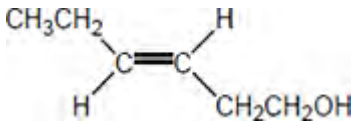
M1.(a)



1

(b)

1

(c) **Stage 1**: consider the groups joined to right hand carbon of the C=C bond

Extended response

Maximum of 5 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

Consider the atomic number of the atoms attached

M1 can be scored in stage 1 or stage 2

1

C has a higher atomic number than H, so CH_2OH takes priority

1

Stage 2: consider the groups joined to LH carbon of the C=C bond

Both groups contain C atoms, so consider atoms one bond further away

1

C, (H and H) from ethyl group has higher atomic number than H, (H and H) from methyl group, so ethyl takes priority

1

Stage 3: conclusion

The highest priority groups, ethyl and CH_2OH are on same side of the C=C bond so the isomer is Z

Allow M5 for correct ECF conclusion using either or both wrong priorities deduced in stages 1 and 2

1

The rest of the IUPAC name is 3-methylpent-2-en-1-ol

1

(d) Moles of maleic acid = 10.0 / 116.0 = 8.62×10^{-2}

AND mass of organic product expected = $(8.62 \times 10^{-2}) \times 98.0 = 8.45$ g

Or moles of organic product formed = 6.53 / 98.0 = 6.66×10^{-2}

1

% yield = 100 × 6.53 / 8.45

OR = $100 \times (6.66 \times 10^{-2}) / (8.62 \times 10^{-2})$

= 77.294 = 77.3%

AND statement that the student was NOT correct

1

[10]

M2. (a) $CH_3COCl + AlCl_3 \rightarrow CH_3\overset{+}{C}O + \overset{-}{AlCl_4}$

(1) equation (1)

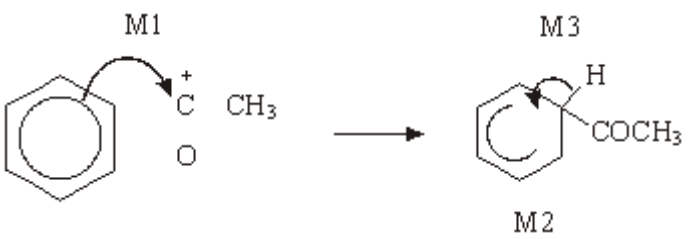
2

penalise wrong alkyl group once at first error
position of + on electrophile can be on O or C or outside [ ]
penalise wrong curly arrow in the equation or lone pair on $AlCl_3$ else ignore

Electrophilic substitution

NOT F/C acylation

1



horseshoe must not extend beyond C2 to C6 but can be smaller

+ not too close to C1

M3 arrow into hexagon unless Kekule

allow M3 arrow independent of M2 structure

M1 arrow from within hexagon to C or to + on C

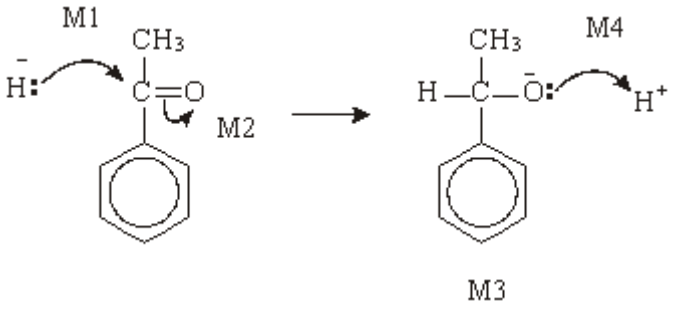
+ must be on C of $\overset{+}{\text{RCO}}$

3

(b) Nucleophilic addition

NOT reduction

1



M2 not allowed independent, but can allow M1 for attack of H^- on C+ formed

4

1–phenylethan(–1–)ol or (1–hydroxyethyl)benzene

1

(c) dehydration or elimination

1

(conc) H_2SO_4 or (conc) H_3PO_4

allow dilute and Al_2O_3

Do not allow iron oxides

1

[14]

M3. (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 CO_2 / CO_2 from the factory / CO_2 from the bioethanol (or biofuel) production

OR

reduces or limits the amount of CO_2 released / given out (into the atmosphere)

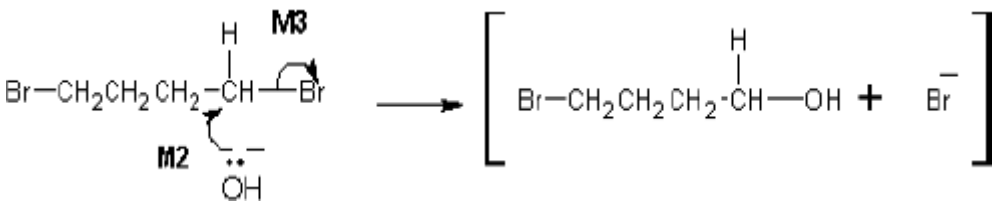
OR

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** <u>fermentation</u>

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

Three conditions <u>in any order</u> 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 <u>acidified potassium or sodium dichromate</u>

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

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

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

$HOCH_2CH_2CH_2CH_2OH + \mathbf{4}[O] \longrightarrow HOOCCH_2CH_2COOH + \mathbf{2}H_2O$

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

3

[15]

M4.(a) To prevent vigorous boiling / uneven boiling / bubbling vigorously

Reference to an effect on 'reaction' here loses this mark.

1

(b) Condenser

Accept 'condensation chamber' or 'condensation tube'.

1

Should show effective water jacket and central tube

If a flask is also drawn then the condenser must be at an appropriate angle.

Apparatus must clearly work.

Ignore direction of water flow.

Diagram must have a clear flow of vapour and water eg unblocked central tube or flow indicated by arrows.

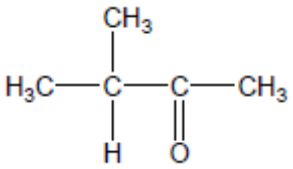
1

[3]

M5.(a) 3-methylbutan-2-ol

1

(b)



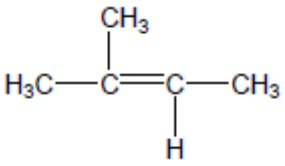
Allow $(CH_3)_2CHCOCH_3$

1

(c) Elimination

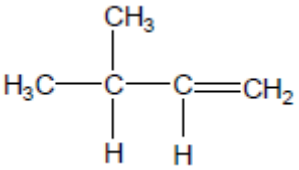
1

(d)



Allow $(CH_3)_2C=CHCH_3$

1



Allow $(CH_3)_2CHCH=CH_2$

1

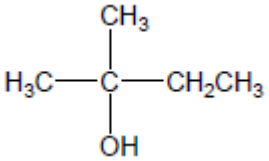
(e) Position

1

(f) C B A

1

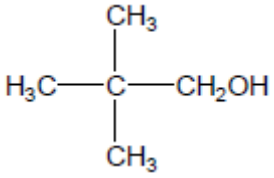
(g)



Allow $(CH_3)_2C(OH)CH_2CH_3$

1

(h)



Allow $(CH_3)_3CCH_2OH$

1

[9]