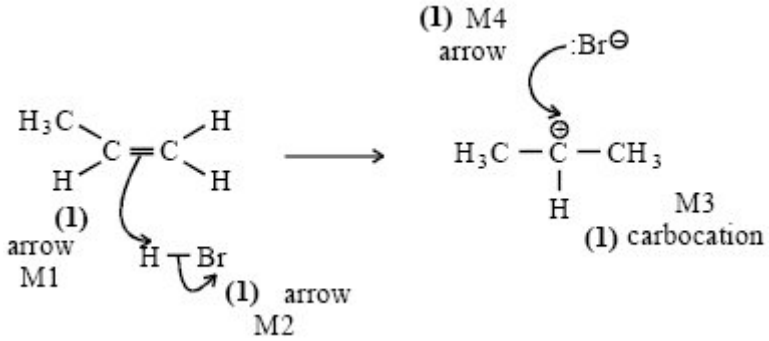
M1.(a) (i)



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 $\overset{\cdot}{-}$ or $\overset{\cdot}{-}\!\!\cdot$

4

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

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

1

(b) (i) *Structure*: $H_3C-\overset{\overset{OH}{|}}{CH}-CH_3$ **(1)** [insist on C — OH bond]

1

Name: propan-2-ol

Not 2-hydroxypropane

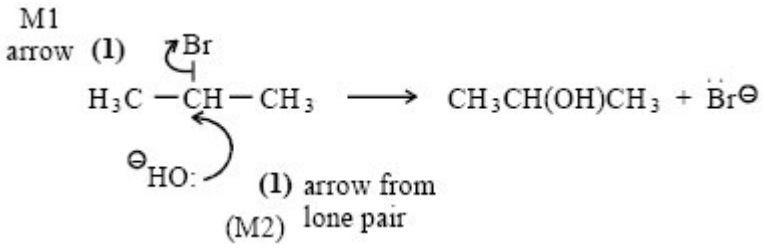
1

(ii) *Name of mechanism*: <u>nucleophilic substitution</u> **(both words)**

(NOT S_N1 or S_N2)

1

Mechanism:



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

2

(c) (i) elimination

1

(ii) base

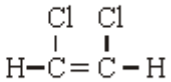
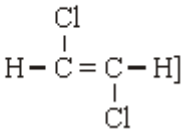
OR proton acceptor
NOT nucleophile

1

[12]

M2. (a) (i)

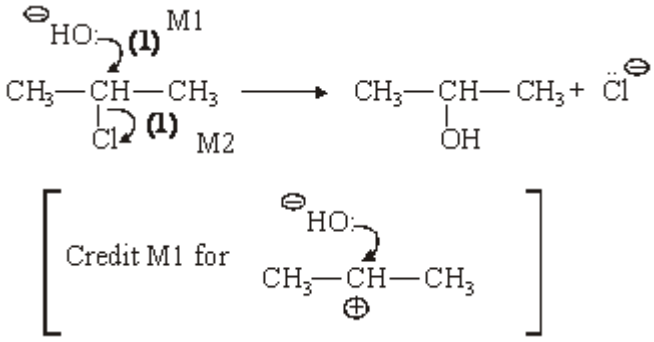
Isomer 1 either order *Isomer 2*

[credit  and ]

(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 must be from a bond or a lone pair

Do not penalise sticks

Penalise M1 if  *precedes (penalise this once)*

Penalise incorrect δ+ δ– for M2

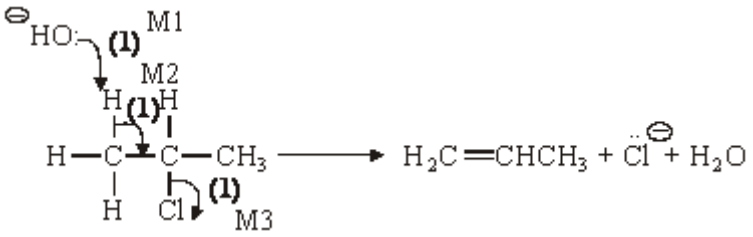
Penalise + on C atom for M2

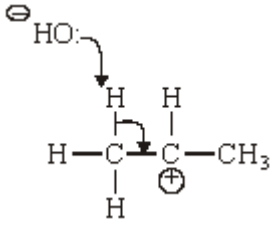
Only allow M1 for incorrect haloalkane

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 $\oplus$ by OH^-

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

7

[10]

