{O}_5)_n$.

(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]

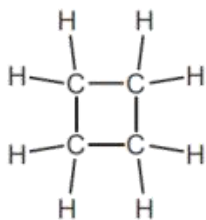
(b) Starch hydrolyses to glucose in the presence of the enzyme, amylase. What is meant by the term *enzyme*?

..... [2]

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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]

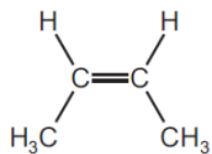
(ii) One mole of an alkane, when cracked, produced one mole of hexane, C_6H_{14} , and two moles of ethene.

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

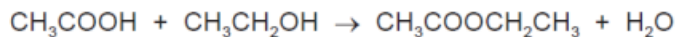
[2]

[Total: 14]

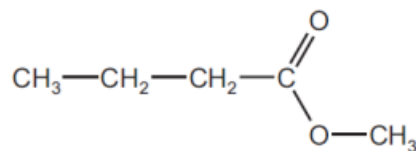
Question 4

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.



- (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]

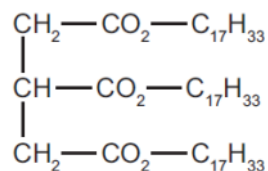
- (b) The following two monomers can form a polyester.



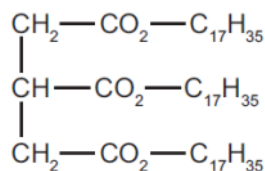
Draw the structural formula of this polyester. Include two ester linkages.

[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 ₃ OH	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.

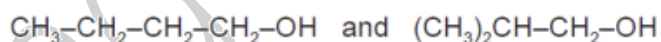


(b) State **three** characteristics of a homologous series other than the variation of physical properties down the series.

.....

 [3]

(c) The following alcohols are isomers.



(i) Explain why they are isomers.

.....

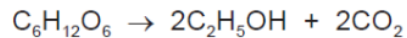
 [2]

(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.

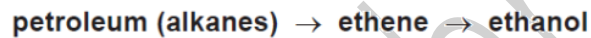


The mass of one mole of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, is 180 g.

Calculate the maximum mass of ethanol which could be obtained from 72 g of glucose.

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

(ii) Describe how ethanol is made from petroleum.



.....
.....
.....
..... [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]

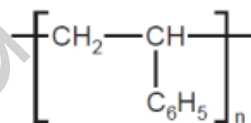
(v) Proteins contain the amide linkage. Name a synthetic macromolecule which contains the same linkage.

..... [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.

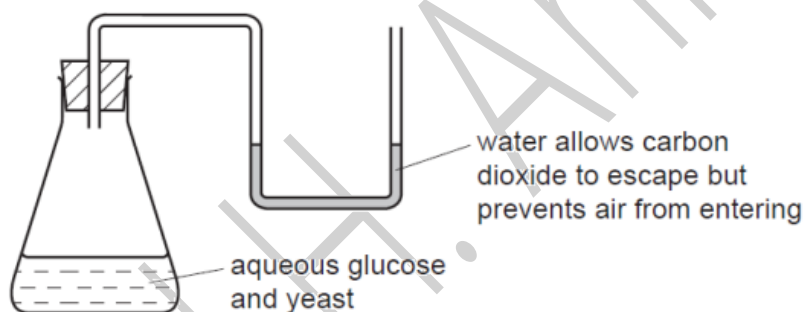
(a) (i) Describe how you could decide from its molecular formula whether a compound is a carbohydrate.

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

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

..... [2]

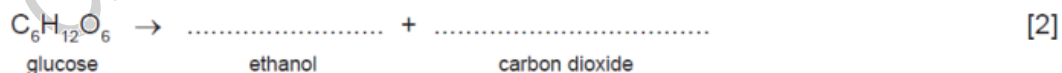
(b) The fermentation of glucose can be carried out in the apparatus shown below. After a few days the reaction stops. A 12% aqueous solution of ethanol has been produced.



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

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

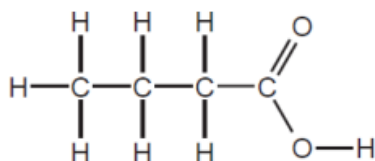
(ii) Complete the equation.



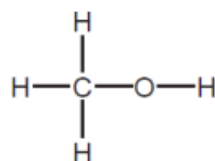
(iii) Why must air be kept out of the flask?

..... [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

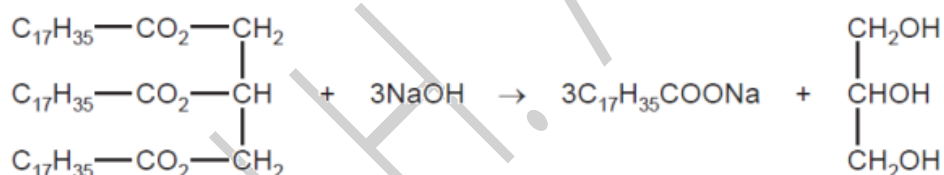


methanol

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, $\text{C}_{17}\text{H}_{35}$, in this ester saturated or unsaturated? Give a reason for your choice. [1]

..... [1]

- (iii) What type of compound is represented by the formula $\text{C}_{17}\text{H}_{35}\text{COONa}$?
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]

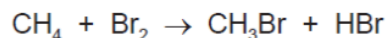
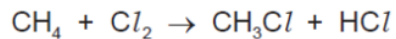
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Question 8

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



- (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]

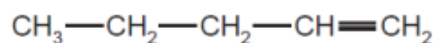
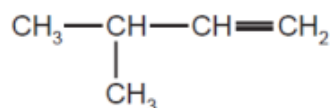
0620/w13/qp31

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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, $\text{CH}_3-\text{CH}=\text{CH}_2$, would produce ethanoic acid, CH_3-COOH , and methanoic acid, $\text{H}-\text{COOH}$. Deduce the formulae of the alkenes which would form the following carboxylic acids when oxidised.

ethanoic acid and propanoic acid

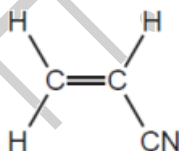
only ethanoic acid

[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?

