M1. (a) (i) UV light OR sunlight OR T $\geq$ 450°C **(1)**
NOT high T

(ii) (free) radical substitution **(1)**

(iii) CCl_4 **(1)** OR named

3

(b) (i) $CH_3Cl + KCN \rightarrow CH_3CN + KCl$ **(1)**
CN^- Cl^-

(ii) nucleophilic substitution **(1)**

(iii) C–Br bond is weaker (than C–Cl bond)
OR C–Br bond enthalpy is less than C–Cl **(1)**
Ignore electronegativity

3

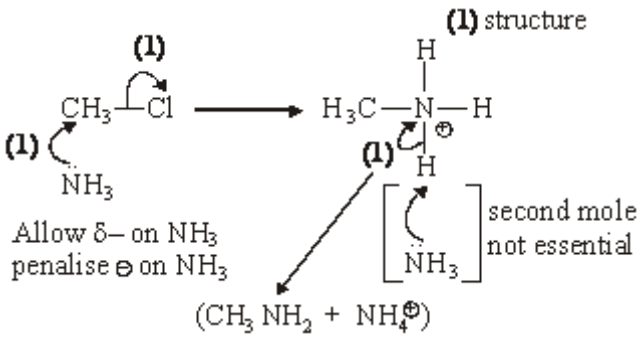
(c) CH_3COOH OR ethanoic acid **(1)**

1

(d) (i) $\overset{\delta+}{C}-\overset{\delta-}{Cl}$ OR C–Cl is polar **(1)** OR C atom is electron deficient / $\delta+$

(ii) methylamine **(1)** only

(iii) S_N1 scores full marks



6

[13]

M2. (a) Reaction 2: NaOH OR KOH **(1)** M1 alcohol (ic) OR ethanol (ic)**(1)** M2

ignore heat

Condition mark linked to correct reagent but award M2 if OH^- or base or alkali mentioned

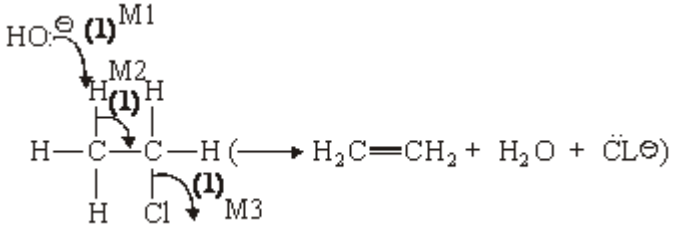
Reaction 3: concentrated H_2SO_4 OR H_3PO_4 M1 **(1)** heat **(1)** M2
OR 150°C - 200°C

Condition mark linked to correct reagent but award M2 if H_2SO_4 or H_3PO_4, but not concentrated

Penalise reagent and condition if dilute H_2SO_4 / H_3PO_4

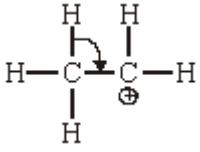
4

(b) Mechanism:



Award M3 *independently*

M1 and M2 must be to / from correct places



E1 mechanism possible in which M2

Name: of mechanism = elimination **(1)**

NOT dehydrohalogenation

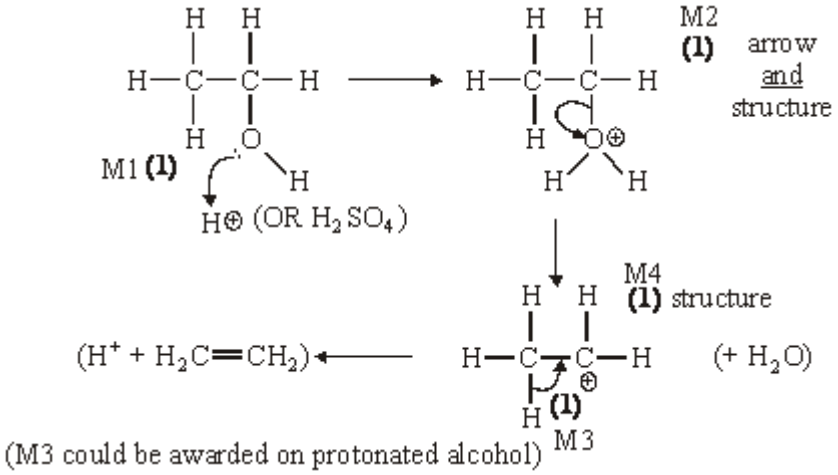
Ignore "base" OR "nucleophilic" before elimination

