Name: _____

Class: _____

Date: _____

Organic Chemistry part 3 AQA Triple Chemistry

Time: **86 minutes**

Marks: **80 marks**

Comments:

1. This question is about cycloalkenes.

Cycloalkenes are ring-shaped hydrocarbon molecules containing a double carbon-carbon bond.

Cycloalkenes react in a similar way to alkenes.

(a) Describe a test for the double carbon-carbon bond in cycloalkene molecules.

Give the result of the test.

Test _____

_____

Result _____

_____

(2)

(b) The table below shows the name and formula of three cycloalkenes.

Name	**Formula**
Cyclobutene	C_4H_6
Cyclopentene	C_5H_8
Cyclohexene	C_6H_{10}

Determine the general formula for cycloalkenes.

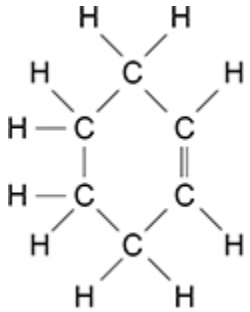
_____

General formula = _____

(1)

Figure 1 shows the displayed structural formula of cyclohexene, C_6H_{10}

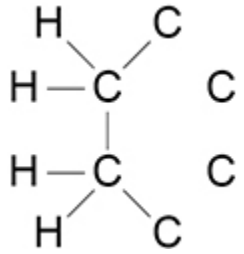
Figure 1



Chlorine reacts with cyclohexene to produce a compound with the formula $C_6H_{10}Cl_2$

(c) Complete **Figure 2** to show the displayed structural formula of $C_6H_{10}Cl_2$

Figure 2



(2)

(d) Calculate the percentage by mass of chlorine in a molecule of $C_6H_{10}Cl_2$

Relative atomic masses (A_r): H = 1 C = 12 Cl = 35.5

_____

_____

_____

_____

Percentage by mass = _____ %

(3)

(Total 8 marks)

2. This question is about alkenes and alcohols.

Ethene is an alkene produced from large hydrocarbon molecules.

Large hydrocarbon molecules are obtained from crude oil by fractional distillation.

(a) Name the process used to produce ethene from large hydrocarbon molecules.

_____

(1)

(b) Describe the conditions used to produce ethene from large hydrocarbon molecules.

_____

_____

_____

_____

(2)

(c) Ethanol can be produced from ethene and steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

(6)

(d) Ethanol can also be produced from sugar solution by adding yeast.

Name this process.

(1)

(e) Butanol can be produced from sugar solution by adding bacteria.

Sugar solution is broken down in similar ways by bacteria and by yeast.

Suggest the reaction conditions needed to produce butanol from sugar solution by adding bacteria.

_____

_____

_____

_____

(2)

Ethanol and butanol can be used as fuels for cars.

(f) A car needs an average of 1.95 kJ of energy to travel 1 m

Ethanol has an energy content of 1300 kilojoules per mole (kJ/mol).

Calculate the number of moles of ethanol needed by the car to travel 200 km

_____

_____

_____

_____

_____

Number of moles = _____ mol

(3)

(g) When butanol is burned in a car engine, complete combustion takes place.

Write a balanced equation for the complete combustion of butanol.

You do **not** need to include state symbols.

_____

(2)

(Total 17 marks)

3. This question is about materials used to make plates.

Plates are made from ceramics, paper or poly(propene).

(a) Paper plates are biodegradable and recyclable.

Which stage of a life cycle assessment (LCA) would contain this information?

Tick (✓) **one** box.

Disposal at the end of useful life	☐
Extracting and processing raw materials	☐
Manufacturing and packaging	☐
Use and operation during lifetime	☐

(1)

(b) Which **two** processes are used to make ceramic plates?

Tick (✓) **two** boxes.

Forming a composite	☐
Galvanising with zinc	☐
Heating in a furnace	☐
Melting sand and boron trioxide	☐
Shaping wet clay	☐

(2)

Poly(propene) is produced from an alkene.

(c) Complete the sentences.

The name for very large molecules such as poly(propene) is _____.

The name of the alkene used to produce poly(propene) is _____.

(2)

(d) The alkene needed to make poly(propene) is produced from crude oil.

Which **two** processes are used to produce this alkene from crude oil?

Tick (✓) **two** boxes.