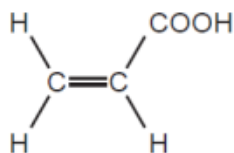
..... [1]

0620/w12/qp33

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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]

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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]

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(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]

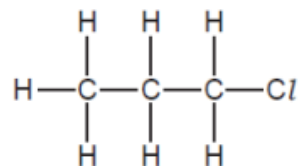
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Question 13

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]

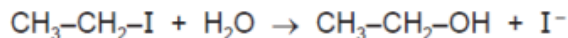
(ii) Describe how 1-chloropropane could be made from propane.

.....
..... [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.



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

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

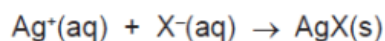
(ii) Name the alcohol formed when 1-chloropropane reacts with water.

..... [1]

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

A mixture of 10 cm³ of aqueous silver nitrate and 10 cm³ 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.



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?

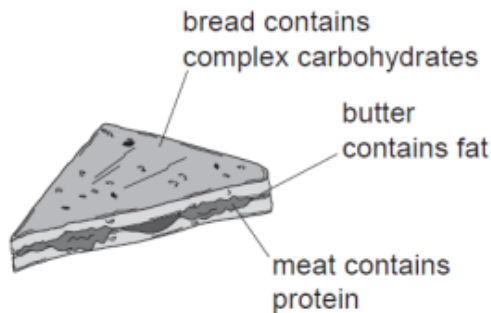
.....
..... [2]

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

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

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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.

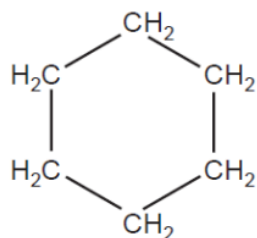
.....

[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]

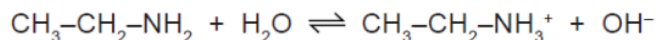
[Total: 8]

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Question 17

8 Ethylamine, $\text{CH}_3\text{-CH}_2\text{-NH}_2$, is a base which has similar properties to ammonia.

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



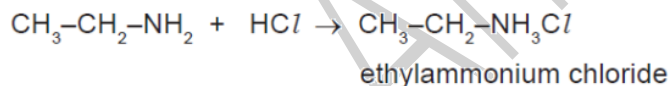
Explain why water is behaving as an acid in this reaction.

..... [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.



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]

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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, $\text{CH}_3\text{-CH}_2\text{-CH=CH-CH}_3$, oxidises to $\text{CH}_3\text{-CH}_2\text{-COOH}$ and CH_3COOH . Name these two acids.

$\text{CH}_3\text{-CH}_2\text{-COOH}$

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) $\text{CH}_3\text{-CH=CH}_2 + \text{Br}_2 \rightarrow$ [1]

(ii) $\text{CH}_3\text{-CH=CH}_2 + \text{H}_2\text{O} \rightarrow$ [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 O₂ : moles of CO₂

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 HO——OH

[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 it is 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]

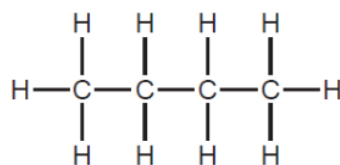
(ii) Give the structural formula of a polymer which is formed from two different monomers.

[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.



..... 40 volume of gas / cm³ [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

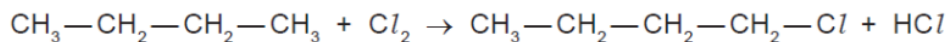
[2]

[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.



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

[1]

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

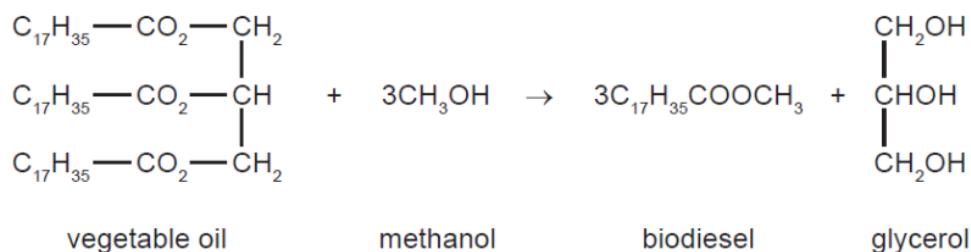
[1]

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

[4]

Question 23

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



(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]

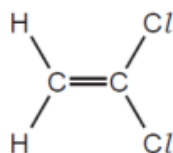
Question 24

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

(a) Explain the difference between them.

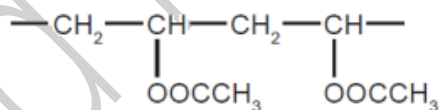
.....
.....
..... [2]

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



[2]

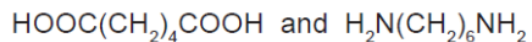
(c) The polymer known as PVA is used in paints and adhesives. Its structural formula is shown below.