Reason: Reaction 2 has (very) low yield **(1)**

5

QoL OR chloroethane has to be made (from ethane)
OR chloroethane is expensive
OR chloroethane is not redily available

(c) Mechanism:



Name of mechanism = elimination **(1)**

NOT dehydration alone

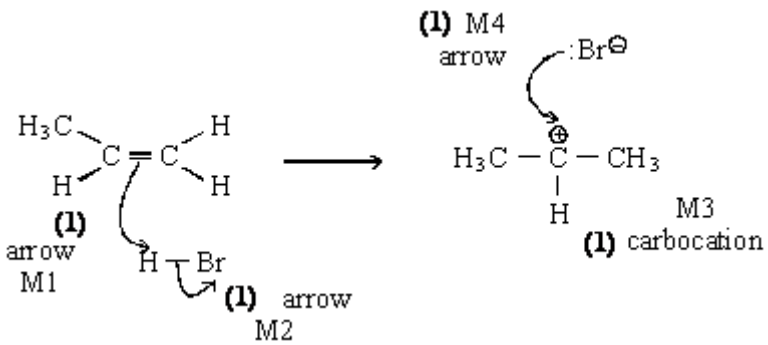
Reason: Ethanol could come from (fermentation of) renewable

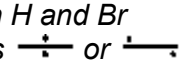
*QoL sugars / glucose / carbohydrates / sources **(1)***

6

[15]

M3. (a) (i)



If wrong carbocation, lose structure mark
If wrong alkene, lose structure mark
Can still score ¾ i.e. penalise M3
Penalise M2 if polarity included incorrectly
no bond between H and Br
bond is shown as  *or*

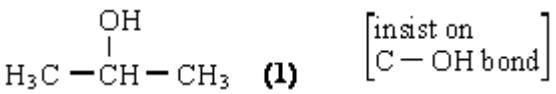
(ii) $CH_3CH_2\overset{\oplus}{C}H_2$ **(1)**

credit secondary carbocation here if primary carbocation has been used in (i)

Ignore attack on this carbocation by $\ddot{B}r^{\ominus}$

5

(b) (i) *Structure*:



(1)

No credit for propan-1-ol even when named correctly

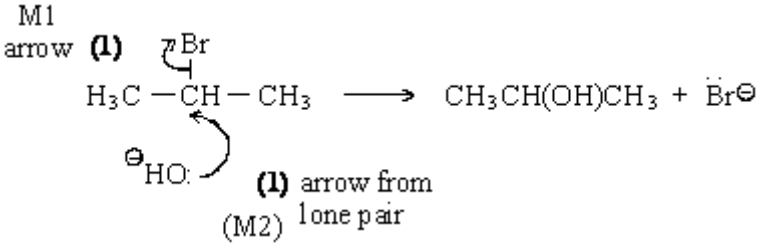
Credit propane-2-ol

Name: propan-2-ol **(1)**

Not 2-hydroxypropane

(ii) *Name of mechanism*: nucleophilic substitution **(1) (both words)**
(NOT S_N1 or S_N2)

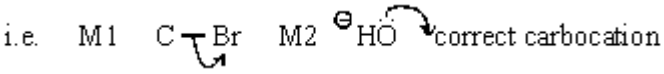
Mechanism:



penalise incorrect polarity on C - Br (M1)

