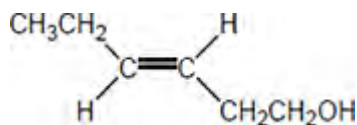


M1.(a)



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<sub>2</sub>OH 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<sub>2</sub>OH 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 =  $10.0 / 116.0 = 8.62 \times 10^{-2}$

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

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

1

% yield =  $100 \times 6.53 / 8.45$

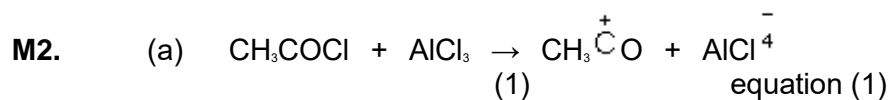
OR =  $100 \times (6.66 \times 10^{-2}) / (8.62 \times 10^{-2})$

=  $77.294 = 77.3\%$

**AND** statement that the student was NOT correct

1

[10]



2

penalise wrong alkyl group once at first error

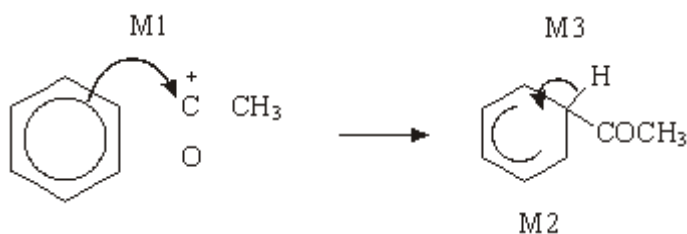
position of + on electrophile can be on O or C or outside [ ]

penalise wrong curly arrow in the equation or lone pair on  $\text{AlCl}_3$  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

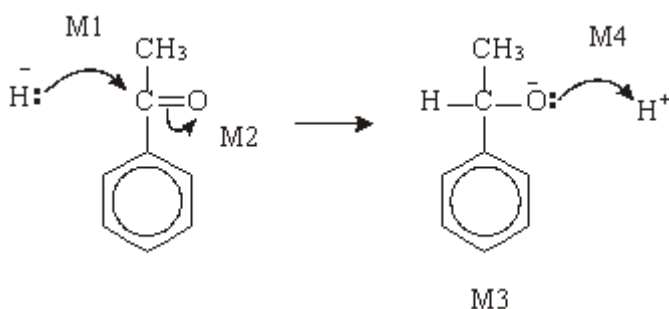
+ must be on C of  $\overset{+}{\text{R}}\text{CO}$

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)  $\text{H}_2\text{SO}_4$  or (conc)  $\text{H}_3\text{PO}_4$

*allow dilute and  $\text{Al}_2\text{O}_3$*

*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<sub>2</sub> / CO<sub>2</sub> from the factory / CO<sub>2</sub> from the bioethanol (or biofuel) production

**OR**

reduces or limits the amount of CO<sub>2</sub> released / given out (into the atmosphere)

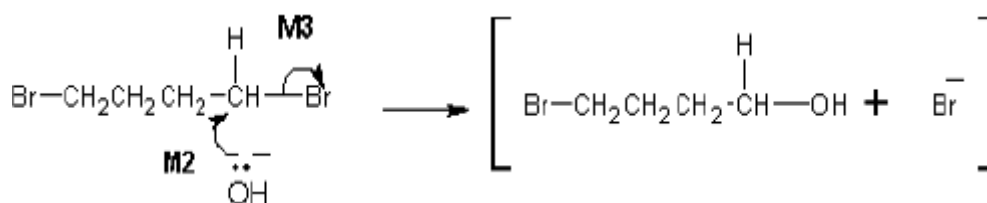
**OR**

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<sub>N</sub>1 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<sup>+</sup>*

*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** H<sub>2</sub>SO<sub>4</sub> / K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> OR H<sup>+</sup> / K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>

*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]

**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.*

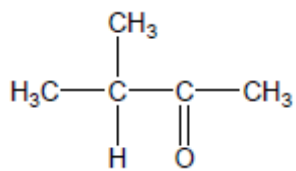
1

[3]

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

1

(b)



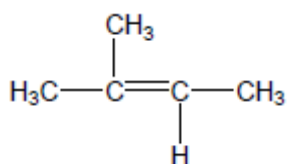
Allow  $(\text{CH}_3)_2\text{CHCOCH}_3$

1

(c) Elimination

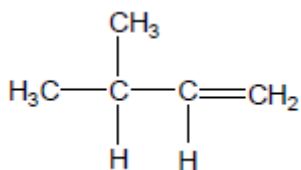
1

(d)



Allow  $(\text{CH}_3)_2\text{C}=\text{CHCH}_3$

1



Allow  $(\text{CH}_3)_2\text{CHCH}=\text{CH}_2$

1

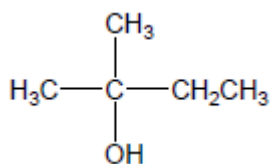
(e) Position

1

(f) C B A

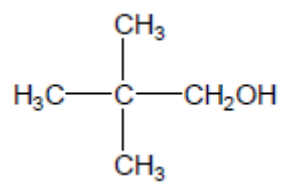
1

(g)



Allow  $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}_2\text{CH}_3$

(h)



*Allow (CH<sub>3</sub>)<sub>3</sub>CCH<sub>2</sub>OH*

1

[9]