ORGANIC CHEMISTRY P2 QUESTIONS

0/N18/21/Q4

The alkanes are a homologous series of saturated hydrocarbons.

(a) (i) Write the general formula for the alkane homologous series.

....[1]

(ii) Each member of a particular homologous series has the same general formula.

Give one other characteristic of a homologous series.

....[1]

(b) What is the meaning of the term *saturated*?

....[1]

(c) Construct the equation for the complete combustion of pentane, C_5H_{12}.

....[2]

(d) Draw the structure of a branched alkane with the formula C_5H_{12}. Show all of the atoms and all of the bonds.

[1]

(e) Chlorine reacts with pentane.

$$C_5H_{12} + Cl_2 \rightarrow C_5H_{11}Cl + HCl$$

(i) What name is given to this type of chemical reaction?

....[1]

(ii) What essential condition is needed for chlorine to react with pentane?

....[1]
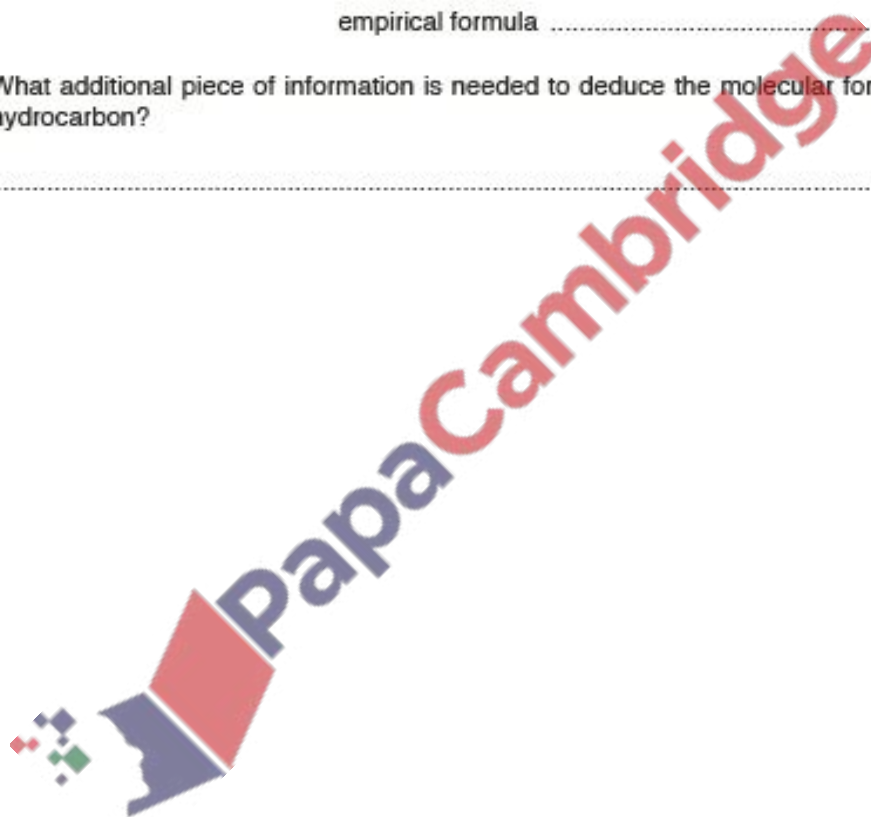
(f) A hydrocarbon contains 90% carbon by mass.

    (i) Deduce the empirical formula of this hydrocarbon.

empirical formula ....[2]

    (ii) What additional piece of information is needed to deduce the molecular formula of this hydrocarbon?

....[1]

[Total: 11]

ORGANIC CHEMISTRY P2 QUESTIONS

O/N18/21/Q7

The products of respiration are carbon dioxide and water.

(a) Complete the equation for respiration.

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

(b) Carbon dioxide and methane are greenhouse gases which contribute to global warming.

   (i) State one effect on the environment of an increase in global warming.

   ....[1]

   (ii) Describe how the carbon cycle regulates the amount of carbon dioxide in the atmosphere.

   ....

   ....

   ....

   ....[2]

(c) Simple sugars can be polymerised to form starch.

HO—☐—OH   —☐—O—☐—O—☐—O—☐—O—

a simple sugar   starch

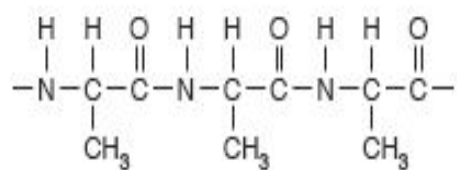   (i) Deduce the formula of the molecule eliminated when simple sugars polymerise to form starch.

   ....[1]

   (ii) State the reagent and conditions needed to hydrolyse starch into simple sugars.

   ....

   ....[2]

(d) The amino acid alanine can form polymers.

Part of the structure of poly(alanine) is shown.

$$-N-C-C-N-C-C-N-C-C-$$

(with H on each N, H and CH_3 on each middle C, and O double-bonded to each carbonyl C)

(i) On the diagram, draw a circle around all of the atoms in one amide linkage. [1]

(ii) Draw the structure of the monomer used to make poly(alanine).

[1]

[Total: 10]
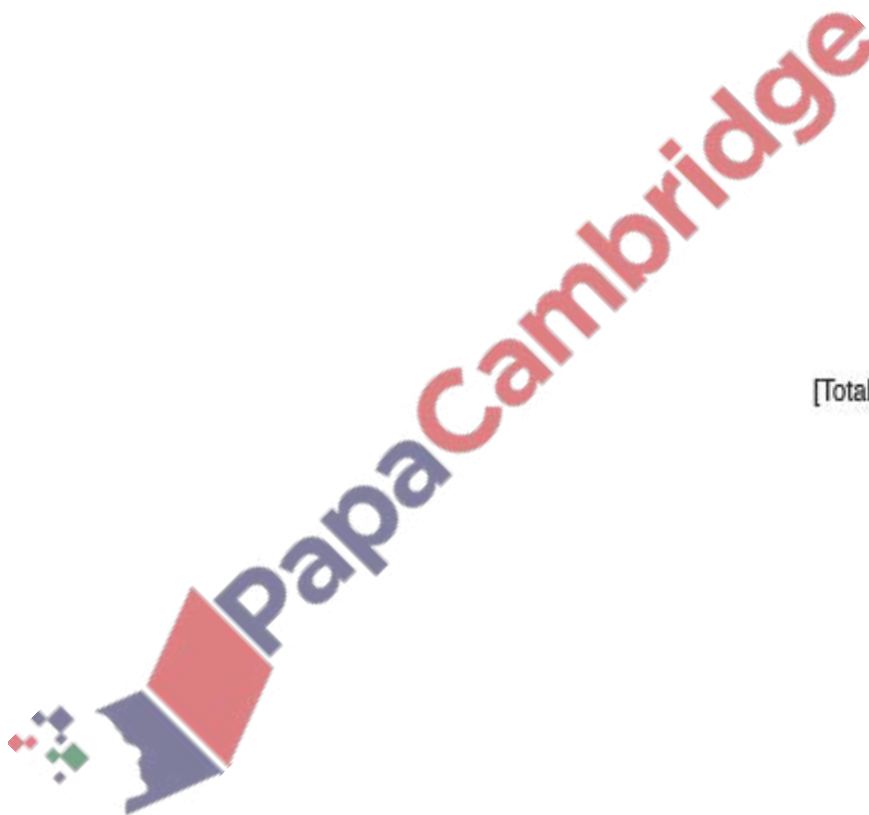
ORGANIC CHEMISTRY P2 QUESTIONS

O/N18/22/Q4

The alkenes are a homologous series of unsaturated hydrocarbons.

(a) Describe two characteristics of a homologous series.

1. ....

2. ....

[2]

(b) Construct the equation for the complete combustion of butene, C_4H_8.

....[2]

(c) Draw the structure of a branched alkene with the formula C_4H_8. Show all of the atoms and all of the bonds.

[1]

(d) Butene reacts with hydrogen in the presence of nickel.

(i) Name the product formed.

....[1]

(ii) What is the purpose of the nickel?

....[1]

(iii) State one other condition needed for this reaction.

....[1]
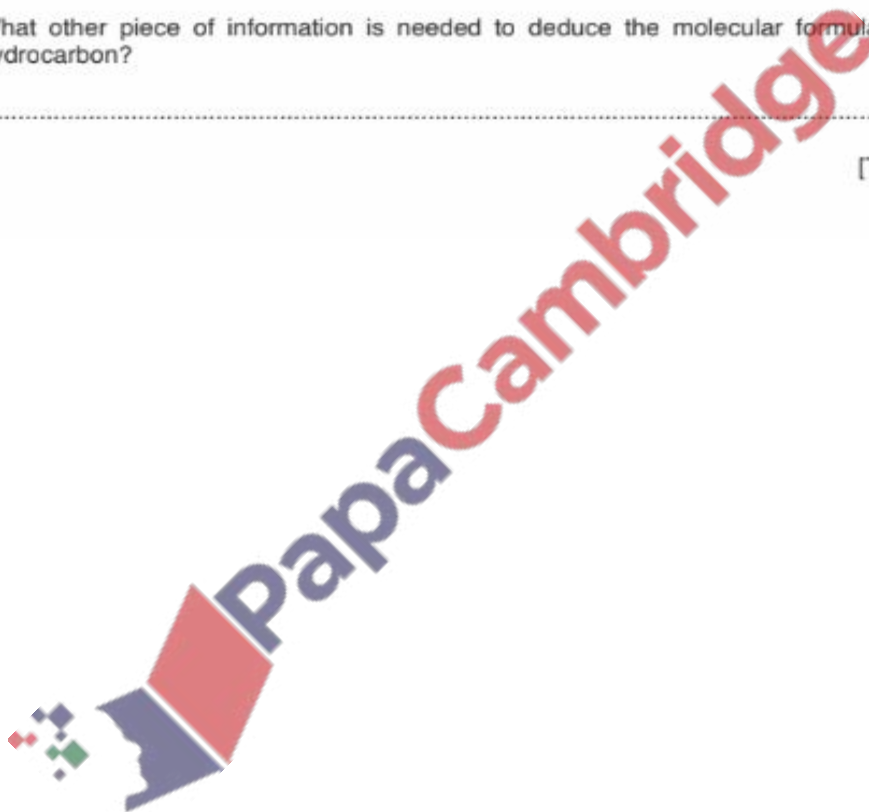
(e) A hydrocarbon contains 85.7% carbon by mass.

    (i) Deduce the empirical formula of this hydrocarbon.

[2]

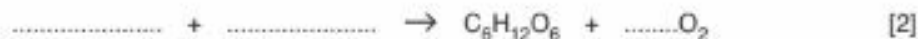   (ii) What other piece of information is needed to deduce the molecular formula of this hydrocarbon?

....[1]

[Total: 11]

O/N18/22/Q7

Plants remove carbon dioxide from the air during photosynthesis.

(a) (i) Complete the equation for photosynthesis.

