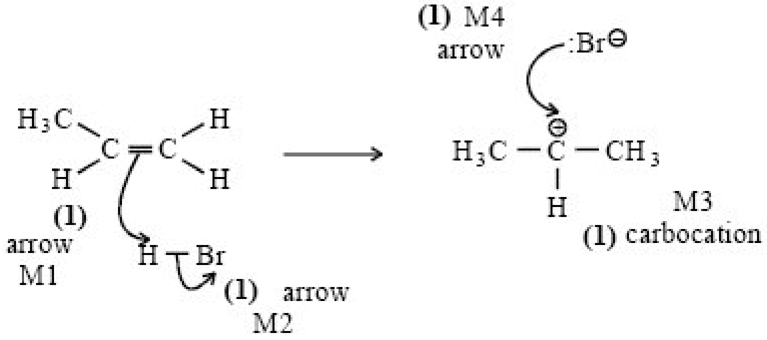
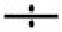
M1.(a) (i)



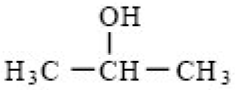
If wrong carbocation, lose structure mark
If wrong alkene, lose structure mark
Can still score ¾ i.e. penalise M3
Penalise M2 if polarity included incorrectly
no bond between H and Br
bond is shown as  or 

4

(ii) ⊕
$CH_3CH_2CH_2$
credit secondary carbocation here if primary carbocation has been used in (i)

Ignore attack on this carbocation by $\ddot{Br}$ ⊖

1

(b) (i) *Structure*: 

$H_3C-\underset{}{\overset{OH}{CH}}-CH_3$ **(1)** [insist on C — OH bond]

1

Name: propan-2-ol

Not 2-hydroxypropane

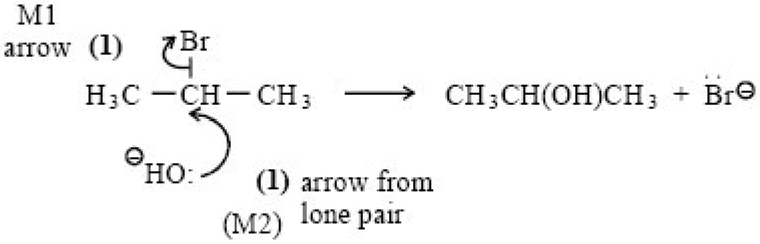
1

(ii) *Name of mechanism*: nucleophilic substitution **(both words)**

(NOT S_N1 or S_N2)

1

Mechanism:



penalise incorrect polarity on C-Br (M1)
Credit ***the arrows*** *even if incorrect haloalkane*
If S_N1, ***both marks*** *possible*

2

(c) (i) elimination

1

(ii) base

OR proton acceptor

NOT nucleophile

1

[12]

M2. (a) (i) Electrophilic addition

(Both words required)

1

(ii) M1 the reaction to form 1-bromopropane goes *via* the primary carbocation OR 1° carbocation

OR *via* $CH_3CH_2\overset{+}{C}H_2$

M2 primary carbocations are less stable than secondary carbocations

(Credit converse arguments for M1 and M2 i.e. the reaction to form 2-bromopropane goes via the secondary carbocation , M1, and secondary carbocations are more stable than primary carbocations, M2)

(Accept the use of "carbonium ions" as an alternative to carbocation)

1

(b) M1 NaOH OR KOH OR correct name

1

M2 aqueous or solution in water *(ignore heat, reflux etc.)*

(Penalise M1 for hydroxide ion alone, but mark on and credit M2)

(Credit M2 ONLY for H_2O as reagent and heat / warm / T=50 to 100°C)

(NaOH(aq) scores M1 and M2 provided it is not contradicted)

(Penalise M2 if NaOH(aq) followed by concentrated or ethanol)

(Penalise M1 and M2 if followed by acid)

1

(c) Ethanolic OR alcoholic OR CH_3CH_2OH / CH_3OH solvent OR aqueous ethanol/alcohol

OR high<u>er</u> temperature *(must be comparative)*

(Ignore heat or heat under reflux)

(Credit part (c) independently from part (b))

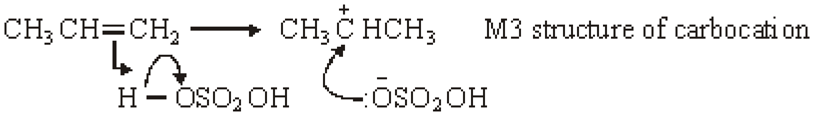
(Penalise "ethanoic")

1

(d) (i) Secondary OR 2°

1

(ii)



M1 arrow from double bond to H of H – O bond

M2 arrow from bond to oxygen atom to show H – O bond breakage

M4 arrow from lone pair of electrons to carbon atom of carbocation

(Penalise M1 if arrow goes to H_2SO_4 or to formal positive charge on H, but ignore partial charges on sulphuric acid unless wrong)