Deduce the structural formula of its monomer.

[1]

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



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.



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

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



.....
.....
..... [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]

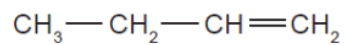
(iii) Draw the structural formula of **X**. Show all the individual bonds.

[2]

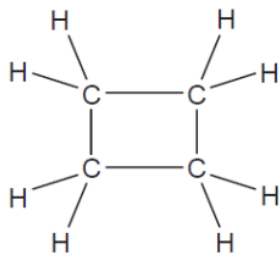
[Total: 12]

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]

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(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.

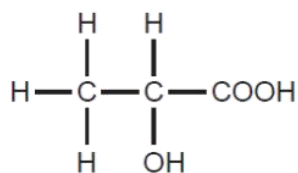
.....
..... [2]

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

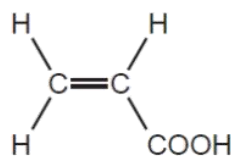
[3]

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(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.

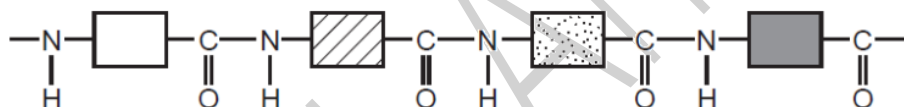
(i) What is the third group?

..... [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?

.....

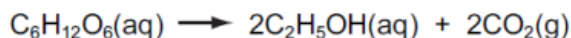
How are they different?

.....

..... [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.



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.

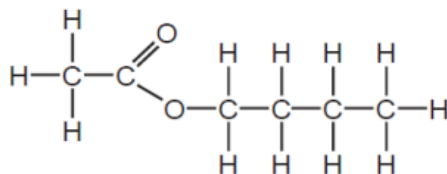
..... [1]

[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]

.....

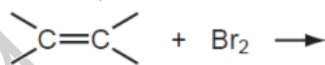
- (c) Cooking products, fats and vegetable oils, are mixtures of saturated and unsaturated esters.

The degree of unsaturation can be estimated by the following experiment. 4 drops of the oil are dissolved in 5 cm³ 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]

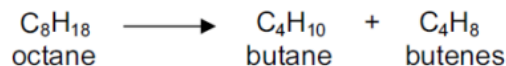
(iii) Give another mixture of liquids that is separated on an industrial scale by fractional distillation.

..... [1]

[Total: 7]

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.



- (a) (i) Write a different equation for the cracking of octane.



- (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, $\text{CH}_3\text{-CH=CH}_2$, is made by cracking. Give the structural formula of the addition product when propene reacts with the following.

(i) water

(ii) bromine

[1]

[1]

0620/s06/qp3

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Question 34

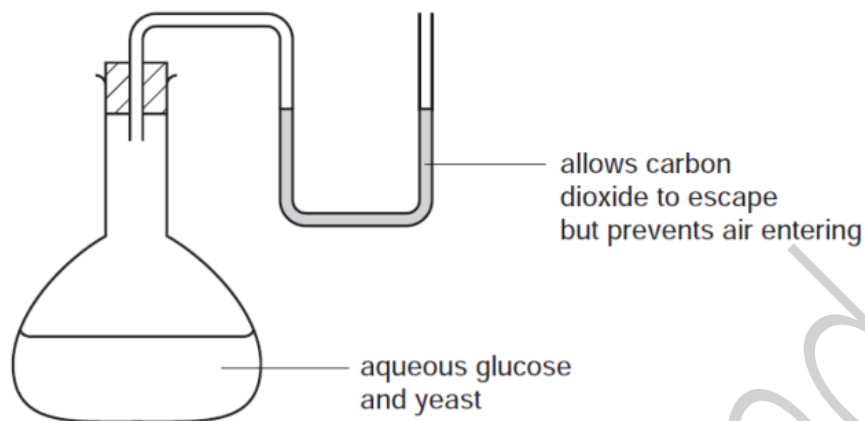
(iv) The synthetic polymer, nylon, has the same linkage as proteins. Draw the structural formula of nylon.

[3]

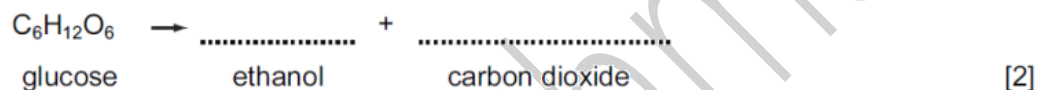
(b) Enzymes called carbohydrases can hydrolyse complex carbohydrates to simple sugars which can be represented as $\text{HO} - \square - \text{OH}$. Draw the structure of a complex carbohydrate.

[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.



- (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 \rightarrow carboxylic acid + [1]

(d) Propanoic acid is a weak acid.

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



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

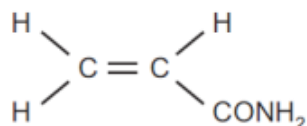
.....
..... [3]

(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

.....

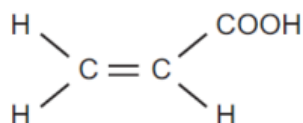
result

..... [2]

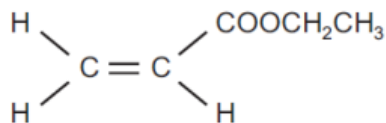
- (ii) Given an aqueous solution, concentration 0.1 mol / dm³, how could you show that acrylic acid is a weak acid.