.... + ... $\rightarrow$ $C_6H_{12}O_6$ + ...O_2 [2]

(ii) State two conditions required for photosynthesis to happen.

1. ....

2. ....

[2]

(iii) Explain how photosynthesis can provide a renewable energy source.

....

....[1]

(b) The structure of a simple sugar is shown.

HO ——[   ]—— OH

Starch is made by the polymerisation of simple sugars.

During this polymerisation, water is formed.

(i) What type of polymerisation occurs?

....[1]

(ii) Draw the partial structure of starch.

You must show at least two repeat units.

[2]

(iii) Name the process by which starch is converted into simple sugars.

....[1]
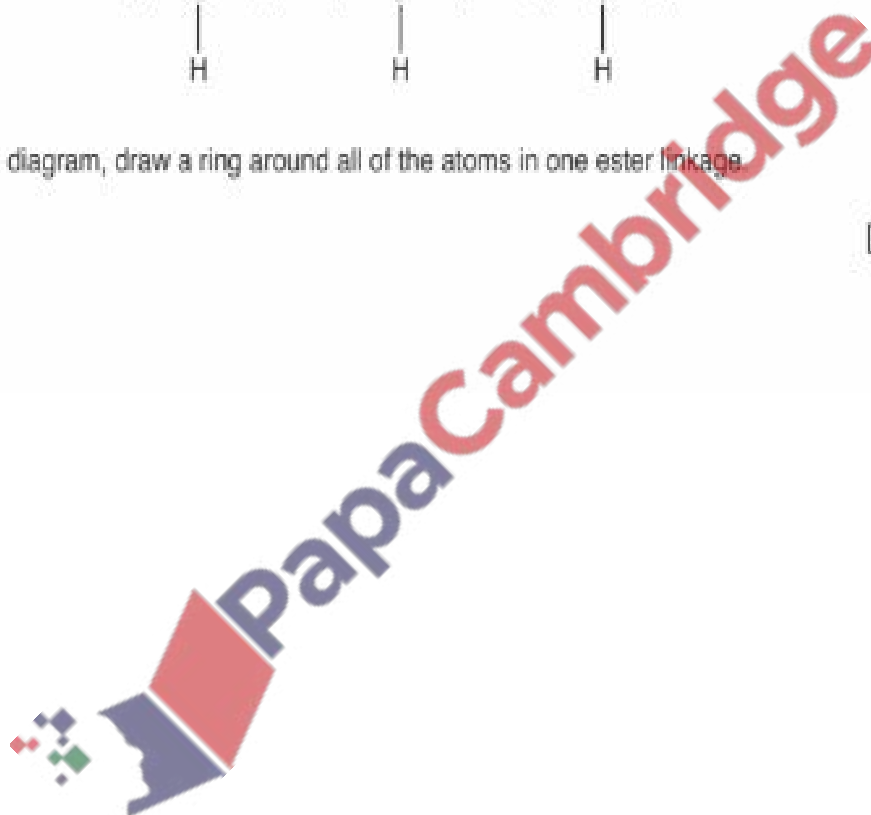
(c) The partial structure of poly(lactic acid) is shown.
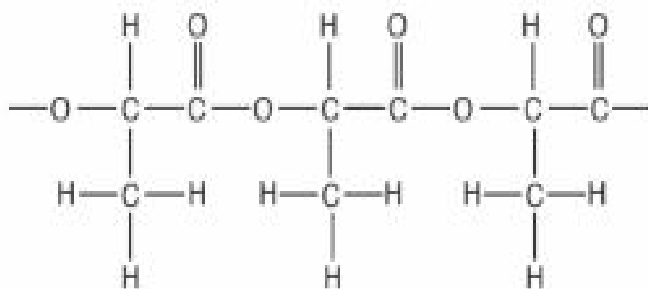
On the diagram, draw a ring around all of the atoms in one ester linkage. [1]

[Total: 10]
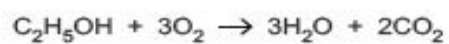
M/J18/21/Q4

This question is about ethanol and ethanoic acid.

ethanol   ethanoic acid

(a) Describe the manufacture of ethanol by fermentation.

....

....

....

....

....

....[3]

(b) Ethanol can be oxidised by oxygen to form ethanoic acid.

Construct the equation for this reaction.

....[1]

(c) A sample of ethanol is heated with ethanoic acid in the presence of concentrated sulfuric acid catalyst.

Draw the structure of the product of this reaction.

Show all of the atoms and all of the bonds.

[1]

(d) Ethanol is used as a fuel.

$$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$$

The complete combustion of one mole of ethanol releases 1350 kJ of energy.

A sample of ethanol reacts with excess oxygen to make 0.240 dm^3 of carbon dioxide, measured at room temperature and pressure.

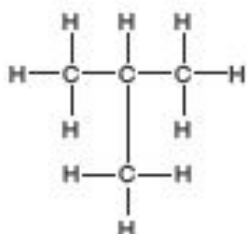Calculate the energy released, in kJ, in this reaction.

energy released .... kJ [2]

[Total: 7]
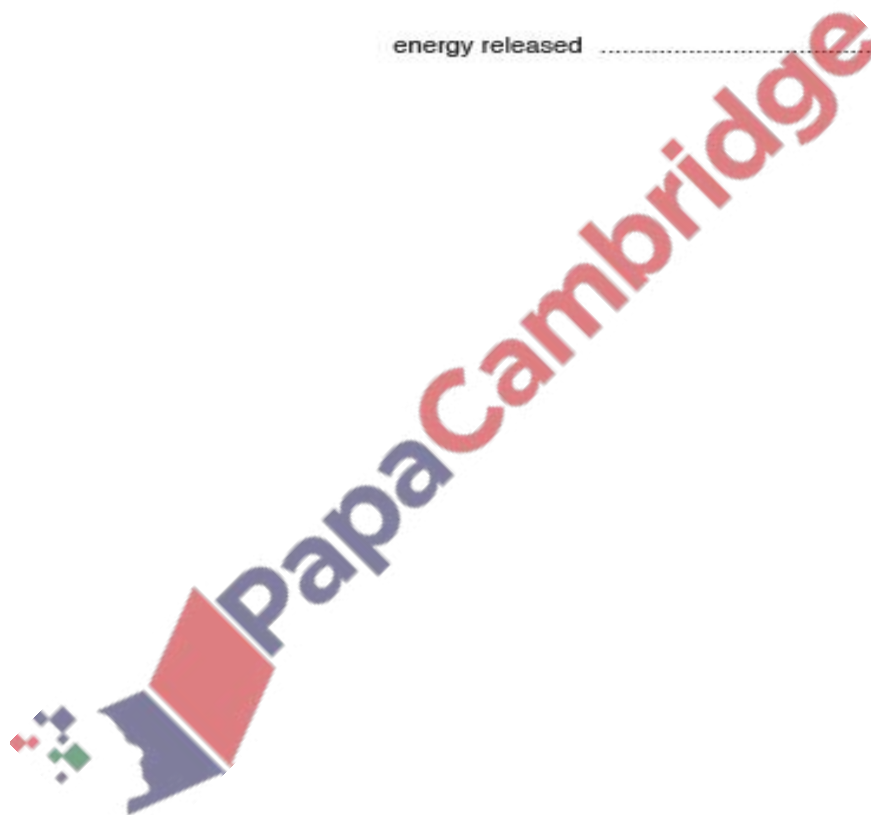
M/J18/21/Q9

Methylpropane is a saturated hydrocarbon.

methylpropane

(a) Methylpropane reacts with chlorine in the presence of ultraviolet light to give several compounds.

   (i) One of these compounds has a relative molecular mass of 127.

     What is the molecular formula of this compound?

     molecular formula ....

     Suggest a structure for this compound. Show all of the atoms and all of the bonds.

     [2]

   (ii) Another compound formed has the percentage composition by mass:

       29.7% carbon; 4.3% hydrogen; 65.9% chlorine.

     Calculate the molecular formula for this compound.

     molecular formula .... [2]

(iii) A compound is formed when one molecule of methylpropane reacts with five molecules of chlorine.

Write the molecular formula for this compound.

....[1]

(b) The structures of propene and cyclopropane are shown.
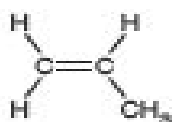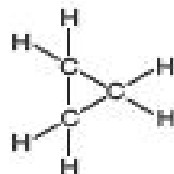
propene   cyclopropane

These two compounds are isomers of each other.

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

....
....[1]

(ii) Both compounds are hydrocarbons.

What is meant by the term *hydrocarbons*?

....
....[1]

(iii) Propene is an unsaturated hydrocarbon and cyclopropane is a saturated hydrocarbon.

What is the difference between an unsaturated and a saturated hydrocarbon?

....
....[1]

(iv) Describe a chemical test to distinguish between unsaturated and saturated hydrocarbons.

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

[Total: 10]

M/J18/22/Q5

Naphtha is a fraction obtained from petroleum (crude oil).

(a) Explain how naphtha is obtained from petroleum (crude oil).

....

....

....

....

....

....[3]

(b) One compound in the naphtha fraction has the formula $C_{12}H_{26}$.

(i) From this formula, how can you deduce that this compound is an alkane?

....

....

....[1]

(ii) The alkane, $C_{12}H_{26}$, can be cracked to form an alkene that has six carbon atoms per molecule.

Construct the equation for this reaction.

....[2]

(c) Ethene, C_2H_4, can be made by cracking hydrocarbons.

Draw a 'dot-and-cross' diagram for ethene.

You only need to show the outer shell electrons.

[2]
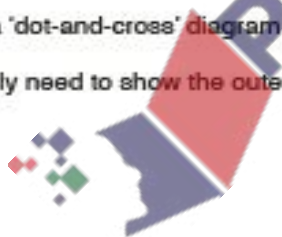
(d) Chlorine reacts with both ethene and ethane.

(i) One molecule of ethene reacts with one molecule of chlorine.

Draw the structure of the product of this reaction. Show all of the atoms and all of the bonds.

[1]

(ii) One molecule of ethane can react with two molecules of chlorine.

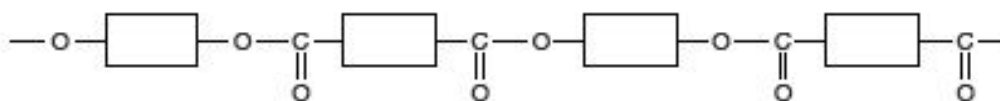What is the molecular formula of the organic product of this reaction?

