Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Reactions of organic compounds

Time allowed: 1 hour 45 minutes

Subject code **0620**

Chemistry

Questions from Paper 3, Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 103

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 103 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

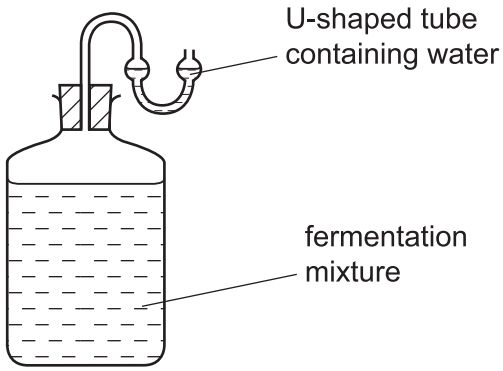
Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Ethanol can be made by fermentation.



(a) Apart from yeast, what other substances are present in the reaction mixture?
Tick **two** boxes.

copper sulfate ☐
ethene ☐
sugar ☐
methane ☐
water ☐

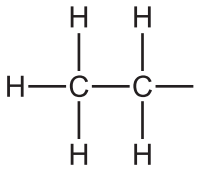
[2]

(b) What method is used to separate ethanol from the rest of the reaction mixture?

.....

[1]

(c) Complete the structure of ethanol.



[1]

(d) Ethanol belongs to the alcohol homologous series.
Which **one** of the following compounds also belongs to the alcohol homologous series?
Put a ring around the correct answer.

butene **hexane** **ethanoic acid** **octanol**

[1]

(e) Describe **one** other way, apart from fermentation, by which ethanol can be made on an industrial scale. Include the necessary reaction conditions in your answer.

.....

.....

..... [3]

[Total: 8]

Alcohols Click for more variations

STEM Exam Builder

1 **(a)** 3rd and 5th boxes ticked (sugar and water) (1 mark each) [2]

(b) (fractional) distillation [1]
IGNORE: fractionation

(c) O-H at right [1]
ALLOW: OH

(d) octanol [1]

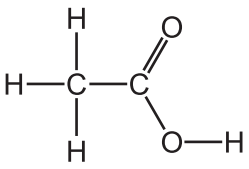
(e) from ethene and steam [1]
ALLOW: from ethene and water
AND any two of: [2]
high temperature / heat / stated temperature between 150 and 1000 °C
catalyst / phosphoric acid
high pressure / stated pressure between 50-100 atm
NOTE: allow sulfuric acid (1) dilute with water (1) heat (1)

[Total: 8]

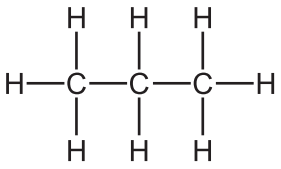
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2 **(a)** The structures of four organic compounds, **B**, **C**, **D** and **E**, are shown.

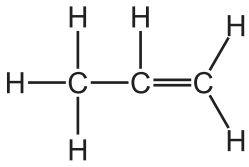
B



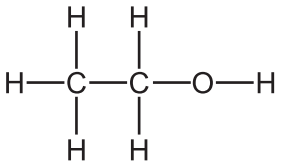
C



D



E



(i) State which compound, **B**, **C**, **D** or **E**, dissolves in water to form an acidic solution.

..... [1]

(ii) State which compound, **B**, **C**, **D** or **E**, is a saturated hydrocarbon.

..... [1]

(iii) State which compound, **B**, **C**, **D** or **E**, is an unreactive compound except in terms of burning.

..... [1]

(iv) State which compound, **B**, **C**, **D** or **E**, decolourises aqueous bromine.

..... [1]

(b) Ethanol can be manufactured from ethene and one other reactant.

Describe the manufacture of ethanol from ethene to include:

- the formula of ethene

.....

- the name of the other reactant

.....

- the conditions needed.

.....

.....

