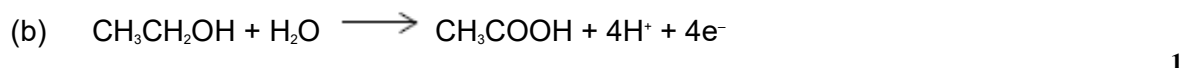


M1.(a) A mixture of liquids is heated to boiling point for a prolonged time 1

Vapour is formed which escapes from the liquid mixture, is changed back into liquid and returned to the liquid mixture 1

Any ethanal and ethanol that initially evaporates can then be oxidised 1



(c) Mixture heated in a suitable flask / container
A labelled sketch illustrating these points scores the marks 1

With still head containing a thermometer 1

Water cooled condenser connected to the still head and suitable cooled collecting vessel 1

Collect sample at the boiling point of ethanal 1

Cooled collection vessel necessary to reduce evaporation of ethanal 1

(d) Hydrogen bonding in ethanol and ethanoic acid or no hydrogen bonding in

ethanal 1

Intermolecular forces / dipole-dipole are weaker than hydrogen bonding 1

(e) Reagent to confirm the presence of ethanal:

Add Tollens' reagent / ammoniacal silver nitrate / aqueous silver nitrate followed by 1 drop of aqueous sodium hydroxide, then enough aqueous ammonia to dissolve the precipitate formed

OR

Add Fehling's solution 1

Warm

M2 and M3 can only be awarded if M1 is given correctly 1

Result with Tollen's reagent:

Silver mirror / black precipitate

OR

Result with Fehling's solution:

Red precipitate / orange-red precipitate 1

Reagent to confirm the absence of ethanoic acid

Add sodium hydrogencarbonate or sodium carbonate 1

Result; no effervescence observed; hence no acid present 1

M5 can only be awarded if M4 is given correctly

OR

Reagent; add ethanol and concentrated sulfuric acid and warm
 Result; no sweet smell / no oily drops on the surface of the liquid,
 hence no acid present

[16]

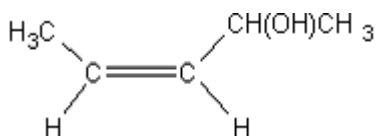
M2. (a) Pentan-2-one
ONLY but ignore absence of hyphens

1

(b) Functional group (isomerism)
Both words needed

1

(c) (i)



Award credit provided it is obvious that the candidate is drawing the Z / cis isomer

The group needs to be CHOHCH₃ but do not penalise poor C–C bonds or absence of brackets around OH

Trigonal planar structure not essential

1

(ii) Restricted rotation (about the C=C)

OR

No (free) rotation (about the C=C)

1

(d)

| | |
|---|--|
| <p>M1 Tollens' (reagent) <i>(Credit ammoniacal silver nitrate OR a description of making Tollens')</i> <i>(Do not credit Ag⁺, AgNO₃ or [Ag(NH₃)₂]⁺ or "the silver mirror test")</i></p> | <p>M1 Fehling's (solution) / Benedict's <i>(Penalise Cu²⁺(aq) or CuSO₄ but mark M2 and M3)</i></p> |
|---|--|

| | |
|--|---|
| <i>on their own, but mark M2 and M3)</i> | |
| M2 <u>silver mirror</u> OR <u>black solid or black precipitate</u> | M2 <u>Red solid/precipitate</u> (Credit <u>orange</u> or <u>brown solid</u>) |
| M3 (stays) colourless OR no (observed) change / no reaction | M3 (stays) blue OR no (observed) change / no reaction |

If M1 is blank CE = 0, for the clip

Check the partial reagents listed and if M1 has a totally incorrect reagent, CE = 0 for the clip

Allow the following alternatives

M1 (acidified) potassium dichromate(VI) (solution); mark on from incomplete formulae or incorrect oxidation state

M2 (turns) green

M3 (stays) orange / no (observed) change / no reaction

OR

M1 (acidified) potassium manganate(VII) (solution); mark on from incomplete formulae or incorrect oxidation state

M2 (turns) colourless

M3 (stays) purple / no (observed) change / no reaction

In all cases for M3

Ignore “nothing (happens)”

Ignore “no observation”

3

(e) (i) **Spectrum is for Isomer 1**

or named or correctly identified

The explanation marks in (e)(ii) depend on correctly identifying Isomer 1.