....[1]

[Total: 10]
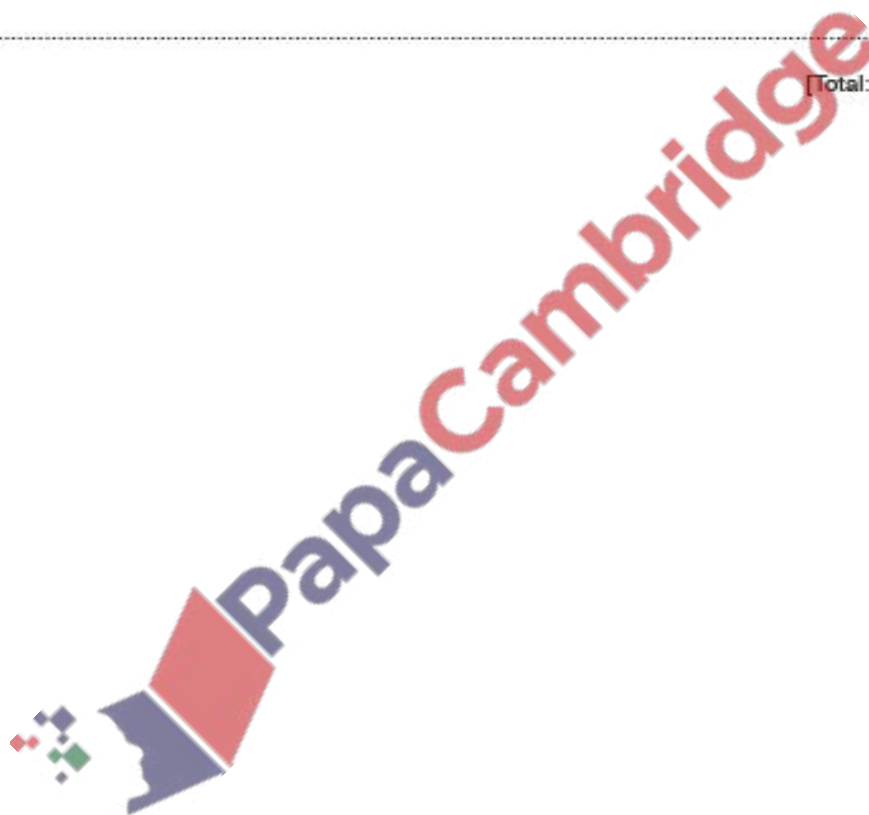
ORGANIC CHEMISTRY P2 QUESTIONS

M/J18/22/Q6

The diagram shows the partial structure of a polyester.

(a) Draw the partial structure of nylon.

[1]

(b) The diagram shows the partial structure of an addition polymer.
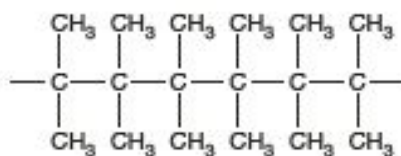
(i) What is meant by the term *addition polymerisation?*

....

....

....[2]

(ii) Draw the structure of the alkene that can be used to make this addition polymer.

[1]

(iii) Describe one pollution problem associated with the disposal of this addition polymer.

....

....[1]

[Total: 5]

M/J18/22/Q10

Ester A has the structure shown.

(a) Name ester A.

....[1]

(b) Ester A reacts with hot aqueous sodium hydroxide to give two compounds, B and C.

(i) Compound B has the percentage composition by mass:

29.3% carbon; 3.7% hydrogen; 39.0% oxygen; 28.0% sodium.

Calculate the empirical formula for this compound.

[2]

(ii) Compound C has a relative molecular mass of 74 and is oxidised by warm acidified potassium manganate(VII) to give butanoic acid.

Suggest a structure for C.

Give reasons for your answer.

....

....

....

....[2]

(c) (i) What is meant by the term *isomerism*?

....

....[1]

(ii) Draw an isomer of ester A.

[1]

(d) Explain why ester A is a saturated compound.

....

....[1]

(e) Ester A can be used as a fragrance or perfume because it diffuses easily.

(i) Explain why the rate of diffusion of the ester decreases as the temperature decreases.

....

....

....[1]

(ii) Suggest one other use for ester A.

....[1]

[Total: 10]

O/N17/21/Q4

The structure of malic acid is shown.

(a) Malic acid is a carboxylic acid because it contains a –COOH group.

Malic acid also contains an –OH group.

Name the homologous series of compounds which contain the –OH group.

....[1]

(b) A diester of malic acid has the formula shown.

$$H_7C_3OOC-CH(OH)-CH_2-COOC_3H_7$$

What reagent and conditions are needed to make this diester from malic acid?

reagent ....

conditions ....
[2]

(c) When heated, malic acid forms fumaric acid.

$$HOOC-CH(OH)-CH_2-COOH \rightarrow HOOC-CH=CH-COOH + H_2O$$
malic acid   fumaric acid

How can aqueous malic acid and aqueous fumaric acid be distinguished when aqueous bromine is added to a sample of each?

....

....

....[2]

(d) The structure of compound **A** is shown.

$$\begin{array}{ccc}
H & & H \\
| & & | \\
C & = & C \\
| & & | \\
COOH & & OH
\end{array}$$
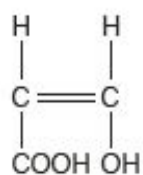
Compound **A** can undergo two types of polymerisation.

(i) Name these two types of polymerisation.

1. ....

2. ....

[2]

(ii) For one of these types of polymerisation, draw a section of the polymer to show two repeat units.

[2]

[Total: 9]
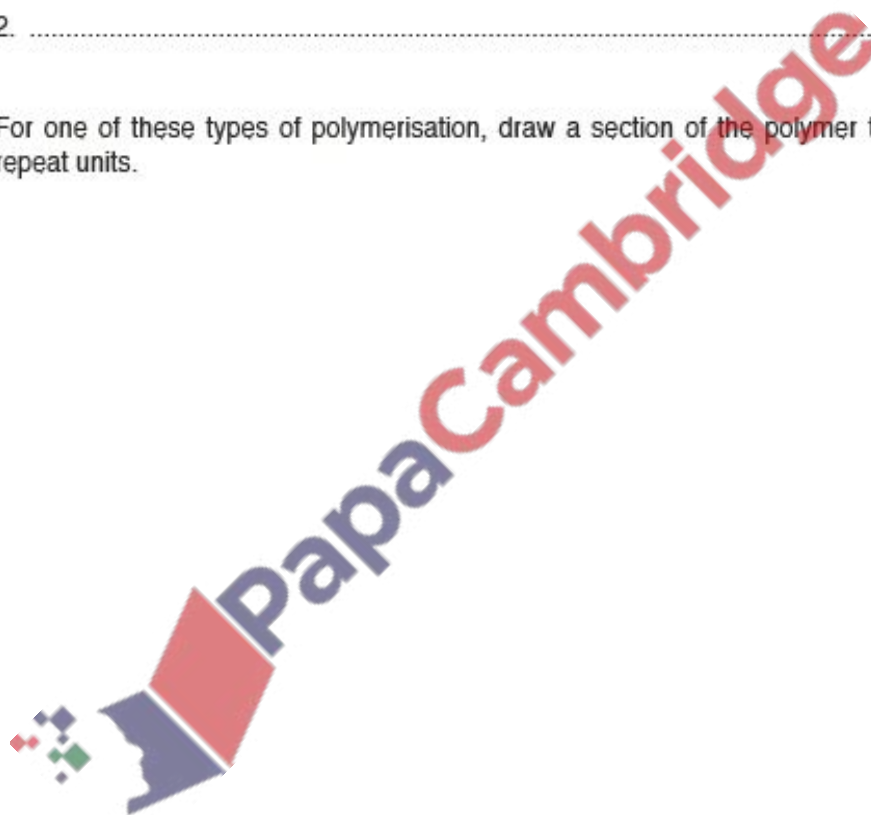
O/N17/21/Q5

Hydrocarbons undergo complete combustion to form carbon dioxide and water.

(a) Construct the equation for the complete combustion of butane, C_4H_{10}.

....[2]

(b) The combustion of butane is exothermic.

Explain in terms of bond making and bond breaking why this reaction is exothermic.

....

....

....

....[2]

(c) Petroleum (crude oil) fractions contain hydrocarbons.

Give one use of the paraffin (kerosene) fraction.

....[1]

[Total: 5]
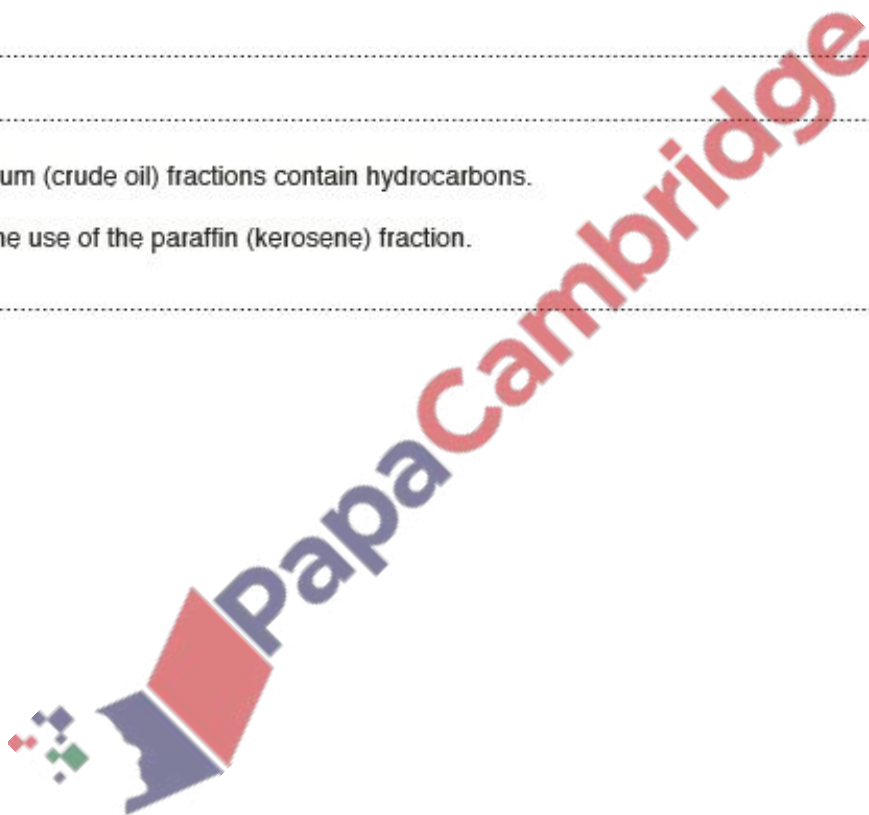
O/N17/21/Q9

Cyclopropane is converted to propene when heated.

$$H_2C \diagdown \atop H_2C \diagup CH_2 \longrightarrow CH_3CH=CH_2$$

cyclopropane

(a) Explain why cyclopropane and propene are isomers.

....[1]

(b) The graph shows how the concentration of propene in this reaction changes with time.

concentration
of propene
in mol/dm³

time/min
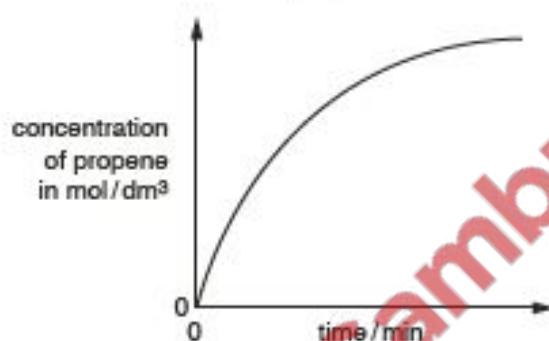
Describe how the rate of this reaction changes with time. Explain your answer by referring to the graph.

