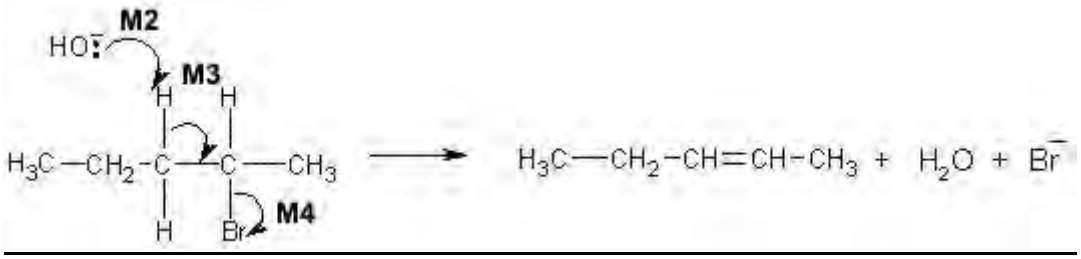
M1. (a) (i) **M1** Elimination



M2 must show an arrow from the lone pair on the oxygen of a negatively charged hydroxide ion to a correct H atom

M3 must show an arrow from a C-H bond adjacent to the C-Br bond towards the appropriate C-C bond.
Only award if a reasonable attempt has been made at the attack on the H atom of the appropriate adjacent C-H

M4 is independent provided it is from their original molecule

Award full marks for an E1 mechanism in which **M3** is on the correct carbocation.

N.B. These are double-headed arrows

For M1, accept ''Base elimination'' but no other prefix.

*Penalise **M2** if covalent KOH*

*Penalise **M4** for formal charge on C of C-Br or incorrect partial charges on C-Br*

Ignore other partial charges

Penalise once only in any part of the mechanism for a line and two dots to show a bond.

*Max any 2 of 3 marks **for the mechanism** for wrong reactant (or wrong product if shown).*

Accept the correct use of ''sticks'' for the molecule except for the C-H being attacked

4

(ii) **Structure for pent-1-ene**

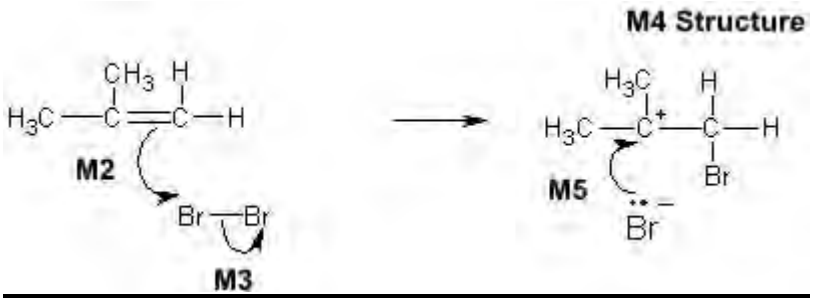
$CH_3CH_2CH_2CH=CH_2$

Penalise C_3H_7

Accept correct ''sticks''

1

(b) **M1 <u>Electrophilic addition</u>**



M2 must show an arrow from the double bond towards the Br atom of the Br-Br molecule

M3 must show the breaking of the Br-Br bond.

M4 is for the structure of the tertiary carbocation with Br on the correct carbon atom.

M5 must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the positively charged carbon atom.

N.B. These are double-headed arrows

For M1, both words required.

For the mechanism

***M2** Ignore partial negative charge on the double bond.*

***M3** Penalise partial charges on Br-Br bond if wrong way and penalise formal charges*

Penalise once only in any part of the mechanism for a line and two dots to show a bond

*<u>Max any 3 of 4 marks **for the mechanism**</u> for*

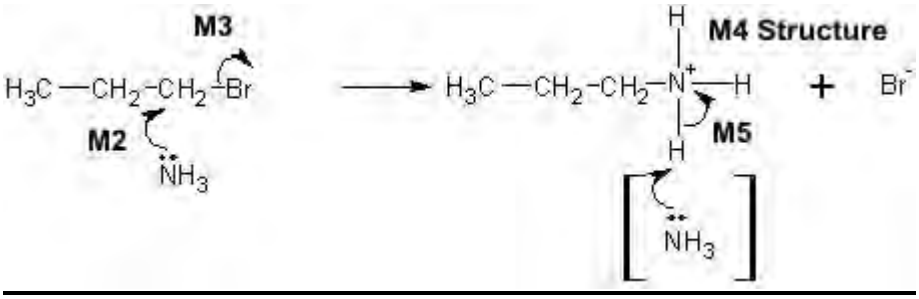
wrong organic reactant or wrong organic product (if shown) or primary carbocation.