.....
 [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.



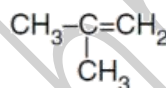
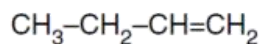
(ii) Propene can be made by the thermal decomposition of chloropropane. Describe how chloropropane can be made from propane.

reagents propane and

conditions

[4]

(b) The following alkenes are isomers.



(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

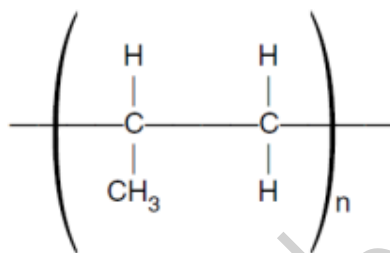
hydrogen

bromine

[3]

(d) Alkenes can polymerise.

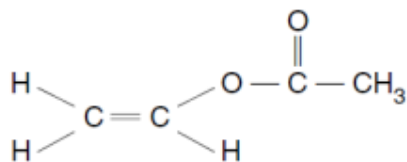
(i) Deduce the name and structural formula of the monomer from the structure of the polymer.



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]

0620/s03/qp3

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 ₃ OH	-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]

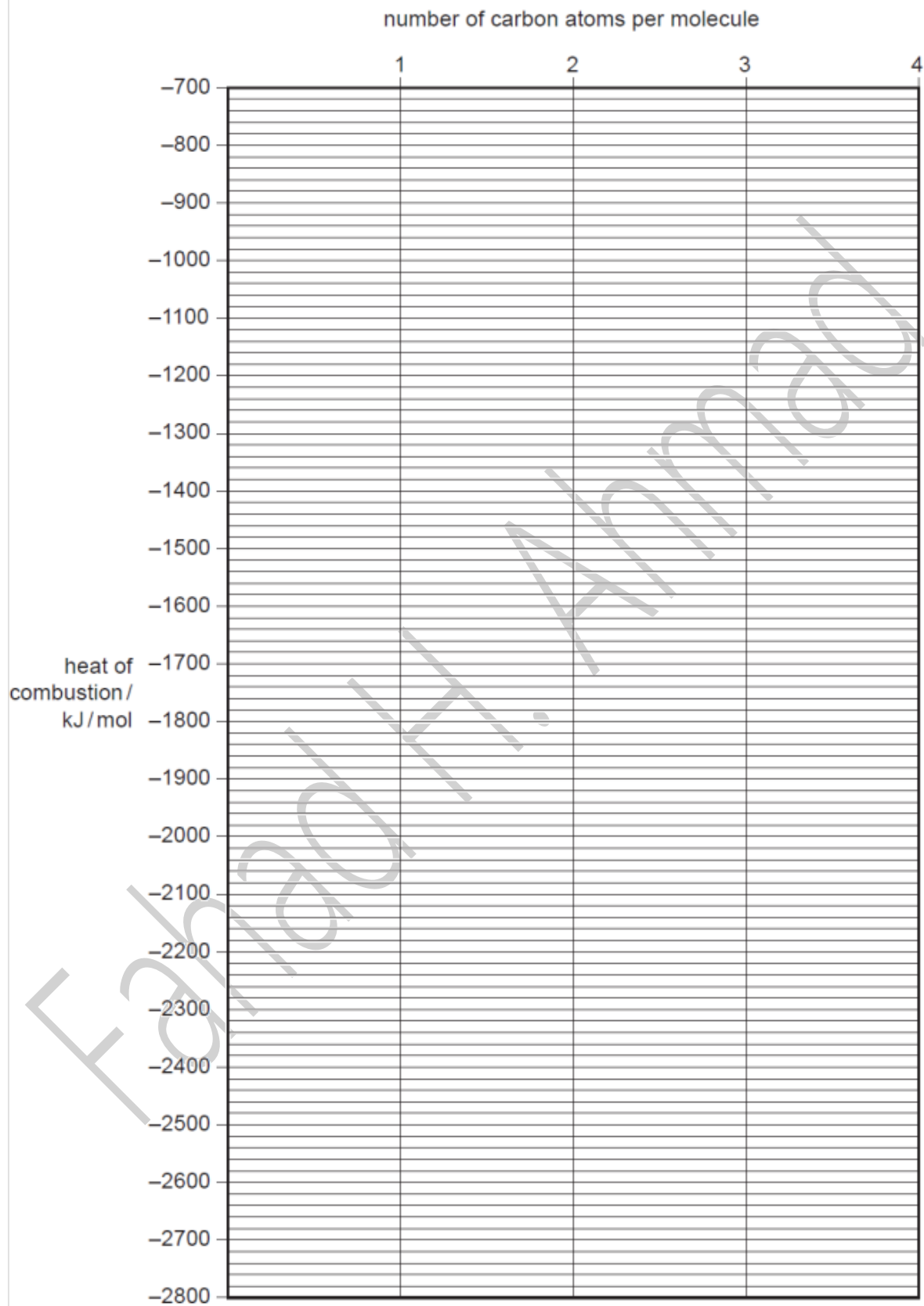
- (ii) Is the reaction exothermic or endothermic?

..... [1]

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



- (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.



(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 H₂O from ethanol (dehydration)

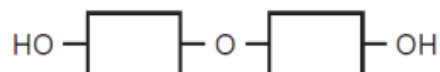
..... [1]

[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.