....

....[2]

(c) Describe and explain the effect of increasing the concentration of cyclopropane on the rate of this reaction.

....

....

....[2]

(d) Describe and explain the effect of decreasing the temperature on the rate of this reaction.

....

....

....[2]

(e) Propene undergoes addition reactions. Two addition reactions of propene are shown in the diagram.

Complete the diagram to show the missing name, formula and conditions.

```
                    ┌─────────────────┐
                    │     propene      │
                    │  CH₃CH = CH₂     │
                    └─────────────────┘
                     /              \
                    /                \        conditions
              + steam              +H₂        1. ......................................
                  /                    \      2. ......................................
                 ↓                      ↓
     ┌──────────────────────┐   ┌─────────────────┐
     │ name ............... │   │     propane      │
     │ formula ........... │   │  CH₃CH₂CH₃       │
     └──────────────────────┘   └─────────────────┘
```

propene
$CH_3CH = CH_2$

conditions
1. ....
2. ....

+ steam   +H$_2$

name ....
formula ....

propane
$CH_3CH_2CH_3$

[3]
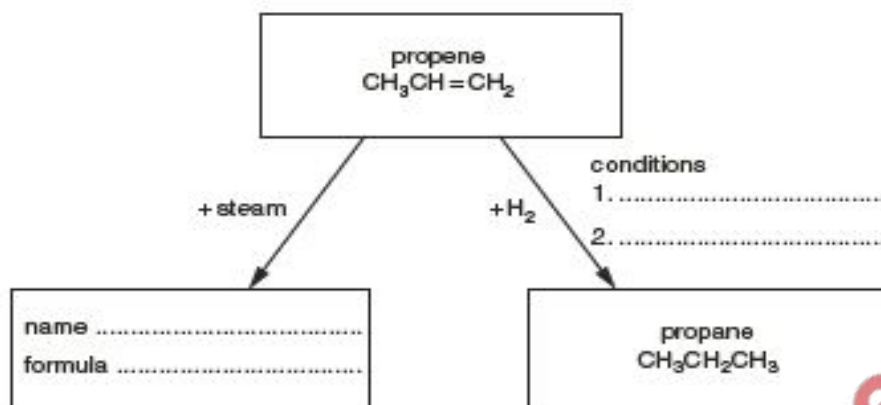
[Total: 10]
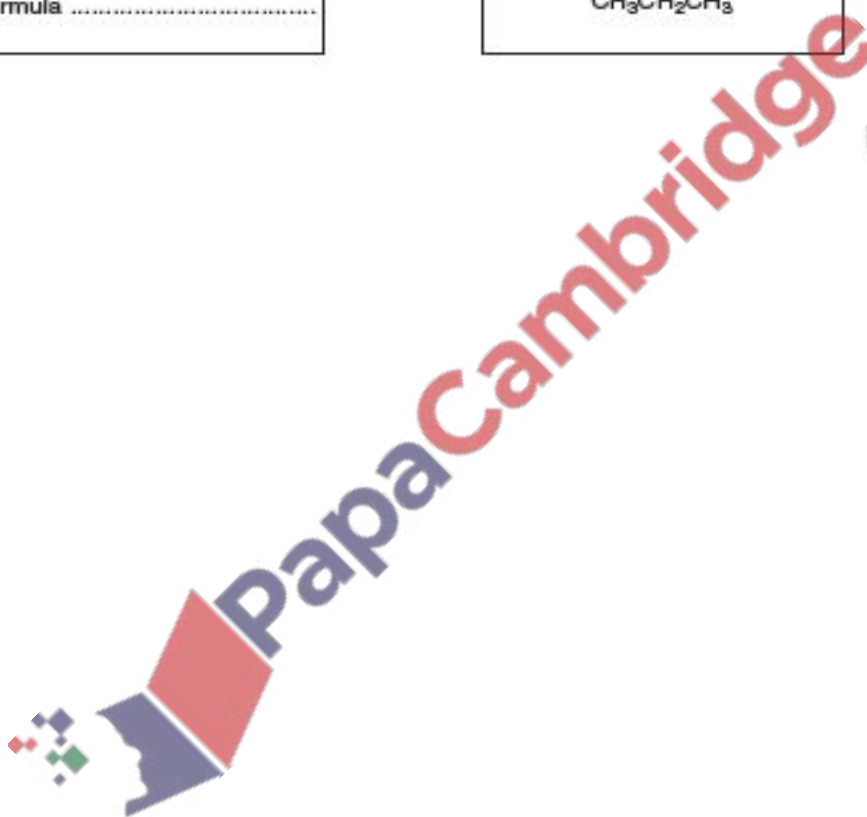
O/N17/22/Q4

Lavandulol is found in lavender plants.
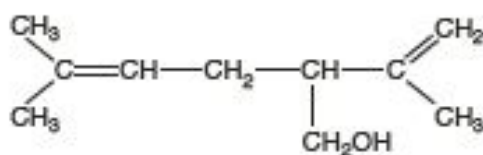
(a) (i) Give the molecular formula for lavandulol.

....[1]

(ii) Lavandulol contains an –OH group.

Name the homologous series of compounds which contain the –OH group.

....[1]

(b) Lavandulol is an unsaturated compound.

Describe a test for an unsaturated compound.

test ....

result ....
[2]

(c) Lavender flowers contain a variety of coloured compounds. These can be extracted from the flowers to give a solution of the coloured compounds.

Describe how to use paper chromatography to identify these coloured compounds.

You may use a labelled diagram in your answer.

....

....

....

....[3]

(d) Compound G is found in the leaves of lavender plants.
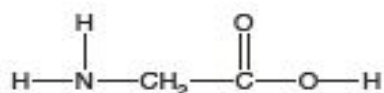
Compound G can undergo polymerisation.

Draw a section of the polymer to show two repeat units.

[2]

[Total: 9]

O/N17/22/Q5

Dilute ethanoic acid reacts with sodium carbonate.

Sodium ethanoate, CH_3COONa, and two other compounds are formed.

(a) Construct the equation for this reaction.

....[2]

(b) The reaction of dilute ethanoic acid with sodium carbonate is endothermic.

Explain in terms of bond making and bond breaking why this reaction is endothermic.

....

....

....

....[2]

(c) Ethanoic acid reacts with alcohols to form esters.

Give one use of esters.

....[1]

[Total: 5]

M/J17/21/Q5

Ethanol and butanol are both alcohols.
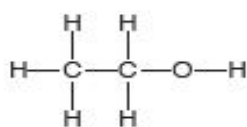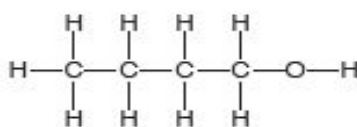
ethanol   butanol

(a) Describe the manufacture of ethanol from ethene.

....

....

....[2]

(b) Ethanol is used as a fuel and as a constituent of alcoholic beverages.

   (i) State one **other** use of ethanol.

   ....[1]

   (ii) Construct an equation to show the **incomplete** combustion of ethanol.

   ....[2]

(c) Ethanol can be oxidised to form ethanoic acid.

   Name a reagent that can be used for this oxidation.

   ....[1]

(d) Draw the structure of an alcohol that is an isomer of butanol.

   Show all of the atoms and all of the bonds.

   [1]

(e) Butanol can be converted into an alkene by loss of a molecule of water.

Draw the structure of the alkene formed.

Show all of the atoms and all of the bonds.

[1]

(f) Butene can be polymerised to give poly(butene).

(i) What type of polymerisation occurs?

....[1]

(ii) Poly(butene) is non-biodegradable.

What does the term *non-biodegradable* mean?

....

....

....[1]

[Total: 10]

M/J17/21/Q10

The table shows some information about the homologous series of unbranched carboxylic acids.

name	structure	boiling point/°C
methanoic acid	HCO_2H	101
ethanoic acid	CH_3CO_2H	118
propanoic acid	$CH_3CH_2CO_2H$	141
butanoic acid	$CH_3CH_2CH_2CO_2H$	164
pentanoic acid	$CH_3CH_2CH_2CH_2CO_2H$	186

(a) A homologous series has a general formula.

(i) Deduce the general formula for the homologous series of unbranched carboxylic acids.

....[1]

(ii) Describe two **other** properties of a homologous series.

1. ....

....

2. ....

....
[2]

(b) An aqueous solution of propanoic acid is a weak acid.

(i) What is the meaning of the term *weak acid*?

....

....[1]

(ii) Aqueous propanoic acid reacts with magnesium carbonate.

Construct the equation for this reaction.

....[1]

(c) Butanoic acid reacts with ethanol to make an ester.

Name and draw the structure of this ester. Show all of the atoms and all of the bonds within the ester linkage.

name ....

structure

[2]

(d) Ethanoic acid is a liquid at room temperature and has a boiling point of 118 °C.

Describe the changes in both the arrangement and movement of the molecules when ethanoic acid is heated from room temperature to 120 °C.

....

....

....

....

....

....[3]

[Total: 10]

M/J17/22/Q5

Ethanoic acid and butanoic acid are both carboxylic acids.
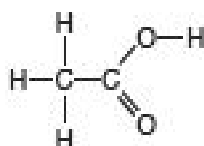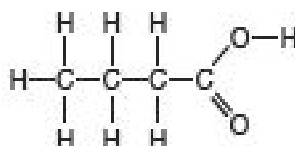
ethanoic acid   butanoic acid

(a) Name a reagent that can be used to make ethanoic acid from ethanol.

....[1]

(b) Dilute ethanoic acid reacts with all carbonates and with some metals.

(i) Name one metal that will react with dilute ethanoic acid and name the products of this reaction.

name of metal ....

products ....
[2]

(ii) Construct an equation to show the reaction of dilute ethanoic acid with calcium carbonate.

....[2]

(c) Draw the structure of a carboxylic acid that is an isomer of butanoic acid.

Show all of the atoms and all of the bonds.

[1]

(d) Lactic acid is both an alcohol and a carboxylic acid.

Lactic acid is a monomer that can be polymerised to form a polyester.

(i) What type of polymerisation occurs during this reaction?

....[1]

(ii) This polyester is biodegradable.

Suggest an advantage of a polymer being biodegradable.

....

....[1]

[Total: 8]

M/J17/22/Q10

) The table shows some information about the homologous series of unbranched alcohols.

name	structure	boiling point / °C
methanol	CH_3OH	65
ethanol	CH_3CH_2OH	79
propanol	$CH_3CH_2CH_2OH$	97
butanol	$CH_3CH_2CH_2CH_2OH$	117
pentanol	$CH_3CH_2CH_2CH_2CH_2OH$	138

(a) One of the characteristics of a homologous series is that it has a general formula.

(i) What is the general formula for the homologous series of unbranched alcohols?

....[1]

(ii) Predict the boiling point of hexanol, an alcohol with six carbon atoms per molecule.