[4]

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(c) Complete the table to show the name and uses of some petroleum fractions.

name of fraction	use of fraction
	making chemicals
kerosene	
fuel oil	

[3]

[Total: 11]

Alcohols Click for more variations

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2(a)(i)	B	**1**
2(a)(ii)	D	**1**
2(a)(iii)	C	**1**
2(a)(iv)	D	**1**

2(b)	• C_2H_4 / correct displayed formula (1) • steam (1) • 1 mark each for any two of: – catalyst – high temperature / heat – high pressure	**4**
2(c)	making chemicals: naphtha (1) kerosene: jet <u>fuel</u> (1) fuel oil: <u>fuel</u> for ships / <u>fuel</u> for (home) heating (1)	**3**

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3 Ethanol can be produced by fermentation or by the catalytic addition of steam to ethene.

(a) (i) Complete the word equation for fermentation.

glucose → ..... + ethanol

[1]

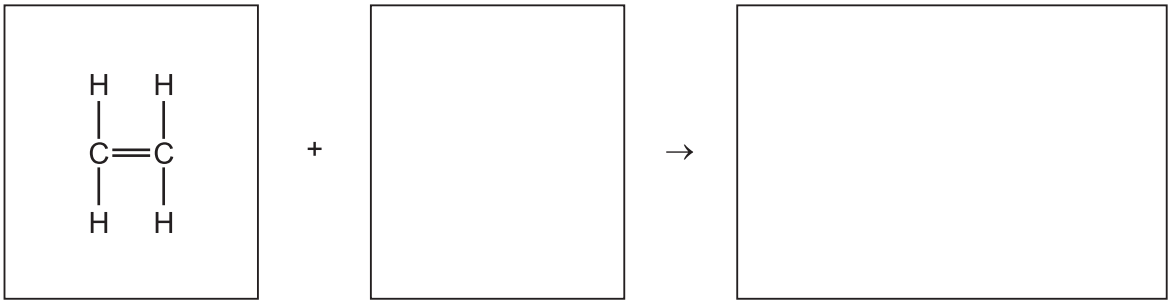
(ii) State the conditions needed for fermentation.

.....

..... [2]

(b) (i) Complete the equation for the catalytic addition of steam to ethene by drawing the structures of water and ethanol in the boxes.

C_2H_4 + H_2O → C_2H_5OH



[2]

(ii) Ethene is an unsaturated hydrocarbon.
Describe a test for an unsaturated hydrocarbon.

test .....

result ..... [2]

(c) Ethanol can be used as a fuel.
State the names of the products formed when ethanol undergoes complete combustion.

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

(d) Complete these sentences using words from the list.

different functional homologous similar unreactive unsaturated

Ethanol is a member of the alcohol ..... series.

All alcohols have ..... chemical properties because they contain the same

..... group. [3]

[Total: 12]

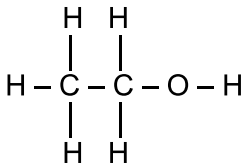
Alcohols Click for more variations

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3 **(a)** **(i)** carbon dioxide [1]
allow CO_2

(ii) any one of: [1]
- room temperature OR temperature quoted from 20–40°C / ignore low temperature / high temperature
- yeast / enzymes / zymase
  ignore catalyst alone
  ignore microbes / viruses / bacteria
- absence of oxygen / anaerobic
- pH 7 / pH near neutral

(b) **(i)** H – O – H [1]
not H_2O

 [1]

allow – OH in place of – O – H
not C_2H_5OH

(ii) aqueous bromine / bromine water [1]
allow bromine / aqueous (acidified) potassium permanganate

turns colourless / decolourises [1]
ignore goes clear

(c) carbon dioxide [1]
water [1]

(d) homologous [1]
similar [1]
functional [1]

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4 **(a)** Fig. 7.1 shows the displayed formula of mesaconic acid.

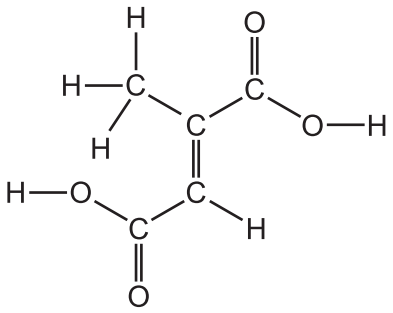


Fig. 7.1

(i) On Fig. 7.1 draw a circle around **one** carboxylic acid functional group. [1]

(ii) Deduce the molecular formula of mesaconic acid.