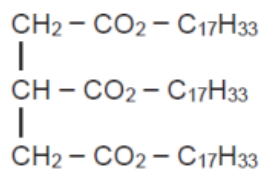
(i) Write the word equation for the preparation of the ester, propyl ethanoate.

..... [2]

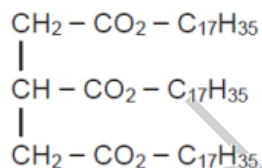
(ii) Deduce the structural formula of this ester showing each individual bond.

(iii) How could you distinguish between these two fats? [2]

Fat 1 has the formula



Fat 2 has the formula



test

result with fat 1

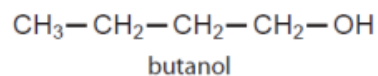
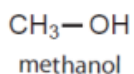
result with fat 2 [3]

(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 C₈ alcohol.

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

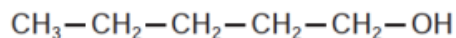
- (b) Give the name and structural formula of the third member of this series.

name

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]

0620/w05/qp3

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]

0620/w05/qp3

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 ₂ H ₄	-102
propene	C ₃ H ₆	-48
butene	C ₄ H ₈	-7
pentene	C ₅ H 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]
--	-----

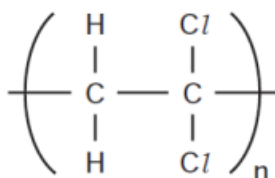
(iii) Draw the structure of the polymer formed from but-2-ene.

	[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-CH₂CH₂-OH and HOOC-C₆H₄-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]

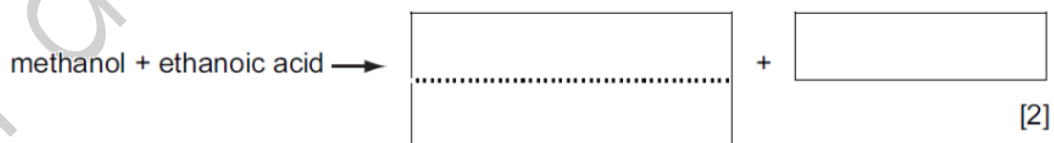
0620/w04/qp3

Question 44

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



(ii) Complete the word equation.



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

[1]

0620/w04/qp3

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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]

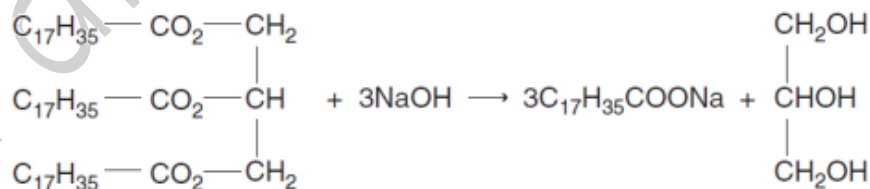
ethanoic acid from ethanol

.....
.....[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.



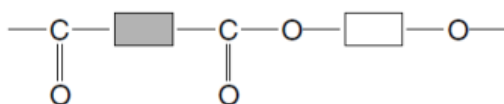
(i) Which substance in the equation is an alcohol? Underline the substance in the equation above.

[1]

(ii) What is the major use for compounds of the type $\text{C}_{17}\text{H}_{35}\text{COONa}$?

.....[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]

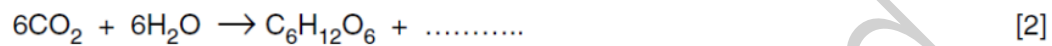
Question 46

(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.



(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.

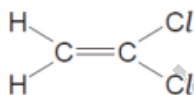
(i) Explain the term *polymerise*.

.....
.....[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

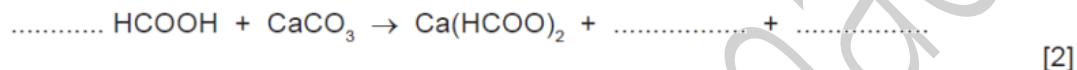
8 Methanoic acid is the first member of the homologous series of carboxylic acids.

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

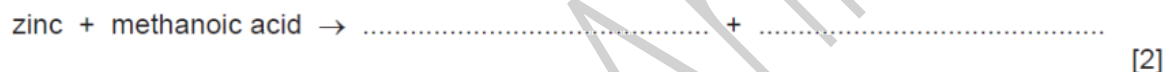
.....
.....
..... [2]

(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.



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



(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]

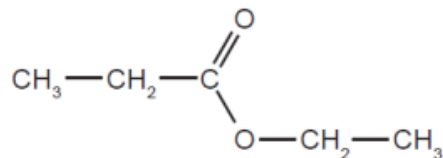
[Total: 10]

Question 49

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

(a) Compounds containing the group $\begin{array}{c} \text{O} \\ \parallel \\ \text{—C—} \\ | \\ \text{O—} \end{array}$ or —COO— are esters.

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

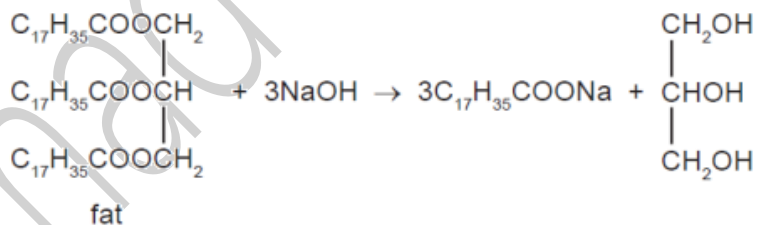


name name

formula formula

[4]

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



What type of compound has the formula $\text{C}_{17}\text{H}_{35}\text{COONa}$ and what is its main use?