.... °C   [1]

(b) Describe the manufacture of ethanol by the fermentation of aqueous glucose.

....

....

....

....

....

....[3]

(c) Butanol reacts with ethanoic acid to make an ester.

Name and draw the structure of this ester.

Show all of the atoms and all of the bonds within the ester linkage.

name ....

structure

[2]

(d) Ethanol is a gas at 100 °C.

Describe the changes in the arrangement and movement of the molecules when ethanol is cooled from 100 °C to 25 °C.

....

....

....

....

....

[3]

[Total: 10]

ORGANIC CHEMISTRY P2 QUESTIONS

O/N16/21/Q3

The alcohols are a homologous series with the general formula $C_nH_{2n+1}OH$.

(a) Deduce the molecular formula of the alcohol having eight carbon atoms.

....[1]

(b) The table shows some information about different alcohols.

alcohol	formula	melting point /°C	boiling point /°C	density in g/cm³
ethanol	C_2H_5OH	−117	79	0.789
propanol	C_3H_7OH	−126	98	0.804
butanol	C_4H_9OH	−89	117	
pentanol	$C_5H_{11}OH$	−79	138	0.815
hexanol	$C_6H_{13}OH$	−47	158	0.820

(I) Describe how the boiling point changes with the number of carbon atoms in the alcohol.

....[1]

(II) Estimate the density, in g/cm³, of butanol.

....[1]

(III) What is the physical state of pentanol at room temperature and pressure? Explain your answer.

....

....

....[1]

(c) How does viscosity change in the homologous series of alcohols?

Explain your answer.

....

....[2]

(d) Construct the equation for the complete combustion of propanol.

....[2]

(e) Propanol can be oxidised to propanoic acid.

(I) Suggest the oxidising agent and describe the conditions used for this reaction.

....

....[2]

(II)   Draw the structure of propanoic acid, showing all the atoms and all the bonds.

[1]

[Total: 11]
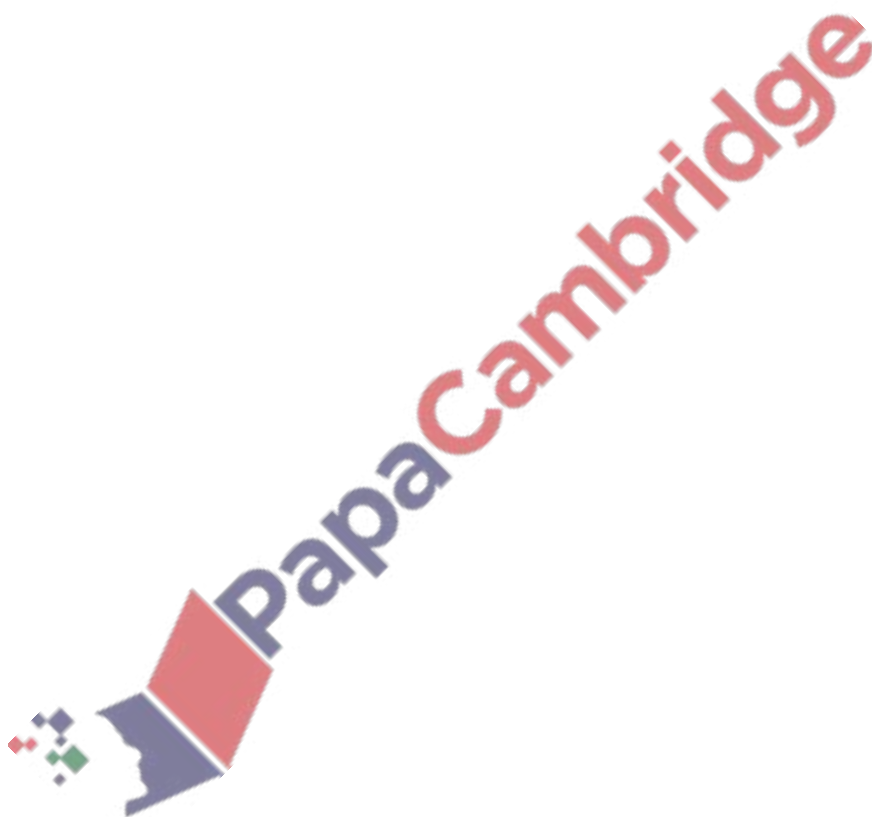
O/N16/21/Q7

Ethenyl ethanoate, $CH_3CO_2CH=CH_2$, is manufactured by passing a mixture of ethanoic acid, ethene and oxygen over a catalyst at 200 °C.

$$CH_3CO_2H + CH_2=CH_2 + \tfrac{1}{2}O_2 \rightarrow CH_3CO_2CH=CH_2 + H_2O$$
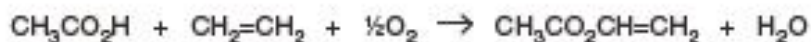
The reaction is exothermic.

(a) Draw an energy profile diagram for this reaction on the axes shown.

On your diagram label
- the reactants and products,
- the enthalpy change for the reaction,
- the activation energy.
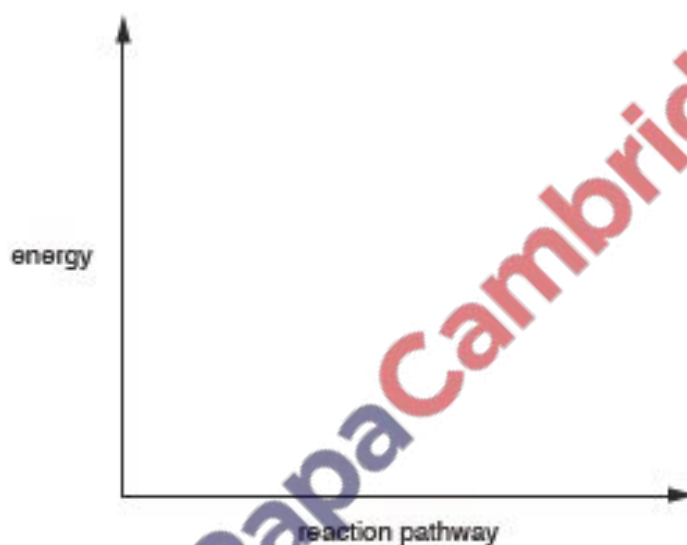
[3]

(b) Ethenyl ethanoate is an unsaturated compound.

Describe a chemical test for an unsaturated compound.

test ....

observation ....

[2]

(c) The catalyst used in the manufacture of ethenyl ethanoate contains copper.

Copper reacts with concentrated nitric acid.

Complete the equation for this reaction.

$$Cu \ + \ ....HNO_3 \ \rightarrow \ Cu(NO_3)_2 \ + \ ....H_2O \ + \ ....NO_2$$ [1]

(d) The structure of ethenyl ethanoate is shown.

$$\begin{array}{c} COCH_3 \\ | \\ O \qquad H \\ | \qquad | \\ C == C \\ | \qquad | \\ H \qquad H \end{array}$$
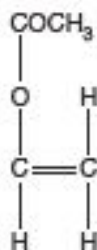
Draw the structure of the addition polymer formed from ethenyl ethanoate.

[2]

(e) State two pollution problems caused by non-biodegradable plastics.

....

....[2]

[Total: 10]

O/N16/22/Q3

The alkanes are a homologous series of hydrocarbons.

(a) State **two** properties of a homologous series.

....

....[2]

(b) Draw the structures of the branched and unbranched alkanes having four carbon atoms.

Show all the atoms and all the bonds.

[2]
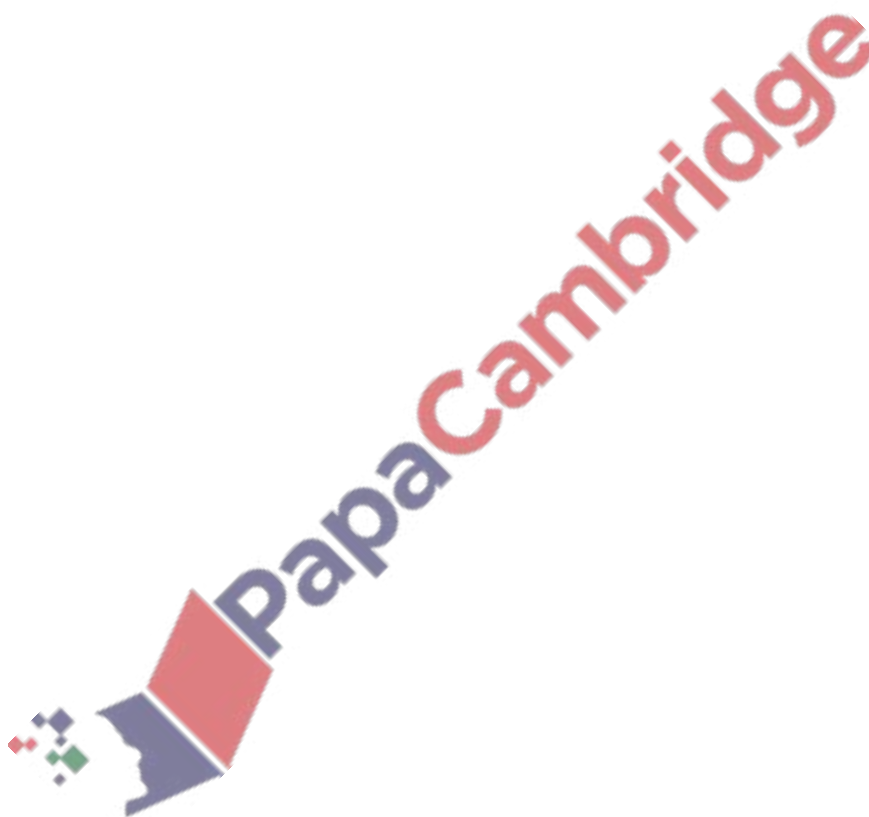
(c) The graph shows how the melting points of the first nine unbranched alkanes vary with the number of carbon atoms per molecule.
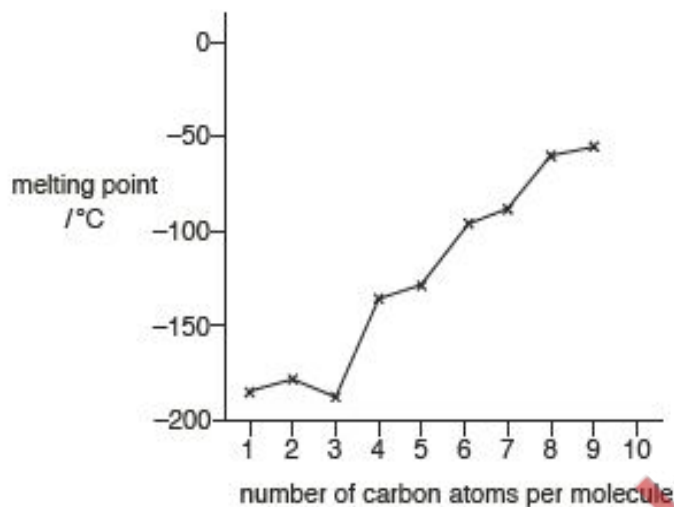
(i) Describe how the melting points of these alkanes change with the number of carbon atoms.