(Credit M2 for H^+ ion)

(For M4, accept negative charge anywhere on the ion)

4

(iii) Catalyst ONLY

(Ignore homogeneous, heterogeneous)

1

[12]

M3. (a) hydration OR (electrophilic) addition

(penalise incorrect words in front of the word "addition" e.g. "nucleophilic")

(penalise "indirect hydration" but credit "direct hydration" or "steam hydration")

1

$H_2C=CH_2 + H_2O \rightarrow CH_3CH_2OH$

(ignore state symbols)

(credit use of C_2H_5OH for ethanol)

(penalise use of C_2H_6O for ethanol on the first occasion)

(credit C_2H_4 and $CH_2=CH_2$ for ethene)

(penalise CH_2CH_2, $CH_2.CH_2$, $CH_2:CH_2$ for ethene on the first occasion)

(ignore H_2SO_4 OR extra H_2O OR H^+ if it appears on both sides)

1

conc. H_2SO_4 OR conc. H_3PO_4

1

(b) (i) Carbon OR C

(credit "soot" or "sooty")

(penalise "coke" or "coal")

(credit "carbon + carbon monoxide" provided it is clear that carbon is solid; penalise "carbon + carbon dioxide")

1

(ii) $CH_3CH_2OH + O_2 \rightarrow 2C + 3H_2O$

OR

$CH_3CH_2OH + 1\frac{1}{2}O_2 \rightarrow C + CO + 3H_2O$

(credit multiples of these equations)

(credit use of C_2H_5OH for ethanol)

(penalise use of C_2H_6O for ethanol, but note a possible repeat error from part (a) above)

1

[5]

M4. (a) (i) An appropriate alkene; $CH_3CH_2CHCH_2$ or $(CH_3)_2CCH_2$

1

Isomer 1

1

Isomer 2

1

Position isomerism

1

Mechanism

electrophilic attack and electron shift to Br (Unless H^+ used)

1

carbocation

1

reaction with carbocation

[Allow mechanism marks for the alkene $CH_3CHCHCH_3$]
[Allow one mark if mechanism for minor product given]

1

(ii) An appropriate carbonyl; CH_3CH_2CHO

1

Mechanism nucleophilic attack and electron shift to O

1

anion intermediate

1

reaction with anion

[Allow mechanism marks for the carbonyl $(CH_3)_2CO$]

1

Isomer 1

1

Isomer 2

1

Optical isomerism

NB Isomer structures must be tetrahedral
NB Penalise "stick" structures once in part (a)

1

(b) QoL
Large charge on carbonyl carbon atom due to bonding
to O and Cl

1

Nucleophiles have electron pairs which can be donated

1

Equation Species

1

Balanced

1

[18]

M5. (a) M1 curly arrow <u>from lone pair</u> on oxygen of hydroxide ion to H atom on C-H adjacent to C-Br

1

M2 curly arrow <u>from single bond</u> of adjacent C-H <u>to adjacent single bond</u> C-C

(only credit M2 if M1 is being attempted to correct H atom)

1

M3 curly arrow <u>from C-Br bond</u> to side of Br atom

(credit M3 independently)

1

(b) MI credit a correct structure for either geometrical E-Z isomer <u>and</u> its designation as either *cis* or *trans.*
OR credit <u>two</u> correct geometrical E-Z isomer structures
(ignore the names)
OR credit <u>two</u> correct names for *cis* pent-2-ene and *trans* pent-2-ene (ignore the structures)

1

M2 credit a second mark if all four parts of the required structures and names are correct.

(credit "linear" structures)
(insist on the alkyl groups being attached clearly by C-C bonds)

1

(c) (i) MI curly arrow <u>from middle of C = C bond</u> to H atom on H-Br

(penalise M1 if partial negative charge or formal positive charge on H)
(penalise MI if pent-2-ene is used)

1

M2 curly arrow <u>from H-Br bond</u> to side of Br atom

1

M3 correct structure for correct secondary carbocation

1

M4 curly arrow <u>from lone pair</u> on bromide ion to the positive <u>carbon</u> of carbocation, ensuring that bromide ion has a negative charge.

(with the exception of pent-2-ene, if the wrong alkene is used, only penalise the structure M3)
(penalise the use of two dots in addition to a covalent bond, once only)

1

(ii) 1-bromopentane

1

(iii) Ml 2-bromopentane is formed *via* the secondary (or 2°) carbocation

1

OR 1-bromopentane is formed *via* the primary (or 1°) carbocation
M2 a secondary carbocation is more stable than a primary carbocation -
award this mark only if the quality of language justifies the award.

(the argument must involve clear statements about <u>carbocations)</u>

1

[12]