The identification should be unambiguous but candidates should not be penalised for an imperfect or incomplete name. They may say “the alcohol” or the “alkene” or the “E isomer”

1

(ii) **If Isomer 1 is correctly identified, award any two from**

- (Strong / broad) absorption / peak in the range

3230 to 3550 cm^{-1} or specified value in this range
or **marked correctly** on spectrum

and

(characteristic absorption / peak for) OH group / **alcohol** group

- No absorption / peak in range **1680 to 1750** cm^{-1} or
absence **marked correctly** on spectrum
and
(No absorption / peak for a) **C=O** group / **carbonyl** group /
carbon-oxygen double bond

- Absorption / peak in the range **1620 to 1680** cm^{-1}
or specified value in this range or marked correctly
on spectrum
and

(characteristic absorption / peak for) **C=C** group
/ **alkene** / **carbon-carbon double bond**

If 6(e)(i) is incorrect or blank, CE=0

Allow the words “dip” OR “spike” OR “trough” OR “low transmittance” as alternatives for absorption.

Ignore reference to other absorptions e.g. C-H, C-O

2

[10]

M3.(Mix the alcohol with warm) $\text{K}_2\text{Cr}_2\text{O}_7 / \text{H}^+$ allows 3° identification by lack of reaction
Scheme must allow the alcohol to be distinguished to get all marks.

1

Distillation of initial product needed for 1° / 2°

If distillation stage not clear then max. 2 (M1 and M3).

Awareness of correct reactions / lack of reaction relating to each class of alcohol is worth 1 mark.

1

Effect of Tollens' / Fehling's on oxidation product to identify 1° or 2° (by default)

Reacting Tollens' / Fehling's with alcohols directly is incorrect and gains no M2 or M3.

Detailed observations relating to the reactions are not

needed but should be penalised where incorrect.

1

[3]

M4.(a) (i) CH₂O

Atoms in any order

Accept a clear indication that C₆H₁₂O₆ yields CH₂O as the answer

1

(ii) No peak / no absorption / no C=O in the **range 1680 to 1750** (cm⁻¹)
(suggesting no evidence of C=O)

Allow the words "dip", "spike", "low transmittance" and "trough" as alternatives for absorption

Ignore references to other wavenumbers

1

(b) M1 C₆H₁₂O₆ \longrightarrow 2CH₃CH₂OH + 2CO₂

Penalise (C₂H₆O)

Allow multiples of the equation in M1

Either order

M2 (enzymes from) yeast or zymase

M3 25 °C ≤ T ≤ 42 °C OR 298 K ≤ T ≤ 315 K

For M2 and M3

Ignore "aqueous"

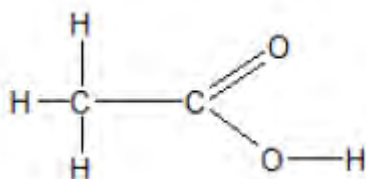
Ignore "anaerobic / absence of oxygen"

Ignore "controlled pH"

Ignore "warm"

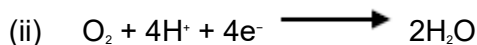
3

(c) (i) Displayed formula for CH₃COOH



All bonds must be drawn out, but ignore bond angles

1



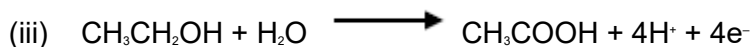
Ignore state symbols

Negative charge on electron not essential

Accept multiples

Accept electrons subtracted from RHS

1



(C_2H_6O or C_2H_5OH)

Ignore state symbols

Negative charge on electron not essential

Accept multiples

Accept electrons subtracted from LHS

1

(iv) M1 Acidified potassium or sodium dichromate

For M1, it must be a whole reagent and / or correct formulae

OR H_2SO_4 / $K_2Cr_2O_7$ OR H^+ / $K_2Cr_2O_7$ etc.

Do not penalise incorrect attempt at formula if name is correct or vice versa

OR correct combination of formula and name

If oxidation state given in name, it must be correct, but mark on from an incorrect attempt at a correct reagent.

M2 (requires an attempt at M1)

orange to green

*Credit **acidified** potassium chromate(VI) / H_2SO_4 + K_2CrO_4*

Possible alternative

M1 (acidified) potassium manganate(VII) **OR** $KMnO_4$ / H_2SO_4

M2 purple to colourless

Other alternatives will be accepted but M2 is dependent on M1 in every case

M2 requires an attempt at a correct reagent for M1

Ignore reference to states

2

(d) (i) An activity which has no net / overall (annual) carbon emissions to the

atmosphere / air

The idea that the carbon / CO₂ given out equals the carbon / CO₂ that was taken in from the atmosphere / air

OR

An activity which has no net / overall (annual) greenhouse gas emissions to the atmosphere / air.