....

....

....[2]

(ii) Use the graph to estimate the melting point of the unbranched alkane which has ten carbon atoms.

....°C [1]

(d) (i) Construct the equation for the complete combustion of pentane, C_5H_{12}.

....[2]

(ii) Name the products of the incomplete combustion of pentane and explain why the incomplete combustion of hydrocarbons is hazardous to health.

....

....[2]

[Total: 11]

M/J16/21/Q1

Choose from the following polymers to answer the questions.

Terylene
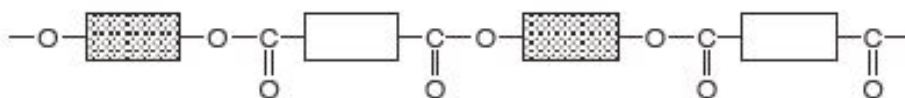
PTFE
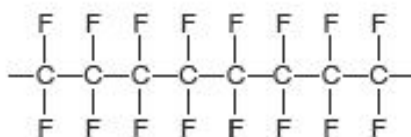
nylon

starch

poly(propene)

PVC
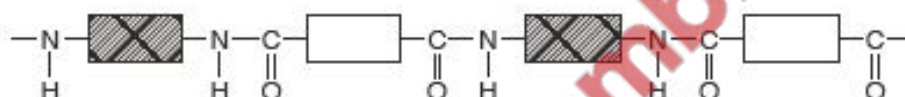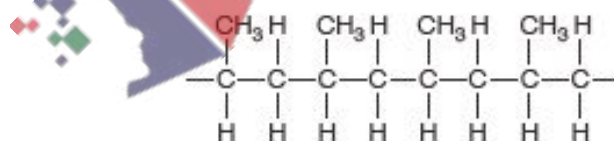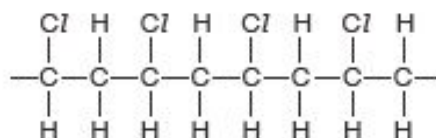
protein
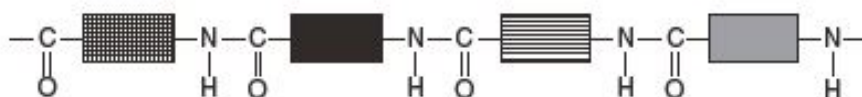
polyester
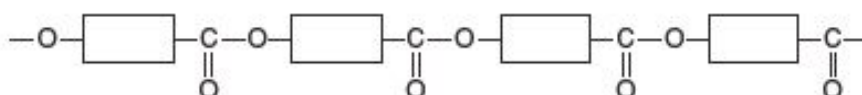
poly(ethene)
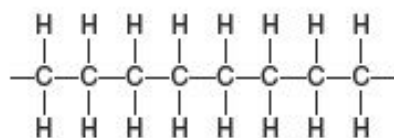
Each polymer can be used once, more than once or not at all.

Which is a polymer that

(a) is made from propene,

.... [1]

(b) will form hydrogen chloride when combusted,

.... [1]

(c) can be hydrolysed to form amino acids,

.... [1]

(d) can be hydrolysed to make simple sugars,

.... [1]

(e) contains the same linkage as that present in a fat?

.... [1]

[Total: 5]

M/J16/21/Q3

Esters, such as propyl ethanoate, are often used as solvents.

(a) Give **one** other use for esters such as propyl ethanoate.

.... [1]

(b) Draw the structure of propyl ethanoate, showing all of the atoms and all of the bonds.

[1]

(c) A bottle of propyl ethanoate is opened in a room. Some of the propyl ethanoate evaporates and then diffuses into the room.

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

....

....

.... [1]

(ii) What happens to the rate of diffusion of propyl ethanoate as the temperature of the room increases?

Explain your answer in terms of the kinetic particle theory.

....

....

.... [2]

(iii) The table shows some information about different esters.

name	structure	relative molecular mass (M_r)
methyl methanoate	HCO_2CH_3	60
ethyl methanoate	$HCO_2C_2H_5$	74
propyl methanoate	$HCO_2C_3H_7$	88
butyl methanoate	$HCO_2C_4H_9$	102
pentyl methanoate	$HCO_2C_5H_{11}$	116

Which ester has the **greatest** rate of diffusion at room temperature and pressure?

....

Explain your answer.

....

....

[2]

[Total: 7]
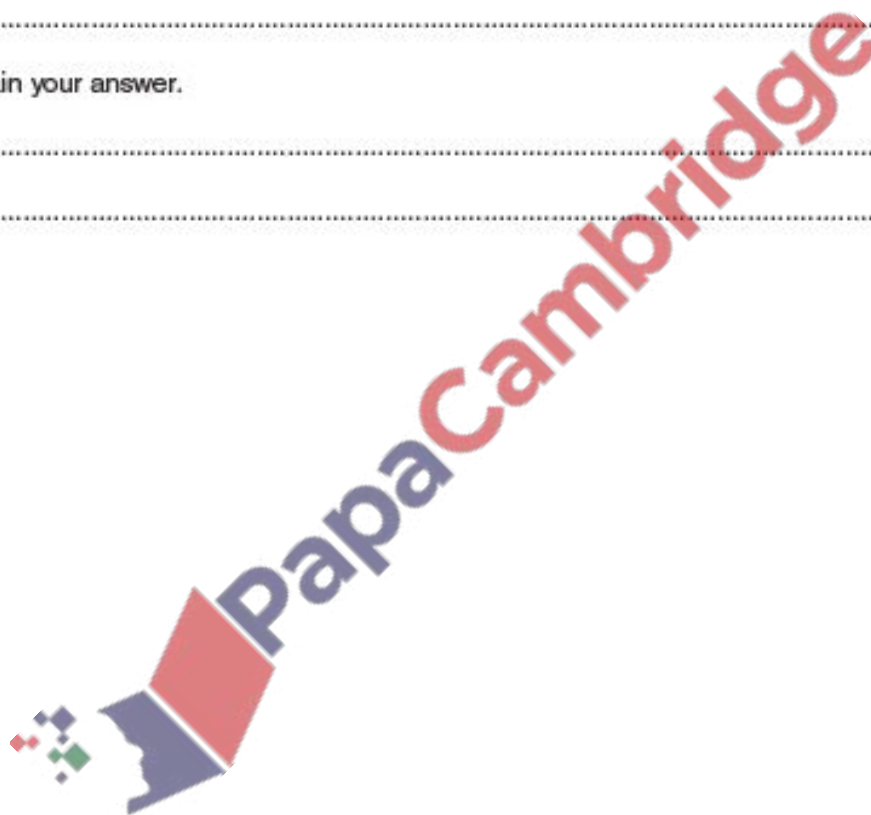
M/J16/21/Q8

Cyclohexane, C_6H_{12}, is a cycloalkane.

Cycloalkanes react in a similar way to alkanes.
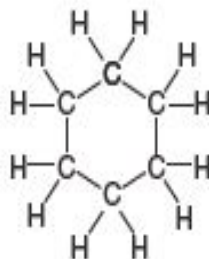
cyclohexane

(a) Cyclohexane is a saturated hydrocarbon.

    (i) What is the meaning of the term *saturated*?

    ....

    .... [1]

    (ii) What is the meaning of the term *hydrocarbon*?

    ....

    .... [1]

(b) Construct the equation for the complete combustion of cyclohexane.

.... [1]

(c) Cyclohexane reacts with chlorine in the presence of ultraviolet light.

This is a substitution reaction.

Write the molecular formulae of **two** products of this reaction.

.... [2]

(d) Cyclohexane can be manufactured from hexane as shown in the equation.

$$C_6H_{14} \rightarrow C_6H_{12} + H_2$$
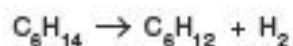
Calculate the mass of cyclohexane that can be made from 258g of hexane.
[M_r of cyclohexane = 84]

mass of cyclohexane = ... g [2]

(e) Another cycloalkane has the following percentage composition by mass.

C, 85.7%; H, 14.3%

(I) Use the percentage composition by mass to show that the empirical formula of the cycloalkane is CH_2.

[2]

(II) Draw the structure of the cycloalkane with an M_r of 56, showing all of the atoms and all of the bonds.

[1]

[Total:10]

M/J16/22/Q1

Choose from the following polymers to answer the questions.

polymer A
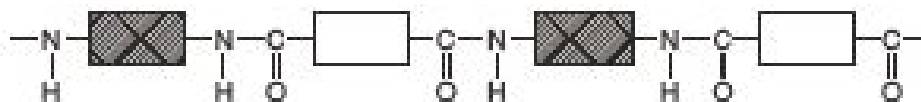
polymer B
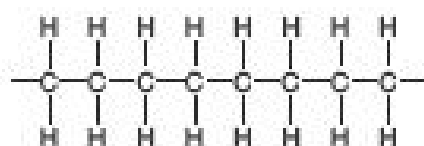
polymer C
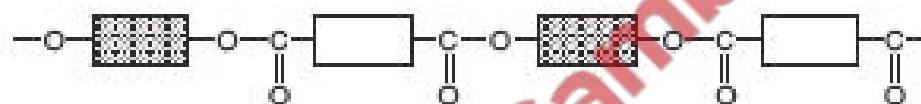
polymer D

polymer E
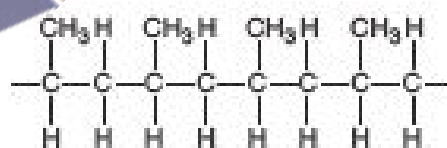
polymer F
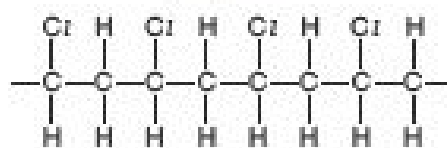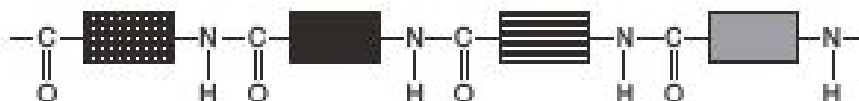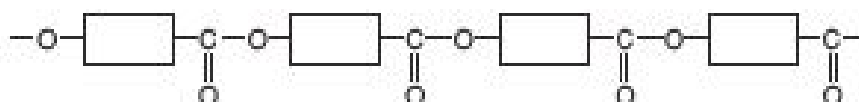
polymer G

polymer H

polymer I
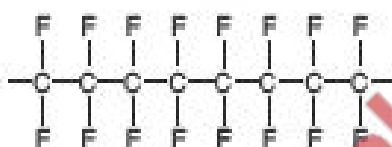
Each polymer can be used once, more than once or not at all.

(a) Which two polymers are polyesters?

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

(b) Which polymer is used to make both clingfilm and plastic bags?

....   [1]

(c) Give the letter of an addition polymer. ....