M3.B

[1]

M4.(a) 2-bromobutane;

1

(b) Elimination;

(penalise "nucleophilic" OR "electrophilic" before the word "elimination")

1

M1: curly arrow <u>from lone pair</u> on oxygen of hydroxide ion to H atom on <u>correct</u> C-H adjacent to C-Br;

(penalise M1 if KOH shown as covalent with an arrow breaking the bond)

1

M2: curly arrow <u>from single bond</u> of <u>adjacent C-H to adjacent</u> single bond 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 unless arrows contradict)
(Credit possible repeat error from 2(c)(iii) for M3)
(If the wrong haloalkane is used OR but-1-ene is produced, award MAX. 2 marks for the mechanism)
(If E1 mechanism is used, give full credit in which M1 and M2 are for correct curly arrows on the correct carbocation)

(c) (i) (structural) isomers/hydrocarbons/compounds/they have <u>the same molecular formula</u>, but <u>different structural formulas/different structures</u>; 1

(penalise statements which are not expressed in good English and which do not refer clearly to structural isomers i.e. plural)
(penalise statements which refer to "different (spatial) arrangements")
(credit" different displayed formulas")
(Q of L mark)

(ii) Correct structure for but-1-ene;

1

[7]

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

1

M2 curly arrow from single bond of adjacent C-H to adjacent single bond C-C

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

1

M3 curly arrow from C-Br bond to side of Br atom

(credit M3 independently)

1

(b) Ml credit a correct structure for either geometrical E-Z isomer and its designation as either *cis* or *trans.*
OR credit two correct geometrical E-Z isomer structures (ignore the names)
OR credit two 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) Ml curly arrow from middle of C = C bond to H atom on H-Br

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

1

M2 curly arrow from H-Br bond 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]

M6. A

[1]

M7. (a) (base) elimination

(penalise other words before 'elimination' e.g. nucleophilic)

1

M1: curly arrow from lone pair of electrons on oxygen of hydroxide ion

(insist on a lone pair of electrons on the oxygen atom and a negative charge, but only credit this mark if the attack is to a correct H atom)

1

M2: curly arrow from the middle of the C-H bond to the middle of the C–C bond

1

(only credit this mark if the arrow originates from the correct C–H bond and if an attempt has been made at M1)

M3: curly arrow from the middle of the C–Br bond towards/alongside the Br atom

(credit M3 independently unless the bond breaking is contradicted by an additional arrow)

(penalise curly arrow if the C–Br has a formal positive charge)

(credit full marks for an E1 mechanism, with M2 awarded for a correct curly arrow on the correct carbocation)

(award a maximum of two marks for either an incorrect haloalkane or an incorrect organic product)

(maximum 2 marks for use of 'sticks' for the haloalkane, unless RE from 2(b), when credit can be given)

(b) (i) **M1**: compounds with the same structural formula

1

M2: but the bonds/groups/atoms have different spatial arrangements or orientation or configuration/are arranged differently in space/3D

(ignore reference to the same molecular formula for M1)

1

(ii) **M1**: correct structural representation for cis-but-2-ene and its name or its identification as the cis isomer

1

M2: correct structural representation for trans-but-2-ene and its name or its identification as the trans isomer

(accept representations which are 90° to linear)

(award one mark for two correct structures but either wrong/no names)

(maximum 1 mark for an incorrect alkene)

1

(iii) geometric(al) or cis-trans

1

(c) nucleophile or electron pair donor

(penalise 'base')

1

(d) $CH_3CH_2CH_2CH_2Br + 2NH_3 \rightarrow CH_3CH_2CH_2CH_2NH_2 + NH_4Br$

(M1 correct product)

(M2 balanced equation using $2NH_3$ and leading to NH_4Br)

(penalise M1 for use of $C_4H_9NH_2$ or for incorrect haloalkane, but allow consequent correct balancing of equation with 2 moles of ammonia)

2

(1–)butylamine

(credit 1–aminobutane and butyl–1–amine)

(award QoL mark for correct spelling)

1

[13]