Credit the arrows even if incorrect haloalkane

If S_N1, both marks possible



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(c) (i) elimination **(1)**

Ignore nucleophylic elimination

Penalise electrophilic elimination

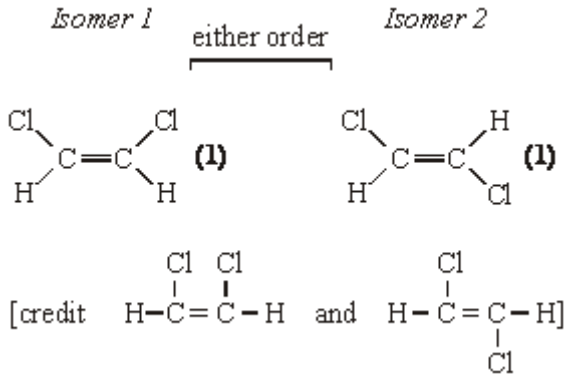
(ii) base **(1)**

OR proton acceptor
NOT nucleophile (base)

2

[12]

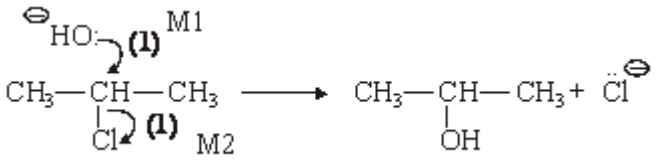
M4. (a) (i)

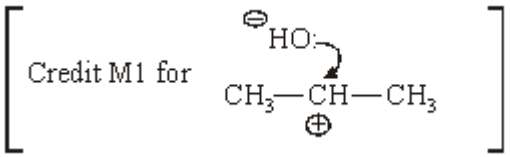


(ii) restricted <u>rotation</u> OR no <u>rotation</u> OR cannot <u>rotate</u> **(1)**

3

(b) (i) *Mechanism*:





M1 and M2 independent
Curly arrows <u>must</u> be from a bond or a lone pair
Do not penalise sticks
Penalise M1 if  *precedes (penalise this once)*
Penalise incorrect $\delta+$ $\delta-$ for M2

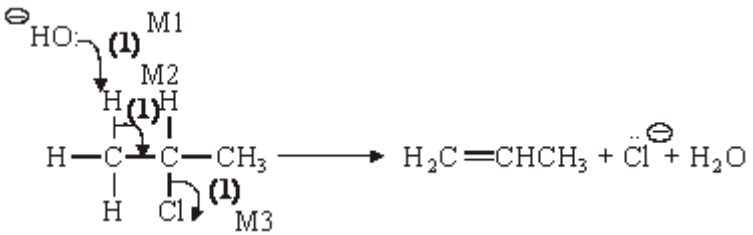
Penalise + on C atom for M2

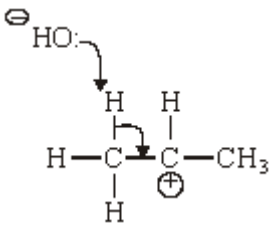
Only allow M1 for incorrect haloalkane

Role of the hydroxide ion: nucleophile **(1)**
electron pair donor
lone pair donor

NOT nucleophilic substitution

(ii) *Mechanism*:





Only allow M1 and M2 for incorrect haloalkane unless RE on (i)

+ charge on H on molecule, penalise M1

M3 independent
M2 must be to correct C–C

M1 must be correct H atom

Credit M1 and M2 via carbocation mechanism

No marks after any attack of C ⊕ by OH^-

Role of the hydroxide ion: base **(1)**
proton acceptor
accepts H^+

7

[10]

M5. (a) (i) $CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$ **(1)**

(ii) UV light / sunlight OR <u>high</u> T OR T ≥ 500°C **(1)**

maxT = 1000°C
NOT heat / light
Ignore pressure

2

(b) *Initial step*: $Cl_2 \rightarrow 2Cl^{\cdot}$ **(1)**

Condition could be on first equation arrow

First propagation step: $CHCl_3 + Cl^{\cdot} \rightarrow \dot{C}Cl_3 + HCl$ **(1)**

Second propagation step: $\dot{C}Cl_3 + Cl_2 \rightarrow CCl_4 + Cl\cdot$ **(1)**

A termination step: $\dot{C}Cl_3 + Cl\cdot \rightarrow CCl_4$ **(1)**

OR $2\dot{C}Cl_3 \rightarrow C_2Cl_6$

Not $2Cl\cdot \rightarrow Cl_2$
Ignore additional termination steps

4

[6]