Give the letter of a condensation polymer. ....   [1]

(d) Give the letter of a polymer that is a saturated hydrocarbon.

....   [1]

(e) Which polymer could be part of a protein?

....   [1]

[Total: 6]

ORGANIC CHEMISTRY P2 QUESTIONS

M/J16/22/Q3

Esters are used as food flavourings and solvents.

(a) Draw the structure of ethyl methanoate, showing all of the atoms and all of the bonds.

[1]

(b) Ethyl ethanoate evaporates at room temperature.

   (I) What is meant by the term *evaporation*?

   ....

   ....

   .... [1]

   (II) A sample of ethyl ethanoate in a beaker is moved into a colder room.

   Explain, in terms of the kinetic particle theory, why this results in a decrease in the rate of evaporation.

   ....

   ....

   ....

   .... [2]

(III) The table shows some information about different esters.

name	structure	relative molecular mass (M_r)
methyl ethanoate	$CH_3CO_2CH_3$	74
ethyl ethanoate	$CH_3CO_2C_2H_5$	88
propyl ethanoate	$CH_3CO_2C_3H_7$	102
butyl ethanoate	$CH_3CO_2C_4H_9$	116
pentyl ethanoate	$CH_3CO_2C_5H_{11}$	130

Which ester has the **lowest** rate of evaporation at room temperature and pressure?

....

Explain your answer.

....

....

[2]

[Total: 6]

ORGANIC CHEMISTRY P2 QUESTIONS

MARK SCHEME

O/N18/21/Q4

(a)(i) C_nH_{2n+2}
4(a)(ii) **Any one from:**
same functional group (1)
similar chemical properties / react similarly (1)
trend in physical properties (1)
successive members differ by CH_2 (1)
4(b) all the carbon-carbon bonds are single bonds
4(c) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2$
correct formulae for reactants and products (1)
balanced equation – dependent on formulae (1)
4(d) any branched chain isomer of pentane drawn
4(e)(i) substitution
4(e)(ii) light / uv
4(f)(i) mole ratio C = 90 / 12 **AND** mole ratio H = 10 / 1
OR C = 7.5 **AND** H = 10 (1)
empirical formula = C_3H_4 (1)
4(f)(ii) (relative) molecular mass

O/N18/21/Q7

7(a) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
correct formulae for reactants and products (1)
balanced equation – dependent on formulae (1)

7(b)(i) rise in sea levels / melting of polar ice caps / desertification / more extreme weather patterns (1)
7(b)(ii) photosynthesis absorbs carbon dioxide AND respiration releases carbon dioxide (1)
the amount of carbon dioxide absorbed is roughly equal to the amount of carbon dioxide released (1)
7(c)(i) H_2O (1)
7(c)(ii) (dilute) sulfuric acid (1)
heat / reflux (1)
7(d)(i) ring around the CONH group (1)
7(d)(ii) $NH_2CH(CH_3)CO_2H$ (1)

O/N18/22/Q4

4(a) Any two from:

• same functional group (1)

• same general formula (1)

• similar chemical properties / react similarly (1)

• trend in physical properties (1)

• successive members differ by CH2 (1)

4(b) $C4H8 + 6O2 \rightarrow 4CO2 + 4H2O$ (2)

ORGANIC CHEMISTRY P2 QUESTIONS

1 mark for correct reactants and products if equation not balanced

4(c) structure of 2-methylpropene drawn showing all atoms and all bonds

4(d)(i) butane 1

4(d)(ii) catalyst / to speed up the reaction / to increase the rate of reaction

4(d)(iii) heat / high temperature 1

4(e)(i) mole ratio C = 85.7 / 12 AND mole ratio H = 14.3 / 1

OR

C = 7.14 AND H = 14.3 (1)

empirical formula = CH2 (1)

4(e)(ii) (relative) molecular mass

O/N18/22/Q7

7(a)(i) $6CO_2 + 6H_2O \rightarrow C_6H_{12}$

$O_6 + 6O_2$ (2)

If 2 marks not scored, award one mark for correct formulae (1)

7(a)(ii) (sun)light (1)

chlorophyll (1)

7(a)(iii) glucose can be used to make a fuel / glucose (can be fermented) to make ethanol 1

7(b)(i) condensation 1

7(b)(ii) 2 or more units polymerised

(2) If two marks not scored, award 1 mark for:

– O – linking two squares / rectangles but no extension bonds

7(b)(iii) hydrolysis 1

7(c)(i) ring around the COO group

M/J18/21/Q4

4(a) use of glucose **AND** yeast (1)
any **TWO** correct conditions from – aqueous conditions / temperature between 10 and 45 °C
/ absence of oxygen / any pH

between 6 to 8 (1)
(fractionally) distil reaction mixture (to get ethanol) (1)

4(b) $CH_3CH_2OH + O_2 \rightarrow CH_3COOH + H_2O$ (1) **1**
4(c)
(1)

(1)
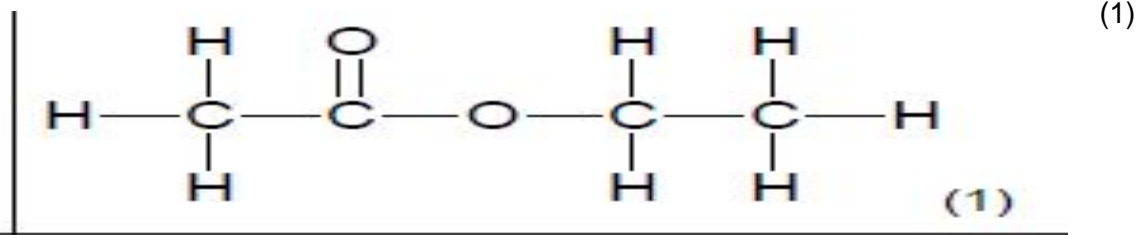
4(d) (moles of CO_2 = 0.01 so) moles of C_2H_5OH = 0.005 (1)
energy released = (moles of $C_2H_5OH \cdot 1350$) = 6.75 (1)

M/J18/21/Q9

9(a)(i) $C_4H_8Cl_2$ (1)
Structure showing all atoms
and all of the bonds of a
compound having two chlorine
atoms substituted and based
on
methylpropane skeleton e.g.

(1)
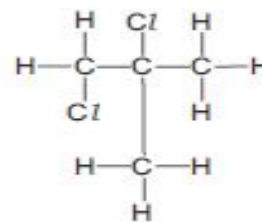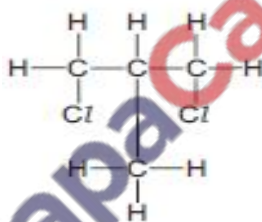
9(a)(ii) molecular formula is
$C_4H_7Cl_3$ (2)
If two marks not scored:
1 mark for mole ratio $C : H : Cl$ is 2.475 : 4.30 : 1.856
OR
1 mark for C = 29.7 / 12, H = 4.3 / 1 and Cl = 65.9 / 35.5
9(a)(iii) $C_4H_5Cl_5$ (1)
9(b)(i) same molecular formula but different structures / same molecular formula but different
arrangement of atoms (1)
9(b)(ii) (compounds) containing only hydrogen and carbon (1)
9(b)(iii) unsaturated contains a carbon-carbon double bond / saturated does not contain
carbon-carbon double bond (1) **1**
9(b)(iv) add (aqueous) bromine (1)
unsaturated goes colourless and saturated stays orange (1)

M/J18/22/Q5

5(a) petroleum is heated / crude oil is heated (1)
fractional distillation / fractionating column (1)
idea that separation works because naphtha has different boiling point to other fractions /
idea of different boiling points at
different places in the column / naphtha comes off at particular height in the column (1)
5(b)(i) (molecular formula) fits the (general) formula C_nH_{2n+2} (1)
5(b)(ii) $C_{12}H_{26} \rightarrow C_6H_{12} + C_6H_{14}$ / $C_{12}H_{26} \rightarrow 2C_6H_{12} + H_2$

formula for C_6H_{12} (1)
equation balanced dependent on alkene formula (1)

5(c)

f 2 marks not obtained, **one mark** for:
EITHER two shared pairs of electrons between the two carbon atoms
OR incorrect number of electrons in carbon-carbon bond (or bond shown by line) BUT one electron pair between each of the two carbon-hydrogen atoms on each of the two carbon atoms (four electron pairs)

(2)

5(d)(i)

(1)

5(d)(ii) $C_2H_4Cl_2$ (1)

M/J18/22/Q6

6(a)		1
6(b)(i)	monomers react together / monomers combine / monomers add together / monomers join / monomers link (1)	2
	to form only one product / to give one product and no other molecule / no by-product formed (1)	
6(b)(ii)		1
6(b)(iii)	non-biodegradable / causes litter / fills land-fill sites / incineration produces atmospheric pollutants (1)	1

M/J18/22/Q9

10(a) butyl ethanoate / butyl acetate (1)
10(b)(i) empirical formula is $C_2H_3O_2Na$ (2)
If two marks not scored:
1 mark for mole ratio C : H : O : Na is 2.44 : 3.70 : 2.44 : 1.22
OR
1 mark for C = 29.3 / 12 H = 3.7 / 1 O = 39.0 / 16 Na = 28.0 / 23
10(b)(ii) $CH_3CH_2CH_2CH_2OH$ (1)
idea that it must be an alcohol since it can be oxidised / must be butanol since it is oxidised
to butanoic acid (1)
10(c)(i) (compounds with) the same molecular formula but different structures / (compounds with) the same molecular formula but
different arrangements of atoms (1)

10(c)(ii) any isomer of butyl ethanoate, e.g. $CH_3CH_2CO_2CH_2CH_2CH_3$ (1)
10(d) does not contains a carbon-carbon double bond / has **only** single carbon-carbon bonds (1)
10(e)(i) molecules move slow**er** / molecules have less kinetic energy (1)
10(e)(ii) solvent / flavourings (1)

O/N17/21/Q4

A4(a) alcohol (1)
A4(b) propanol (1)
reflux / heat (with sulfuric / strong acid / conc acid) (1)
A4(c) bromine decolourised by fumaric acid / colour of bromine goes (brown to) colourless
with fumaric acid (1)
no colour change with malic acid / bromine remains brown with malic acid / bromine remains the same colour with malic
acid (1)
A4(d)(i) addition (1)
condensation (1)

A4(d)(ii)

for addition polymer:
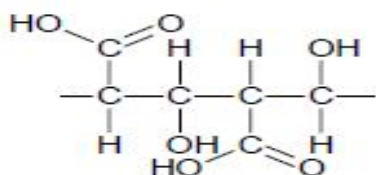
two (or more) repeat units with single bonds between carbon atoms (1)

continuation bonds dependent on correct structure (1)