Answer must refer to the atmosphere or air

OR

There is no change in the total amount of carbon dioxide / carbon / greenhouse gas present in the atmosphere / air

1

(ii) Renewable / sustainable ONLY

Ignore references to global warming or greenhouse gases

1

(iii) **Any one statement about this process from**

Subject to weather / climate

Ignore "batch"

OR

Depletes food supply OR the land use for (specified) food

OR

Requires use of / uses more fossil fuels

OR

Not carbon-neutral OR CO₂ produced during a named process (eg harvest, transport etc.)

OR

Slow process / slow rate of reaction / takes a long time (to grow crops)

OR

This route leads to the production of a mixture of water and ethanol / impure ethanol that requires separation / further processing

1

[13]

M5. (a) M1 Safety (in Process 1)

Sodium hydroxide / alkali is corrosive / harmful / caustic or sodium hydroxide is alkali(ne)

Ignore references to chromium compounds

OR

Bromine compounds are toxic / poisonous

“Carbon-neutral” alone is insufficient for M2

M2 Environmental

Ignore references to greenhouse gases

Process 2 could be used as a carbon sink / for carbon capture

OR

uses waste / recycled CO₂ / CO₂ from the factory / CO₂ from the bioethanol (or biofuel) production

OR

reduces or limits the amount of CO₂ released / given out (into the atmosphere)

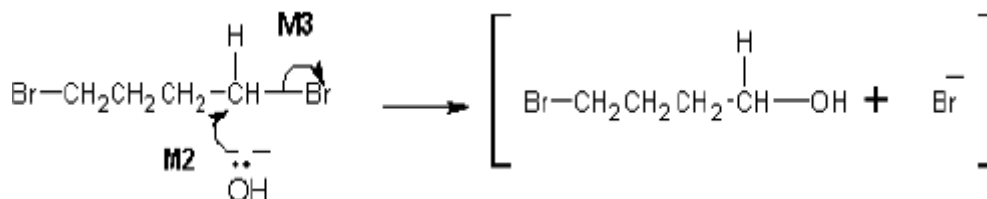
OR

Process 2 uses renewable glucose / renewable resource(s)

2

(b) (i) M1 nucleophilic substitution

For M1, both words required



M2 must show an arrow from the lone pair of electrons on the oxygen atom of the negatively charged hydroxide ion to the C atom.

Penalise M2 if covalent NaOH / KOH is used

Penalise one mark from M2 or M3 if half-headed arrows are used

M3 must show the movement of a pair of electrons from the C–Br bond to the Br atom. Mark **M3** independently provided it is from the original molecule

Penalise M3 for formal charge on C of the C–Br or incorrect partial charges on C–Br

Penalise once only for a line and two dots to show a bond.

For **M2** and **M3** award full marks for an S_N1 mechanism

*For **M2** and **M3**, maximum 1 of 2 marks for the mechanism if wrong reactant is used.*

*Penalise **M3** if an extra arrow is drawn from the Br of the C–Br bond to, for example, K⁺*

Accept the correct use of “sticks

NB The arrows here are double-headed

3

(ii) **M1** B

M2 C

M3 A

3

(c) **M1** fermentation

*Mark **M2** to **M4** independently*

Three conditions in any order for **M2 to **M4****

Penalise “bacteria” and “phosphoric acid” using the list principle

M2 (enzymes from) yeast or zymase

M3 25°C ≤ T ≤ 42°C OR 298 K ≤ T ≤ 315 K

Ignore reference to “aqueous” or “water”, “closed container”, “pressure”, “lack of oxygen”, “concentration of ethanol” and “batch process” (i.e. not part of the list principle)

M4 anaerobic / no oxygen / no air OR neutral pH

4

(d) **M1** primary OR 1° (alcohol)

Mark independently

M2 acidified potassium or sodium dichromate

*For **M2**, it must be a whole reagent and/or correct formulae*

OR H₂SO₄ / K₂Cr₂O₇ OR H⁺ / K₂Cr₂O₇

Do not penalise incorrect attempt at formula if name is correct or vice versa

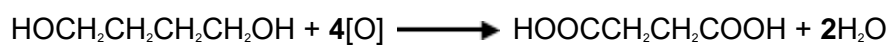
Accept phonetic spelling

If oxidation state given in name, it must be correct.

For **M2** accept acidified potassium manganate(VII)

OR correct combination of formula and name

M3



For **M3** structures must be correct and not molecular formula

3

[15]