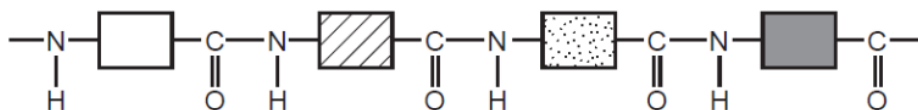
type of compound [1]

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]

0620/s10/qp31

Question 50

(iii) How can chloromethane be made from methane?

reagent

condition [2]

0620/s10/qp31

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]

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(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

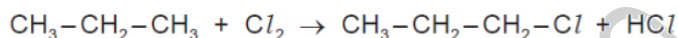
alkenes

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.



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

..... [1]

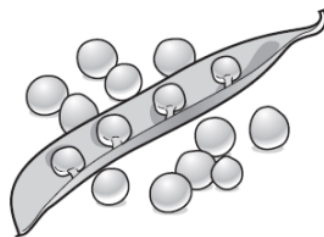
(ii) There is more than one possible substitution reaction between chlorine and propane. Suggest the structural formula of a different product.

..... [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

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Question 53

4 Propanoic acid is a carboxylic acid. Its formula is $\text{CH}_3\text{-CH}_2\text{-COOH}$.

(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 \rightarrow + hydrogen [1]

(ii) calcium + propanoic \rightarrow +
oxide acid [1]

(iii) $\text{LiOH} + \text{CH}_3\text{CH}_2\text{COOH} \rightarrow$ + [1]

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]

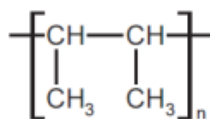
[Total: 8]

Fahad

Question 55

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

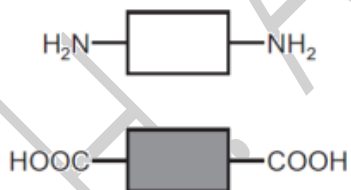
(a) (i) The structural formula of a polymer is given below.



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.

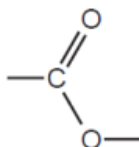
.....
..... [2]

[Total: 14]

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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]

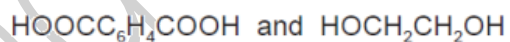
(ii) Deduce the name of the ester formed from methanoic acid and butanol.

[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.



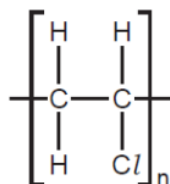
You are advised to use the simpler form of the ester linkage.

[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.

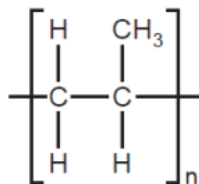
..... [1]

(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]

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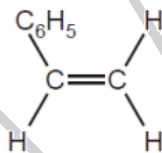
(b) (i) Deduce the structural formula of the monomer from that of the polymer.



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} .



(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.

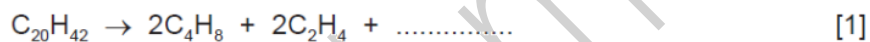
(a) (i) Explain the term *hydrocarbon*.

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

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

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

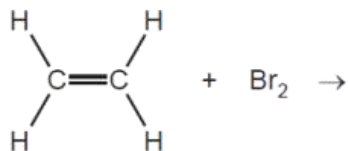
(b) Alkenes and simpler alkanes are made from long-chain alkanes by cracking.
Complete the following equation for the cracking of the alkane $C_{20}H_{42}$.



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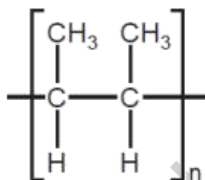
(c) Alkenes such as butene and ethene are more reactive than alkanes. Alkenes are used in the petrochemical industry to make a range of products, which includes polymers and alcohols.

(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, $\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}_2$? 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 cm³ of a hydrocarbon was burnt in 175 cm³ of oxygen. After cooling, the volume of the remaining gases was 125 cm³. The addition of aqueous sodium hydroxide removed carbon dioxide leaving 25 cm³ of unreacted oxygen.

(i) volume of oxygen used = cm³ [1]

(ii) volume of carbon dioxide formed = cm³ [1]

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

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

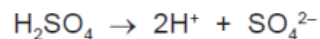
[Total: 15]

0620/s13/qp33

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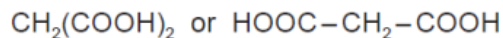
Question 60

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



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.



- (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?

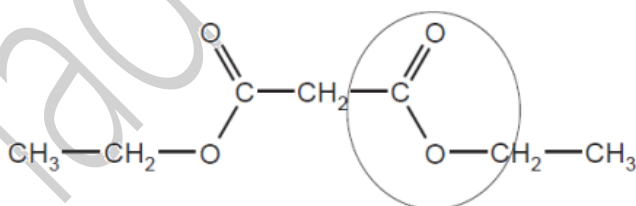
..... [1]

- (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 \rightarrow + [1]
.....