Chromatography	☐
Cracking	☐
Fermentation	☐
Fractional distillation	☐
Quarrying	☐

(2)

(e) What type of bond joins the atoms in a molecule of poly(propene)?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

(1)

The table below shows information about two polymers used to make plates.

Polymer	Effect of heating the polymer
A	does not melt
B	melts at 50 °C

(f) What type of polymer is polymer **A**?

Use the table above.

_____

_____

(1)

(g) Why does polymer **A** behave differently to polymer **B** when heated?

You should refer to crosslinks in your answer.

_____

_____

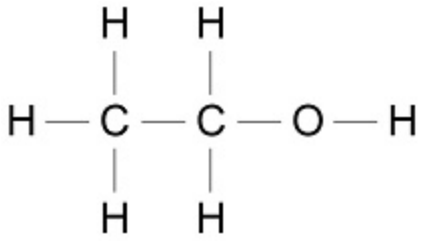
(1)

(Total 10 marks)

4. This question is about ethanol and ethanoic acid.

Ethanol is an alcohol.

(a) The diagram below shows the displayed structural formula of ethanol.



Draw a circle on the diagram above around the alcohol functional group.

(1)

(b) An ethanol molecule contains atoms of three different elements.

Complete the table below to show:

- the name of each element
- the symbol for each element
- the number of atoms of each element in one molecule of ethanol.

Use the diagram above.

Name of element	**Symbol for element**	**Number of atoms in one molecule of ethanol**
Carbon	C	
Hydrogen		6
	O	1

(3)

(c) Ethanol removes grass stains from clothes.

What type of substance is ethanol when used to remove grass stains?

Tick (✓) **one** box.

A solute ☐

A solution ☐

A solvent ☐

Wine contains ethanol.

Wine is produced from grape juice by fermentation.

(1)

(d) Complete the sentence.

Grape juice can be fermented to produce wine because

grape juice contains _____.

(1)

(e) What is added to grape juice to cause fermentation?

_____

(1)

(f) Ethanol reacts with ethanoic acid to produce an ester.

What is the name of the ester produced when ethanol reacts with ethanoic acid?

Tick (✓) **one** box.

Ethane ☐

Ethene ☐

Ethyl ethanoate ☐

(1)

(g) Ethanoic acid reacts with sodium carbonate.

The equation for the reaction is:

$$2\ CH_3COOH(aq) + Na_2CO_3(s) \rightarrow 2\ CH_3COONa(aq) + H_2O(l) + CO_2(g)$$

What is the name of the liquid produced by this reaction?

_____

(1)

(h) Vinegar is a solution that contains ethanoic acid.

400 cm^3 of vinegar contains 20 g of ethanoic acid.

Calculate the mass of ethanoic acid in 1.0 dm^3 of vinegar.

_____

_____

_____

_____

_____

_____

Mass = _____g

(3)

(Total 12 marks)

5. This question is about carboxylic acids.

Carboxylic acids belong to a homologous series.

The table below shows information about the first three carboxylic acids in this homologous series.

Name	**Formula**	**pH of a 0.01 mol/dm^3 solution**
Methanoic acid		2.91
Ethanoic acid	CH_3COOH	3.39
	CH_3CH_2COOH	3.44

(a) Complete the table above.

(2)

(b) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

Explain how the equation shows that ethanoic acid is a weak acid.

(2)

(c) A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

(3)

(d) The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm^3 methanoic acid
- 0.01 mol/dm^3 ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.

Explain why.

You should refer to ions in your answer.

Use the table above.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

Ethanoic acid reacts with ethanol to produce an ester.

(e) Give the name of the ester produced when ethanoic acid reacts with ethanol.

_____

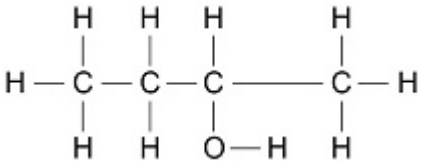
(1)

(f) Hexanedioic acid and ethanediol join together to produce a polyester.

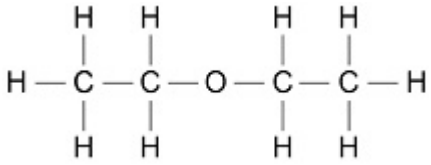
Ethanoic acid and ethanol join together in the same way to produce an ester.

Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?

Tick (✓) **one** box.