..... [1]

(iii) Mesaconic acid is a colourless compound.

Describe the colour change when excess mesaconic acid is added to aqueous bromine.

from ..... to ..... [2]

(b) Ethanoic acid belongs to the homologous series of carboxylic acids.

Define the term homologous series.

.....

..... [2]

(c) Complete the word equation for the reaction of ethanoic acid with magnesium.

ethanoic acid	+	magnesium	→	....	+	.....

[2]

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(d) Ethanoic acid reacts with ethanol.
The organic product has the molecular formula $C_4H_8O_2$.

Complete Table 7.1 to calculate the relative molecular mass of $C_4H_8O_2$.

Table 7.1

atom	number of atoms	relative atomic mass	
carbon	4	12	$4 \times 12 = 48$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

(e) Ethanol can be manufactured by fermentation.

Complete the word equation for one **other** method of manufacturing ethanol.

..... + ... → ethanol [2]

[Total: 12]

Alkenes Click for more variations

Reduced to 77% to fit the page (wider than A4).

4(a)(i)	circle around one or both COOH groups	**1**
4(a)(ii)	$C_5H_6O_4$	**1**
4(a)(iii)	orange (1) to colourless (1)	**2**
4(b)	(family / group of similar) **compounds** with similar chemical properties (1) having the same functional group (1)	**2**
4(c)	magnesium ethanoate (1) hydrogen (1)	**2**
4(d)	88 (2) If 2 marks not scored 1 mark for 32 (for O) OR 8 (for H)	**2**
4(e)	ethene (1) steam / water (1)	**2**

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5

Fats and oils

Unsaturated fats and oils contain at least one carbon to carbon double bond.
These double bonds react with bromine water which changes colour from orange to colourless.

Plan an experiment that could be carried out to compare samples of sunflower oil, olive oil and butter to find out which of these contains the largest number of carbon to carbon double bonds.

You are provided with common laboratory apparatus and an organic solvent to dissolve the fats and oils.

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

[Total: 7]

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Practical skills: planning, apparatus, measuring and results Click for more variations

5 any 7 from: [7]

known mass or volume of fats/oil (1)

add organic solvent (1)

shake/stir (1)

add drops of bromine water (1)

until orange colour seen (1)

read and record volume/number of drops (1)

compare oils (1)

conclusion (1)

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6 Alkenes and alkanes are homologous series of compounds containing carbon and hydrogen atoms.

(a) State the name of the type of compound made from carbon and hydrogen atoms only.

..... [1]

(b) Alkenes take part in addition reactions.

(i) Describe what is meant by the term *addition reaction*.

..... [1]

(ii) Draw the structure of the product made in the addition reaction between propene and bromine. Show all of the atoms and all of the bonds.

[2]

(iii) Describe the colour change seen when propene is added to aqueous bromine.

from ..... to ..... [2]

(iv) Draw the structures of molecules of **two** different alkenes which both undergo an addition reaction with steam to form butan-2-ol. Show all of the atoms and all of the bonds.

[2]

(c) Propane undergoes a substitution reaction with chlorine.

Write the chemical equation for the reaction between one molecule of propane and one molecule of chlorine.

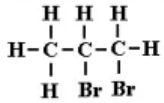
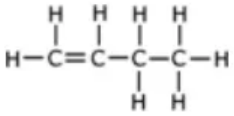
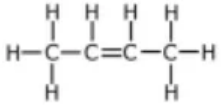
..... [2]

[Total: 10]

Alkenes Click for more variations

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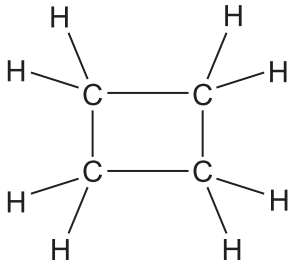
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6(a)	hydrocarbon	1
6(b)(i)	(only) one product is formed	1
6(b)(ii)	 3 single bonded C atoms entire molecule correct	2
6(b)(iii)	orange (1) to colourless (1)	2
6(b)(iv	structure of but-1-ene  structure of but-2-ene 	2
6(c)	$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$ HCl as product rest of equation	2