OR

for condensation polymer:
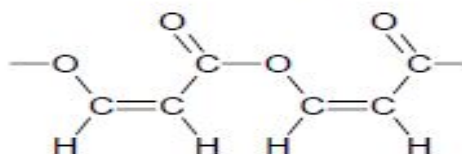
two (or more) repeat units with ester link and continuation bonds (2)

if 2 marks not awarded, 1 mark for ester link drawn correctly

O/N17/21/Q5

A5(a) $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$
correct reactants and products (1)
balancing dependent on correct formulae (1)
A5(b) bond breaking is endothermic **and** bond making is exothermic (1)
more energy released (in bond making) than absorbed (in bond breaking) (1)
2A5(c) jet fuel, heating oil (1)

O/N17/21/Q9

B9(a) they have the same molecular formula but the atoms are arranged differently (1)
B9(b) rate decreases (1)

the gradient of the graph decreases / slope of the graph decreases (1)
B9(c) increases rate (no marks)
particles closer together / more particles in a given volume / more crowded particles (1)
greater collision frequency / more collisions per second / rate of collisions increases (1)

B9(d) decreases rate (no marks)
particles move more slowly / particles have less kinetic energy (1)
number of particles with energy equal to or greater than the activation energy is decreased /
fewer successful collisions / fewer
effective collisions (1)
B9(e) left hand box:
propanol (1)
C_3H_7OH (1)
right hand conditions:
catalyst / Ni **AND** heat / high temperature / high pressure (1)

O/N17/22/Q4

A4(a)(i)	$C_{10}H_{18}O$ (1)	1
A4(a)(ii)	Alcohol (1)	1
A4(b)	Bromine / bromine water (1) Turns colourless (1)	2
A4(c)	1 mark each for any three of: • Pigment(s) / dyes / coloured compounds on paper and paper (dipping) in solvent • Spot of dye above solvent level • Measure distance moved by dye and solvent (front) • Calculate R_f value • Compare with known R_f value(s)	3
A4(d)	Two correct repeat units with amide link (2 marks) e.g. $- NH - CH_2 - \overset{\overset{\textstyle O}{\|}}{C} - NH - CH_2 - \overset{\overset{\textstyle O}{\|}}{C} -$ If 2 marks not awarded, 1 mark for two amide links drawn correctly	2

O/N17/22/Q5
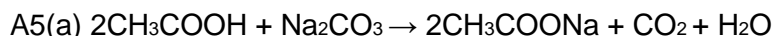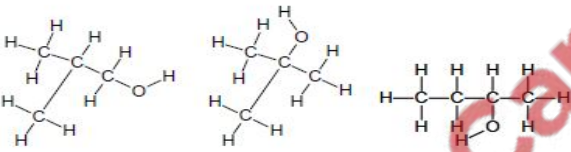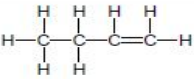
A5(a) $2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 + H_2O$
Correct formulae (1)
Correct balance (1)
A5(b) Bond breaking is endothermic and bond making is exothermic (1)
Less energy released (in bond making) than absorbed (in bond breaking) (1)
A5(c) Solvents / flavourings / perfumes (1)

M/J17/21/Q5

A5(a)	Reaction with steam (1)	2
	In presence of a catalyst (1)	
A5(b)(i)	Solvent / making vinegar	1
A5(b)(ii)	$C_2H_5OH + O_2 \rightarrow 2C + 3H_2O$ OR $C_2H_5OH + 2O_2 \rightarrow 2CO + 3H_2O$ Correct products (1) Balancing (1)	2
A5(c)	(Acidified) potassium manganate(VII) / oxygen	1
A5(d)	ANY ONE FROM 	1
A5(e)		1
A5(f)(i)	Addition	1
A5(f)(ii)	Do not decay / do not decompose naturally / not attacked by bacteria or microbes	1

M/J17/21/Q10

B10(a)(i)	$C_nH_{2n+1}COOH$ / $C_nH_{2n}O_2$	1
B10(a)(ii)	**ANY TWO FROM:** Same functional group (1) Idea that each member varies by a CH_2 group (1) Same or similar chemical properties (1) Physical properties change with a trend (1)	2
B10(b)(i)	An acid that partially ionises / partially dissociates	1
B10(b)(ii)	$MgCO_3 + 2CH_3CH_2CO_2H \rightarrow Mg(CH_3CH_2CO_2)_2 + CO_2 + H_2O$	1
B10(c)	Ethyl butanoate (1) $C_3H_7 - C$ with $O - C_2H_5$ and $=O$ (1)	2
B10(d)	(Molecules) move faster / have more kinetic energy (as temperature increases) (1) (Molecules) are further apart (as temperature increases) (1) (Molecules) are arranged more randomly / more irregularity (as temperature increases) (1)	3

M/J17/22/Q5

A5(a)	(Acidified) potassium manganate(VII) / oxygen	1
A5(b)(i)	Lithium / sodium / potassium / calcium / magnesium (1) Corresponding ethanoate **AND** hydrogen (1)	2
A5(b)(ii)	$CaCO_3 + 2CH_3CO_2H \rightarrow Ca(CH_3CO_2)_2 + H_2O + CO_2$ (2) IF: two marks not scored H_2O and CO_2 as products = 1 mark	2
A5(c)		1
A5(d)(i)	Condensation	1
A5(d)(ii)	Decomposes / decays / will not fill up land-fill sites / less litter / no need for incineration	1

M/J17/22Q10

Question	Answer	Mark
B10(a)(i)	$C_nH_{2n+1}OH$ / $C_nH_{2n+2}O$	1
B10(a)(ii)	Any value between 154 – 164 (°C) (inclusive of these values)	1
B10(b)	(Add) yeast (1) Temperature between 5 and 40 °C / no oxygen present / anaerobic (1) (Fractionally) distil (to get ethanol) (1)	3
B10(c)	Butyl ethanoate (1) H–C–C–O–C–C–C–C–H (1)	2
B10(d)	They get slower / they move less rapidly (when temperature decreases) / molecules slow down (when temperature decreases) / molecules have less kinetic energy (when temperature decreases) (1) They / molecules get closer together (when temperature decreases) (1) They / molecules arranged less randomly / less irregularly (when temperature decreases) (1)	3

O/N16/21/Q3

Question	Answer	Mark
A3(a)	$C_8H_{18}O$ (1)	1
A3(b)(i)	increases with increased number of carbon atoms (1)	1
A3(b)(ii)	values between 0.806 and 0.813 (inclusive) (1)	1
A3(b)(iii)	liquid because melting point is below room temperature and boiling point is above room temperature (1)	1
A3(c)	(viscosity) increases as number of C atoms increases / increases down the alcohols (1) any correct answer related to length / size / mass of molecule e.g. size of molecule increases / length of carbon chain increases / chains get more tangled / van der Waals' forces increase / intermolecular forces increase (1)	2
A3(d)	$C_3H_7OH + 4\frac{1}{2}O_2 \rightarrow 3CO_2 + 4H_2O$ correct formulae for reactants and products (1) correct balancing, dependent on correct formulae (1)	2
A3(e)(i)	(acidified) potassium manganate(VII) / potassium permanganate (1) heat / reflux (1)	2
A3(e)(ii)	(1)	1
	Total:	11

O/N16/21/Q7

B7(a) reactants labelled on left and products labelled on right AND product level below reactant level (1)

enthalpy change labelled and shown by downward arrow (1)
activation energy as upward arrow from left hand energy level to energy 'hump' above the highest energy level of
both products and reactant (1)
B7(b) bromine water / aqueous bromine / bromine (1)
turns colourless (1)
B7(c) $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$ (1) **1**
B7(d) OCOCH$_3$
|
CH—CH$_2$ (1)
extension bonds shown (1)
B7(e) One mark each for any **two** suitable points e.g. :
☐ fills landfill sites
☐ litter
☐ when burnt greenhouse gases given off / burning produces poisonous gases
☐ get caught in birds / fish gullets (causing choking / death)
Total: 10

O/N16/22/Q3

A3(a)	One mark each for any two of : • same functional group • (same) general formula • similar chemical properties/react similarly • trend in physical properties • each differs by CH$_2$	2
A3(b)		2
A3(c)(i)	One mark each for any two of: • (generally) increases as number of carbon atoms increases • increases in zigzag way/idea of going up irregularly/idea of going up unevenly • decreases between C2 and C3 compound (or words to that effect)	2
A3(c)(ii)	any value between $-25\,(°C)$ and $-45\,(°C)$ (inclusive of these values) (1)	1
A3(d)(i)	$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ correct formulae (1) correct balance dependent on correct formulae (1)	2

A3(d)(ii) Any **two** of: carbon monoxide/carbon/water (1)
carbon monoxide is toxic/carbon monoxide is poisonous (1)
2
Total: 11

M/J16/21/Q1

A1(a) Poly(propene) (1) 1
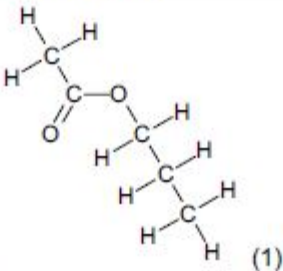A1(b) PVC (1) 1
A1(c) Protein (1) 1
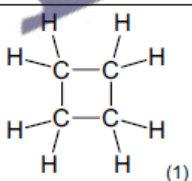A1(d) Starch (1) 1
A1(e) Terylene / polyester (1) 1
Total: 5

M/J16/21/Q3

A3(a)	Flavouring (1)	1
A3(b)		1
A3(c)(i)	(Net) movement of a substance from a region of high concentration to low concentration (1)	1
A3(c)(ii)	Rate of diffusion increases (1) Particles have more energy / particles are moving faster (1)	2
A3(c)(iii)	Methyl methanoate / HCO_2CH_3 (1) Lowest relative formula mass (1)	2
	Total:	7

M/J16/21/Q8

B8(a)(i)	Contains only carbon-carbon single bonds (1)	1
B8(a)(ii)	Contains only carbon and hydrogen (1)	1
B8(b)	$C_6H_{12} + 9O_2 \rightarrow 6CO_2 + 6H_2O$ (1)	1
B8(c)	HCl (1) $C_6H_{11}Cl$ (1)	2
B8(d)	Moles of C_6H_{14} = 3.0 (1) Mass of C_6H_{12} = 252 (g) (1)	2
B8(e)(i)	Mole ratio C : H = 7.14 : 14.3 **or** 85.7 / 12 and 14.3 / 1 (1) Divide by 7.14 to get empirical formula (1)	2
B8(e)(ii)		1
	Total:	10

M/J16/22/Q1

A1(a) C and H (1) 1
A1(b) B (1) 1
A1(c) Addition – B / E / F / I
AND
Condensation – A / C / D / G / H
(1)
1

A1 (d) B / E (1) 1
A1 (e) G (1) 1
Total 5

M/J16/22/Q3

A3(a)	(1)	1
A3(b)(i)	Changing of a liquid into a gas / changing liquid to vapour (happening at any temperature) (1)	1
A3(b)(ii)	Molecules have less energy / molecules move slower (1) Molecules don't have enough energy to overcome force between molecules / molecules don't have enough energy to escape (into the air) (1)	2
A3(b)(iii)	Pentyl ethanoate / $CH_3CO_2C_5H_{11}$ (1) Highest relative formula mass (1)	2
	Total	6