☐



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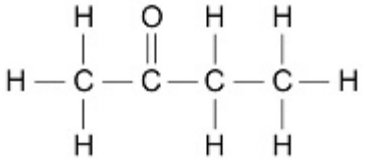

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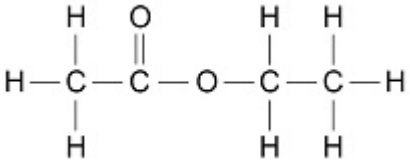


☐

(1)

(Total 12 marks)

6. This question is about hydrocarbons.

Hexane and hexene are hydrocarbons containing six carbon atoms in each molecule.

Hexane is an alkane and hexene is an alkene.

(a) Draw **one** line from each hydrocarbon to the formula of that hydrocarbon.

Hydrocarbon	**Formula**
	C_6H_8
Hexane	C_6H_{10}
	C_6H_{12}
Hexene	C_6H_{14}
	C_6H_{16}

(2)

(b) Bromine water is added to hexane and to hexene.

What would be observed when bromine water is added to hexane and to hexene?

Hexane _____

_____

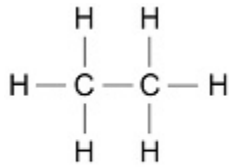
Hexene _____

_____

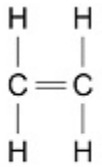
(2)

(c) Ethane is an alkane and ethene is an alkene.

The diagram below shows the displayed structural formulae of ethane and of ethene.



Ethane



Ethene

Compare ethane with ethene.

You should refer to:

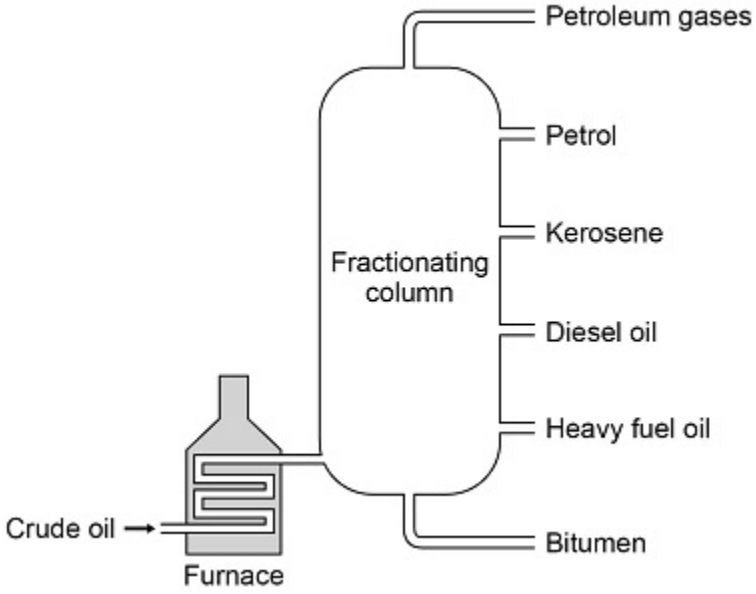
- their structure and bonding
- their reactions.

(6)

(Total 10 marks)

7. This question is about crude oil and hydrocarbons.

The figure below shows a fractionating column used to separate crude oil into fractions.



The following table gives information about some of the fractions.

Fraction	**Boiling point range in °C**
Petroleum gases	Below 30
Petrol	40-110
Kerosene	180-260
Diesel oil	260-320
Heavy fuel oil	320-400
Bitumen	400-450

(a) Suggest a suitable temperature for the furnace in the figure.

_____ °C

(1)

(b) Explain why diesel oil collects above heavy fuel oil but below kerosene in the fractionating column.

Use the table above.

_____

_____

_____

_____

(2)

(c) Suggest **two** reasons why bitumen is **not** used as a fuel.

1 _____

_____

2 _____

_____

(2)

(d) Petrol contains mainly alkanes.

Which of the following compounds is an alkane?

Tick (✓) **one** box.

C_2H_4 ☐

C_4H_8 ☐

C_6H_{14} ☐

C_8H_{16} ☐

(1)

Large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

(e) Describe the conditions needed to crack hydrocarbon molecules from the diesel oil fraction.