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

$$CH_3 — CH_2 — CH = CH_2$$

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]

Introduction to organic chemistry Click for more variations

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7 **(a) (i)** same molecular formula / same number of C and H atoms [1]
different structural formula or structure [1]
same compound = [1]

(ii) correct **formula** of but-2-ene / methylpropene / methyl cyclopropane [1]

(iii) bromine / bromine water / aqueous bromine [1]
brown to colourless **not** clear [1]
stays brown [1]
brom**ide** loses the first mark only

OR alkaline potassium manganate(VII) [1]
from purple/pink to green/brown [1]
stays purple [1]

OR acidic potassium manganate(VII) [1]
from purple/pink to colourless **not** clear [1]
stays purple [1]

(b) heat / high temperature (temperature need not be stated, but if it is stated it must be 500ºC or above) [1]

catalyst (need not be named, but if they are named accept any metal oxide or zeolite / aluminosillicates / silicon dioxide) [1]
not nickel/platinum

(c) (1,2)dibromobutane [1]
if numbers given must be correct
butane [1]
butanol [1]
accept butan-1-ol or butan-2-ol **not** but-1-ol / but-1-anol / buthanol

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8 Compound **E** shown in Fig. 6.1 is an ester.

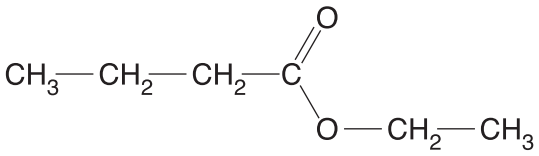


Fig. 6.1

(a) **On Fig. 6.1**, draw a circle around all the atoms which make up the ester linkage. [1]

(b) Name compound **E**.

..... [1]

(c) Deduce the empirical formula of compound **E**.

..... [1]

(d) Compound **E** is produced when two different compounds react together in the presence of a catalyst.

(i) Name the **two** compounds that react together to produce compound **E**.

1 .....

2 .....
[2]

(ii) Suggest a suitable catalyst for this reaction.

..... [1]

(e) Determine the number of unbranched esters which have the molecular formula $C_5H_{10}O_2$.

..... [1]

(f) All unbranched esters with the molecular formula $C_5H_{10}O_2$ combust completely to form carbon dioxide and water only.

Write the symbol equation for the complete combustion of $C_5H_{10}O_2$.

..... [1]

[Total: 8]

Carboxylic acids and esters Click for more variations

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8(a)	correctly circled ester link (including 2 C atoms and 2 O atoms)	1
8(b)	ethyl butanoate	1
8(c)	C_3H_6O	1
8(d)(i)	**M1** butanoic acid **M2** ethanol	2
8(d)(ii)	acid	1
8(e)	4	1
8(f)	$2C_5H_{10}O_2 + 13O_2 \rightarrow 10CO_2 + 10H_2O$	1

9 Methanol, CH_3OH, is a member of the homologous series of alcohols.

(a) Methanol can be made from methane in a two-step process.

step 1 Methane is reacted with chlorine gas to produce chloromethane, CH_3Cl.

step 2 CH_3Cl is reacted with sodium hydroxide to produce CH_3OH and one other product.

(i) What conditions are needed in **step 1**?

..... [1]

(ii) Write the chemical equation for the reaction which occurs in **step 1**.