*If HBr is used, max 2 marks **for their mechanism***

Accept the correct use of ''sticks''

5

(c) **M1 <u>Nucleophilic substitution</u>**



M2 must show an arrow from the lone pair of electrons on the nitrogen atom of an ammonia molecule to the C atom.

M3 must show the movement of a pair of electrons from the C-Br bond to the Br atom. **M3** is independent provided it is from their <u>original molecule</u>

M4 is for the structure of the alkylammonium ion, which could be a condensed formula. A positive charge must be shown on/or close to, the N atom.

M5 is for an arrow from the N-H bond to the N atom.

Award full marks for an S_N1 mechanism in which M2 is the attack of the ammonia on the intermediate carbocation.

N.B. These are double-headed arrows

*For **M1**, both words required.*

*Penalise **M2** if NH_3 is negatively charged.*

*Penalise **M3** for formal charge on C or incorrect partial charges*

The second mole of ammonia is not essential for M5; therefore ignore any species here.

Penalise once only for a line and two dots to show a bond.

*Max any 3 of 4 marks **<u>for the mechanism</u>** for wrong organic reactant (or wrong organic product if shown)*

Accept the correct use of ''sticks''

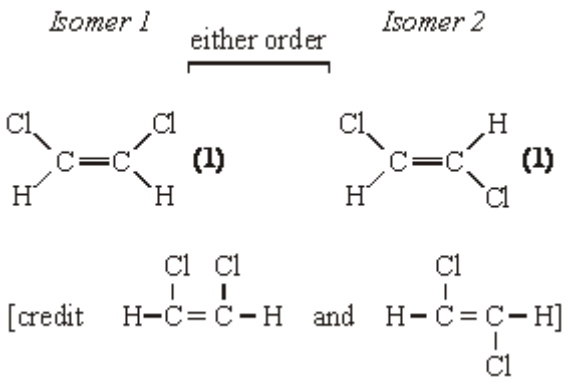
5

[15]

M2.C

[1]

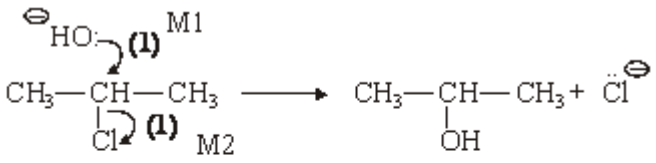
M3. (a) (i)

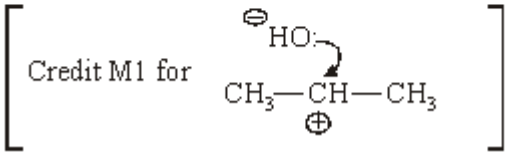


(ii) restricted <u>rotation</u> OR no <u>rotation</u> OR cannot <u>rotate</u> **(1)**

3

(b) (i) *Mechanism*:



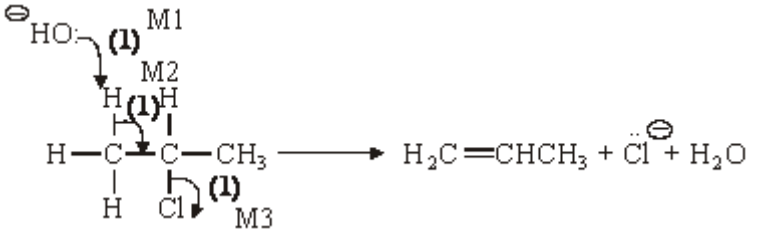


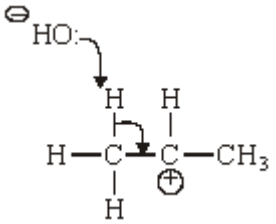
M1 and M2 independent
Curly arrows <u>must</u> be from a bond or a lone pair
Do not penalise sticks
Penalise M1 if  *precedes (penalise this once)*
Penalise incorrect δ+ δ– for M2
Penalise + on C atom for M2
Only allow M1 for incorrect haloalkane

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 ⊕ by OH^-

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

7

[10]