_____

_____

_____

_____

(2)

(f) Explain why large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

_____

_____

_____

_____

(2)

(g) Complete the equation for the cracking of $C_{15}H_{32}$

$$C_{15}H_{32} \rightarrow C_{12}H_{26} + \_\_\_\_\_$$

(1)

(Total 11 marks)

1.

(a) (test)
(add) bromine (water)

1

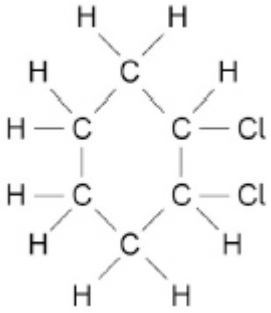
(result)
(changes from) brown / orange to colourless
ignore clear

1

(b) C_nH_{2n-2}

1

(c)



*allow **1** mark for the structure of*
*1, 1-dichlorocyclohexane **or***
*1, 3-dichlorocyclohexane **or***
1, 4-dichlorocyclohexane

2

(d) (M_r ($C_6H_{10}Cl_2$) =) 153

1

(% chlorine=) $\frac{71}{153} \times 100$
allow correct use of an incorrectly calculated value of M_r

1

= 46.4 (%)
allow 46.405228758 (%) correctly rounded to at least 2 significant figures

1

[8]

2.

(a) (steam / catalytic) cracking
allow thermal decomposition

1

(b) high temperature

1

steam / catalyst
allow a temperature in the range 300 – 900 °C

1

(c) **Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

5–6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

No relevant content

0

Indicative content

Rate
- higher temperature gives higher rate
- because more frequent collisions
- higher pressure gives higher rate
- because more frequent collisions
- a catalyst can be used to give a higher rate
- because the activation energy is reduced

Yield
- higher temperature gives lower yield
- because the reaction is exothermic
- higher pressure gives higher yield
- because there are more molecules on left hand side

Other factors
- higher temperatures use more energy so costs increase
- higher pressures use more energy so costs increase
- higher pressures require stronger reaction vessels so costs increase

Compromise
- chosen temperature is a compromise between rate and yield
- chosen temperature is a compromise between rate and cost (of energy used)
- chosen pressure is a compromise between rate and cost (of energy used)
- chosen pressure is a compromise between yield and cost (of energy used)

(d) fermentation

allow ferment(ing)

1

(e) warm

allow a value in the range 25 °C to 45 °C

1

anaerobic (conditions)

allow without oxygen / air

1

(f) (conversion)
200 km = 200,000 m

1

(moles =) $\text{(moles =)}\ \frac{200000 \times 1.95\ \text{(mol)}}{1300}$

allow correct use of incorrect / no conversion for distance

1

= 300 (mol)

1

(g) $C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

allow $C_4H_{10}O$ for C_4H_9OH

allow multiples

*allow **1** mark for*

$C_4H_9OH + O_2 \rightarrow CO_2 + H_2O$

with incorrect / no multipliers

ignore state symbols

2

[17]

3. (a) disposal at the end of useful life

1

(b) heating in a furnace

1

shaping wet clay

1

(c) polymers

1

propene

allow (a) monomer

1

(d) cracking

1

fractional distillation

1

(e) covalent

1

(f) thermosetting

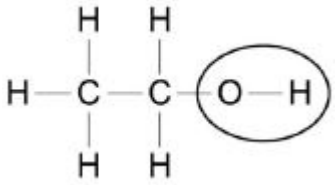
1

(g) polymer **A** has crosslinks (between polymer molecules)
or
polymer **B** has no crosslinks (between polymer molecules)

1

[10]

4. (a)



1

(b)

Name of element	Symbol for element	Number of atoms in one molecule of ethanol
carbon	C	**2**
hydrogen	**H**	6
oxygen	O	1

ignore O2

1
1
1

(c) a solvent

1

(d) sugar

allow named sugar
allow saccharide

1

(e) yeast

1

(f) ethyl ethanoate

1

(g) water

ignore H_2O

1

(h) 400 cm^3 = 0.40 dm^3

1

$\frac{1.00}{0.40}$ × 20

allow correct use of incorrectly converted or unconverted volume

1

= 50 (g)

1

alternative approach:

1.0 dm^3 = 1000 cm^3 (1)

$\frac{1000}{400}$ × 20 (1)

allow correct use of incorrectly converted or unconverted volume

= 50 (g) (1)

[12]