..... [1]

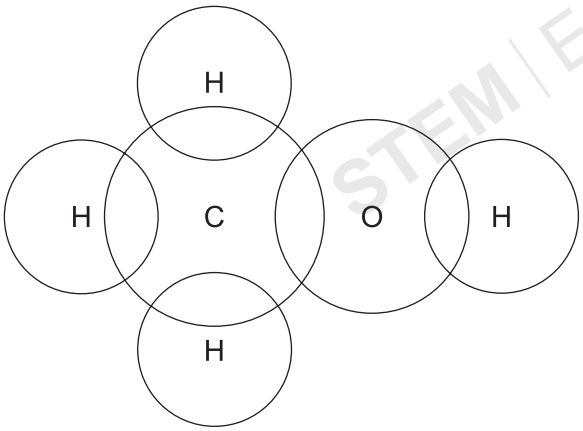
(iii) State the type of organic reaction occurring in **step 1**.

..... [1]

(iv) Complete the chemical equation for **step 2**.

$CH_3Cl + NaOH \rightarrow CH_3OH +$ ..... [1]

(b) Draw a dot-and-cross diagram to show the electron arrangement in a molecule of methanol. Show outer shell electrons only.



[2]

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(c) Methanol reacts with propanoic acid to form an ester with a molecular formula $C_4H_8O_2$.

(i) Name the ester formed when methanol reacts with propanoic acid.

..... [1]

(ii) Name **one** other substance formed when methanol reacts with propanoic acid.

..... [1]

(iii) Draw the structure of an ester which is a structural isomer of the ester named in **(c)(i)**. Show all of the atoms and all of the bonds.

[3]

(iv) State the conditions needed to form an ester from a carboxylic acid and an alcohol.

..... [1]

[Total: 12]

Alkanes Click for more variations

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9(a)(i)	ultraviolet light	1
9(a)(ii)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$	1
9(a)(iii)	substitution	1
9(a)(iv)	$NaCl$	1
9(b)	all bonding pairs correct (1) H atoms have 2 electrons and C and O atoms have 8 electrons (1)	2
9(c)(i)	methyl propanoate	1
9(c)(ii)	water	1
9(c)(iii)	molecular formula = $C_4H_8O_2$ (1) correct ester link showing all atoms and all bonds (1) rest of molecule (1)	3
9(c)(iv)	(acid) catalyst	1

10 Ethanol, C_2H_5OH, belongs to the homologous series called alcohols.

(a) Write the general formula of alcohols.

..... [1]

(b) Explain why ethanol **cannot** be described as a hydrocarbon.

..... [1]

(c) Ethanol can be manufactured from different substances by reaction with steam or by fermentation.

(i) Give the formula of the substance which reacts with steam to form ethanol.

..... [1]

(ii) Name a substance which will undergo fermentation to form ethanol.

..... [1]

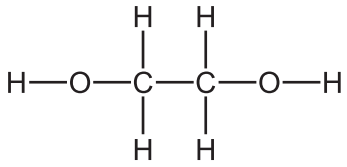
(d) Ethanol is a fuel.

Write the chemical equation for the complete combustion of ethanol.

..... [2]

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(e) Ethane-1,2-diol has two alcohol functional groups.



One molecule of ethane-1,2-diol will react with two molecules of ethanoic acid to form molecule **X**.

X has two ester functional groups and a molecular formula of $C_6H_{10}O_4$.

(i) State the empirical formula of **X**.

..... [1]

(ii) Draw the structure of **X**.

Show all of the atoms and all of the bonds.

[2]

(iii) Name the **other** substance formed in this reaction.

..... [1]

(f) Each alcohol functional group in ethane-1,2-diol reacts with acidified potassium manganate(VII) to form a different organic compound, **Y**.

(i) Name the functional groups formed in **Y**.

..... [1]

(ii) Draw the structure of **Y**.

Show all of the atoms and all of the bonds.

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[1]

[Total: 12]

Alcohols Click for more variations

10(a)	$C_nH_{2n+1}OH$ (1)	**1**
10(b)	not all atoms are C or H	**1**
10(c)(i)	C_2H_4	**1**
10(c)(ii)	glucose	**1**
10(d)	$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$ species (1) correct equation (1)	**2**
10(e)(i)	$C_3H_5O_2$	**1**
10(e)(ii)	any one ester link (1) rest of molecule (1)	**2**
10(e)(iii)	water	**1**
10(f)(i)	carboxylic acid	**1**
10(f)(ii)	structure of ethanedioic acid	**1**

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