M4. (a) (i) **3**-bromo-**3**-methylpentane ONLY

Must be correct spelling but ignore hyphens and commas

1

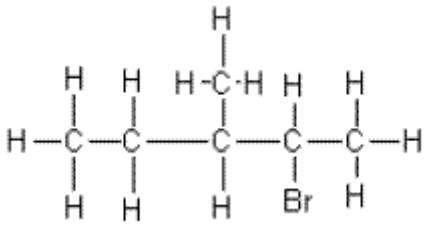
(ii) Electrophilic addition (reaction)

Both words needed

Accept phonetic spelling

1

(iii) **M1** Displayed formula of 2-bromo-3-methylpentane



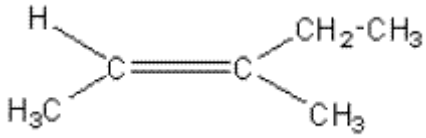
All the bonds must be drawn out but ignore bond angles

M2 Position(al) (isomerism)

Do not forget to award this mark

2

(iv) Structure of (E)-3-methylpent-2-ene



The arrangement of groups around the double bond must be clear with the ethyl group attached in the correct order.
Ignore bond angles.

Accept C_2H_5 for ethyl

Be lenient on C — C bonds. The main issue here is whether they have drawn an (E) isomer.

Accept "sticks" for C — H bonds and correct skeletal formula

1

(b) (i) **M1** R is represented by **Spectrum 2**

M2 Spectrum 2 shows an infrared absorption/spike/dip/ trough/peak with any value(s)/range within the range 1620 to 1680 (cm^{-1}) OR this range quoted/identified and this is due to C=C
OR this information could be a correctly labelled absorption on the spectrum

OR Spectrum 1 does not have an infrared absorption in range 1620 to 1680 (cm^{-1}) and does not contain C=C.

Award M1 if it is obvious that they are referring to the second spectrum (or the bottom one)

M2 depends on a correct M1

Ignore other correctly labelled peaks

Ignore reference to "double bond" or "alkene"

2

(ii) Functional group (isomerism)

1

(iii) Cyclohexane

OR

Methylcyclopentane etc.

Named correctly

Ignore structures and ignore numbers on the methyl group of methylcyclopentane

1

[9]

M5. (a) Contains a C=C ***OR*** a double bond

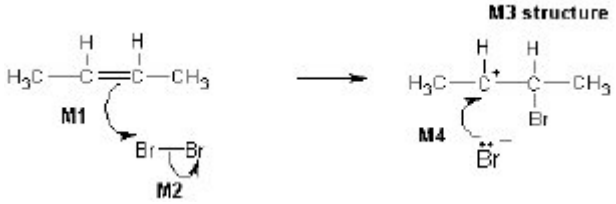
1

(b) **Electrophilic addition**

Both words needed

1

Mechanism:



Ignore partial negative charge on the double bond.

M2 Penalise partial charges on bromine if wrong way and penalise formal charges

Penalise once only in any part of the mechanism for a line and two dots to show a bond.

M1 Must show an arrow from the double bond towards one of the Br atoms on a Br-Br molecule.

Deduct 1 mark for sticks.

M2 Must show the breaking of the Br-Br bond.

M3 Is for the structure of the secondary carbocation with Br substituent.

M4 Must show an arrow from the lone pair of electrons on a negatively charged bromide ion towards the positively charged carbon atom.

Deduct 1 mark for wrong reactant, but mark consequentially.
If HBr, mark the mechanism consequentially and deduct one mark
If but-1-ene, mark the mechanism consequentially and deduct one mark.
If both HBr and but-1-ene, mark the mechanism consequentially and deduct ONLY one mark.

4

(c) (i) **M1** Compounds with the same structural formula

Penalise M1 if "same structure"
Ignore references to "same molecular formula" or "same empirical formula"

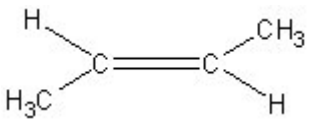
1

M2 With atoms/bonds/groups arranged differently in space
OR
atoms/bonds/groups have different spatial arrangements/ different orientation.

Mark independently.

1

(ii)



Award credit provided it is obvious that the candidate is drawing the trans isomer.

Do not penalise poor C–C bonds

Trigonal planar structure not essential

1

[9]