5. (a) HCOOH

allow HCO_2H

1

propanoic acid

1

(b) incomplete / partial ionisation

allow incomplete / partial dissociation

1

(because) reaction is reversible

allow (because) reaction is in equilibrium

1

(c) mass (of flask and contents) decreases

1

(because) carbon dioxide is produced

1

(and) carbon dioxide escapes (from the flask)

*allow **1** mark for the gas produced escapes (from the flask)*

1

(d) (0.01 mol/dm^3) methanoic acid has a lower pH

allow converse argument for ethanoic acid

allow (0.01 mol/dm^3) methanoic acid is a stronger acid

1

(so 0.01 mol/dm^3) methanoic acid has a higher concentration of hydrogen ions

1

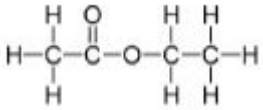
(therefore) more collisions per unit time

1

(e) ethyl ethanoate

1

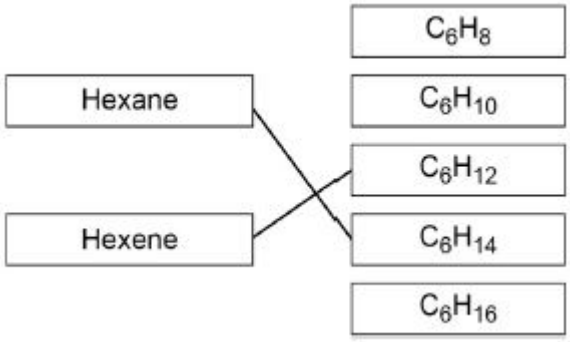
(f)



1

[12]

6. (a)



1

additional line from a box on the left negates the mark for that box

1

(b) (remains) orange

must be in this order

allow no (colour) change

1

(becomes) colourless

ignore initial colour ignore clear

1

(c) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.

4–6

Level 1: Relevant features are identified and differences noted.

1–3

No relevant content

0

Indicative content

Structure and bonding

- both are hydrocarbons
- both contain two carbon atoms (per molecule)
- ethane contains six hydrogen atoms (per molecule)
- (but) ethene contains four hydrogen atoms (per molecule)

- both have covalent bonds
- ethane contains a single C—C bond
- (but) ethene contains a double bond
- both contain C—H bonds

- both small molecules

Reactions

- both react with oxygen in complete combustion reactions
- to produce water and carbon dioxide
- both react with oxygen in incomplete combustion reactions
- to produce water, carbon monoxide and carbon
- incomplete combustion is more likely with ethene

- ethene decolourises bromine water
- (but) ethane does not decolourise bromine water

- ethene is more reactive (than ethane)
- ethene can react with hydrogen (to produce ethane)
- ethene can react with water (to produce ethanol)
- ethene can react with halogens (to produce halogenoalkanes)
- ethene can undergo addition reactions
- ethene can polymerise (to produce poly(ethene))

ignore physical properties
ignore references to flammability

[10]

7. (a) a temperature between 400 (°C) and 500 (°C) inclusive

allow a temperature range entirely within 400 (°C) and 500 (°C) inclusive

1

(b)

ignore quoted values for boiling points
ignore references to melting points
ignore references to intermolecular forces or chain length
allow temperature of vaporisation / condensation for boiling points throughout

(diesel oil has a) lower boiling point / range than heavy fuel oil

1

(but diesel oil has a) higher boiling point / range than kerosene

*allow the boiling range (of diesel oil) is between those of heavy fuel oil and kerosene for **2** marks.*

1

(c)

ignore references to cost

any **two** from:

- (too) viscous
  allow references to difficulty of flow
- not (very) flammable
  allow references to difficulty of ignition / burning
  *do **not** accept bitumen takes more energy to burn*
- boiling point (too) high
  allow not (very) volatile

2

(d) C_6H_{14}

1

(e)

ignore references to pressure

high temperature

allow a quoted temperature above 320 °C
ignore hot / heat

1

any **one** from:

- steam
- catalyst

ignore name of catalyst
allow alumina
allow aluminium oxide
allow porous pot
allow zeolite

1

(f)

allow converse argument for larger molecules

greater demand (for smaller molecules)

1

any **one** from:
(because smaller molecules are)

- more useful
- better fuels
- used to make alkenes
- used to make polymers

allow a named polymer
ignore plastics

1

(g) C_3H_6

1

[11]