(ii) $\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow$ + [2]

(iii) $\text{Mg} + \text{CH}_2(\text{COOH})_2 \rightarrow$ + [2]

(iv) $\text{K}_2\text{CO}_3 + \text{H}_2\text{SO}_4 \rightarrow$ + + [2]

[Total: 16]

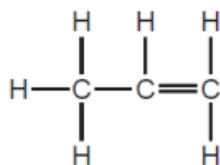
Question 61

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]

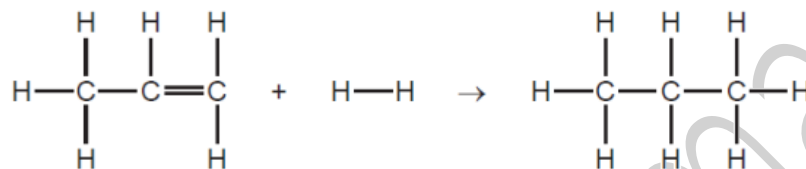
(ii) Draw the structure of the polymer formed from propene

[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.



.....

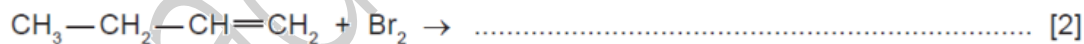
 [3]

(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.



- (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]

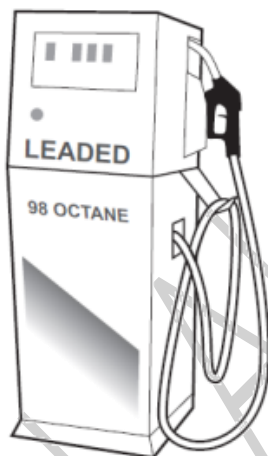
Question 63

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.

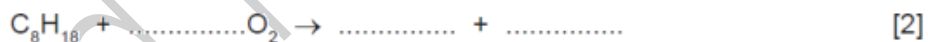
(a) Petrol is obtained from the gasoline fraction, boiling point range 40 °C to 100 °C, from the distillation of petroleum. Explain the term *fraction*.

.....
 [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.



(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	$\text{CH}_3-\text{CH}_2-\text{OH}$	46	78
propan-1-ol	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{OH}$	60	98
butan-1-ol	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH}$	74	118
pentan-1-ol			138
hexan-1-ol	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH}$	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]

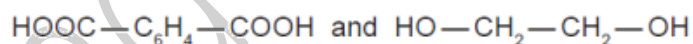
(ii) ethanol

[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.

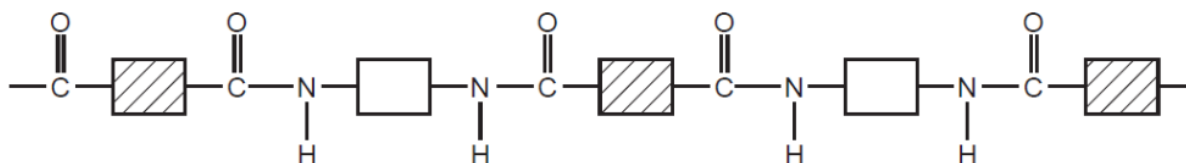


[3]

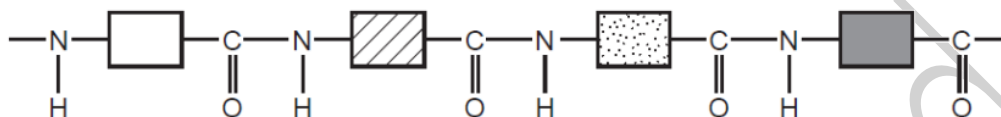
(iii) Describe the pollution problems caused by non-biodegradable polymers.

.....
.....
..... [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]

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5 Monomers polymerise to form polymers or macromolecules.

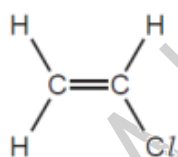
(a) (i) Explain the term *polymerise*.

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

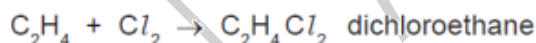
(ii) There are two types of polymerisation - addition and condensation. What is the difference between them?

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

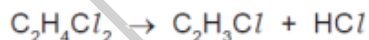
(b) An important monomer is chloroethene which has the structural formula shown below.



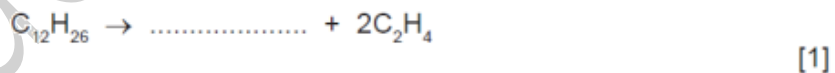
It is made by the following method.



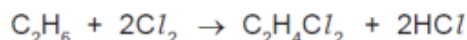
This is heated to make chloroethene.



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



Another method of making dichloroethane is from ethane.



(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]

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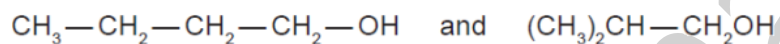
Question 67

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.



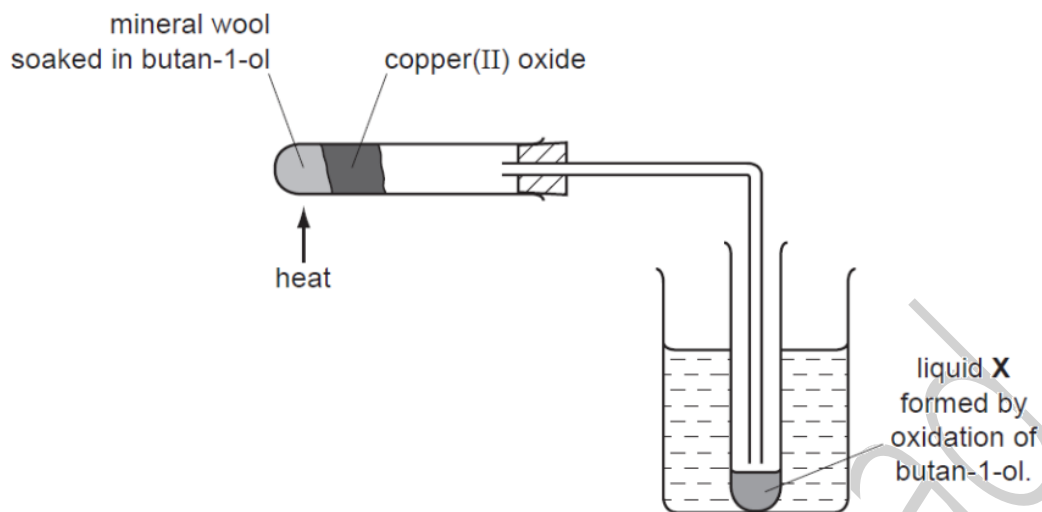
(i) Explain why they are isomers.

