4.2 Alcohols acids and esters

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

Objective

Build the skills to answer exam questions on **alcohols, carboxylic acids and esters** 、 : making ethanol by fermentation and by hydration of ethene, oxidation of ethanol, reactions of carboxylic acids, and making esters.

You must be able to:

- name alcohols, carboxylic acids and esters
- compare fermentation and the hydration of ethene
- write equations for the reactions of ethanoic acid
- calculate reacting masses in organic reactions

1 Key knowledge and worked examples

■ Ethanol and its products

idea	rule
functional groups	alcohols −OH; carboxylic acids −COOH; esters −COO−
fermentation	glucose → ethanol + carbon dioxide, using yeast
hydration of ethene	ethene + steam → ethanol (300 °C, 60 atm, catalyst)
oxidation	ethanol → ethanoic acid (bacteria in air, or potassium dichromate)
esters	alcohol + acid ⇌ ester + water; ethanol + ethanoic acid gives ethyl ethanoate

Worked example 1: naming an ester. Name the ester made from methanol and propanoic acid.

1. Known: alcohol methanol; acid propanoic acid.
2. Rule: alcohol part (-yl) then acid part (-oate).
3. Numbers: methyl + propanoate.
4. Result: **methyl propanoate**.

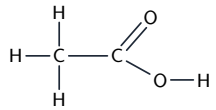
Worked example 2: reacting mass. Find the mass of carbon dioxide made when 90 g of glucose ferments (M_r: glucose 180, CO_2 44).

1. Known: $90 \div 180 = 0.50$ mol glucose; ratio 1 : 2.
2. Rule: mass = moles $\times M_r$.
3. Numbers: 1.0 mol $\times 44$.
4. Result: 44 **g**.

Answer shapes: when comparing two methods, compare the same points for both: raw material, rate, purity, energy.

2 Practice

2.1 Name the homologous series of the compound shown, and give the functional group of an alcohol. [2]



2.2 Give **two** conditions needed for fermentation, other than yeast. [2]



2.3 Name the **three** products when ethanoic acid reacts with sodium carbonate. [2]



3 Exam-style questions

3.1 Write the equation for ethanol reacting with ethanoic acid to make ethyl ethanoate, and name the catalyst. [3]



3.2 A country can make ethanol by fermentation or by the hydration of ethene. The table compares the two methods. (M_r: glucose 180, ethanol 46)

(a) Calculate the maximum mass of ethanol that can be made from 180 g of glucose. [3]

	fermentation	hydration of ethene
raw material	sugar (crops)	ethene (crude oil)
conditions	35 °C, 1 atm	300 °C, 60 atm
rate	slow, batch	fast, continuous
product	about 15% ethanol	pure ethanol

(b) Explain why fermentation is done at about 35 °C and not at 80 °C, and describe how ethanol is separated from the fermentation mixture. [4]

(c) The country grows a lot of sugar cane but has no crude oil. Evaluate which method it should use. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- carboxylic acids
- $-\mathrm{OH}$

2.2

Any two (1 mark each):

- a temperature of about 30–40 °C
- no air (anaerobic)
- sugar dissolved in water

2.3

- sodium ethanoate, water and carbon dioxide

3.1

- $\mathrm{C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O}$
- concentrated sulfuric acid

3.2

(a) moles glucose = 1; moles ethanol = 2; $2 \times 46 =$ **92** g

(b) yeast enzymes work best at about 35 °C; at 80 °C the enzymes are denatured, so fermentation stops; separate by fractional distillation; ethanol boils at 78 °C, below water, so it evaporates first and is condensed and collected

(c) points to include:

- fermentation uses sugar cane, a renewable raw material the country already grows (App)
- hydration needs ethene from crude oil, which the country would have to import (App)
- fermentation is slow (a batch process) and gives only about 15% ethanol, so it needs distillation (K)
- hydration is fast, continuous and gives pure ethanol, but needs high temperature and pressure, which cost energy (K)
- fermentation uses low temperature and pressure, so it needs less energy (An)
- conclusion: fermentation fits this country best, though land is needed to grow the cane (An)

Levels: **5–6** a full, logical answer with correct chemistry and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.

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