.....
.....
..... [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]

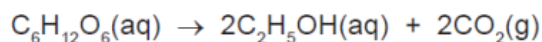
(ii) What type of compound is liquid X and what is its formula?

type of compound

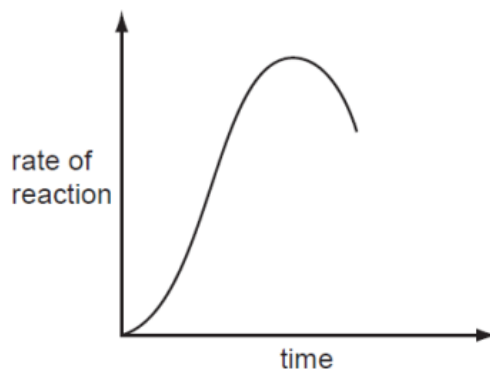
formula of liquid X

[1]

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



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]

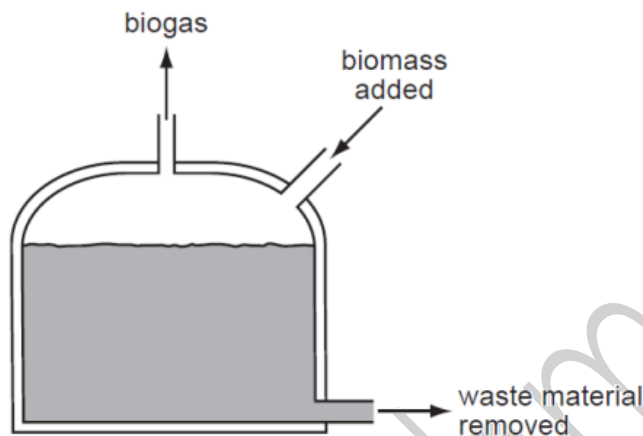
(iv) Why is fermentation carried out in the absence of air?

.....
..... [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.

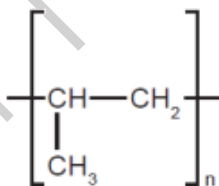
.....
..... [2]

(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.

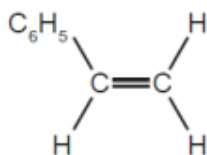


Give the name and structural formula of the monomer.

name of monomer [1]

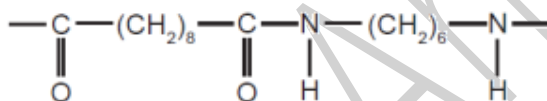
structural formula of monomer

- (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.

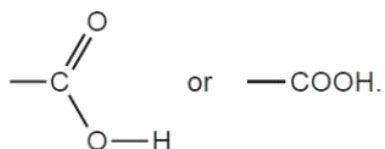
monomer

monomer

[2]

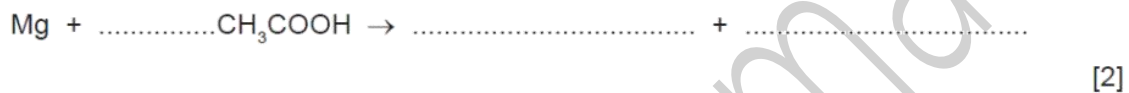
Question 70

5 Carboxylic acids contain the group



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

(i) Complete the following equations.



(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.

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

[1]

.....

[2]

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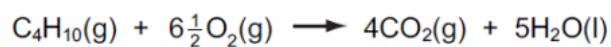
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Question 73

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 cm³ of butane is mixed with 100 cm³ 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?



Volume of oxygen left = cm³
Volume of carbon dioxide formed = cm³ [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.

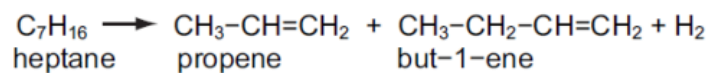


(i) Name the organic product.
..... [1]

(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.



- (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?

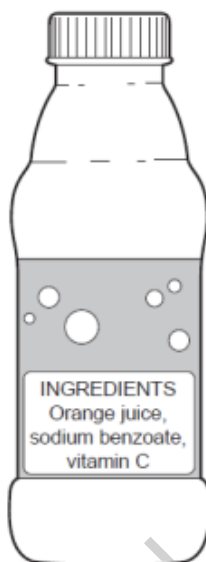
..... [2]

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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.

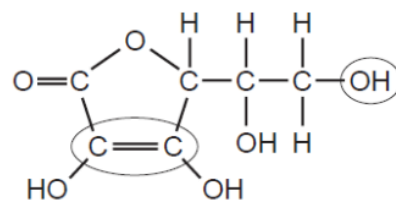
.....
..... [2]

(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]

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