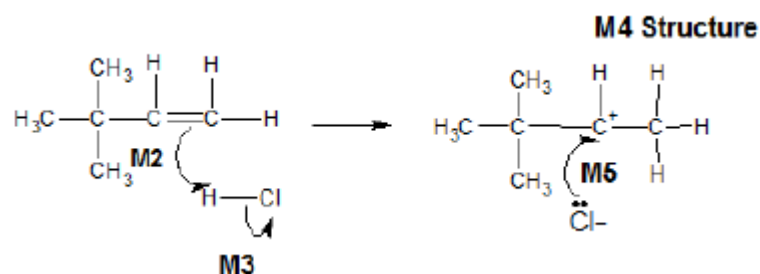


- M1.(a) P** 3,3-dimethylbut-1-ene  
**OR**  
 accept 3,3-dimethylbutene  
*Ignore absence of commas, hyphens and gaps*  
*Require correct spelling*
- Q** 3-chloro-2,2-dimethylbutane  
**OR**  
 accept 2-chloro-3,3-dimethylbutane  
*In Q, "chloro" must come before "dimethyl"*

2

(b) **M1 Electrophilic addition**



- M2** must show an arrow from the double bond towards the H atom of HCl  
**M3** must show the breaking of the H-Cl bond  
**M4** is for the structure of the carbocation  
**M5** must show an arrow from the lone pair of electrons on the negatively charged chloride ion towards the positively charged carbon atom on their carbocation.

**NB The arrows here are double-headed**

*M1 both words required*

**For the mechanism**

**M3** Penalise incorrect partial charge on H-Cl bond and penalise formal charges

*Ignore partial negative charge on the double bond.*

**Maximum 3 of 4 marks for a correct mechanism** using HBr or the wrong organic reactant or wrong organic product (if shown) or a primary carbocation

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

*Credit the correct use of "sticks"*

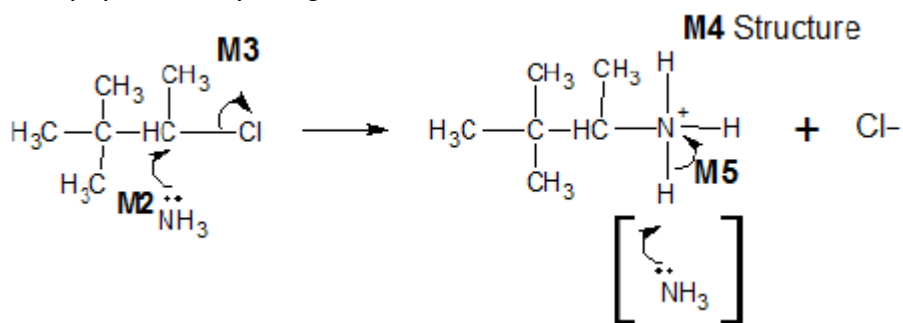
*For M5, credit attack on a partially positively charged carbocation structure, but penalise M4*

5

(c) **M1** Nucleophilic substitution

For **M1**, both words required.

Accept phonetic spelling



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

**M3** must show the movement of a pair of electrons from the C-Cl bond to the Cl atom. Mark **M3** independently provided it is from their original molecule

**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<sub>N</sub>1 mechanism in which **M2** is the attack of the ammonia on the intermediate carbocation

**NB** These are double-headed arrows

**For the mechanism**

Penalise **M2** if NH<sub>3</sub> is negatively charged.

Penalise **M3** for formal charge on C of the C-Cl or incorrect partial charges on C-Cl

Penalise **M3** for an additional arrow from the Cl to something else

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

**Maximum 3 of 4 marks for the mechanism** for wrong organic reactant OR wrong organic product if shown

Accept the correct use of "sticks"

5

(d) **M1** (base) elimination

**M1** Dehydrohalogenation

**M2** KOH OR NaOH

**M3** Must be consequential on a correct reagent in **M2**, but if incomplete or inaccurate attempt at reagent (e.g. hydroxide ion), **penalise M2 only and mark on**

Any **one** from

- high temperature OR hot OR heat / boil under reflux
- concentrated
- alcohol / ethanol (as a solvent) / (ethanolic conditions)

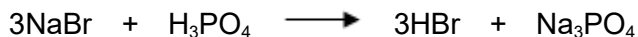
**M3** not "reflux" alone

**M3** if a temperature is stated it must be in the range 78C to 200 °C

Ignore "pressure"

3

(e) **M1**



**M1** Credit correct ionic species in the equation

**M2 and M3**

$\text{SO}_2$  and  $\text{Br}_2$  identified

**M4**

Concentrated sulfuric acid

- is an oxidising agent
- oxidises the bromide (ion) or  $\text{Br}^-$  or NaBr or HBr
- is an electron acceptor

*In **M2** and **M3** the two gases need to be identified. If equations are used using sulfuric acid and the toxic gases are not identified clearly, allow one mark for the formulas of  $\text{SO}_2$  and  $\text{Br}_2$*

- apply the list principle as appropriate but ignore any reference to HBr
- the marks are for identifying the two gases either by name or formula

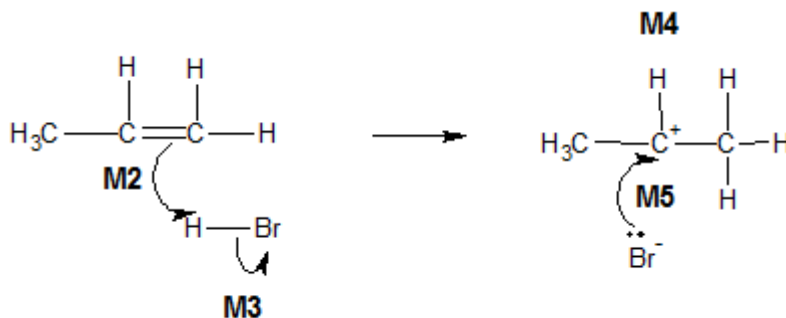
4

[19]

**M2.(a) M1 electrophilic addition**

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

*Accept phonetic spelling*



**For the mechanism**

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

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

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

M3 must show the breaking of the H–Br bond

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

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

**Maximum any 3 of 4 marks for the mechanism** for wrong (organic) reactant **OR** wrong organic product (if shown) **OR** primary carbocation

*Accept the correct use of sticks*

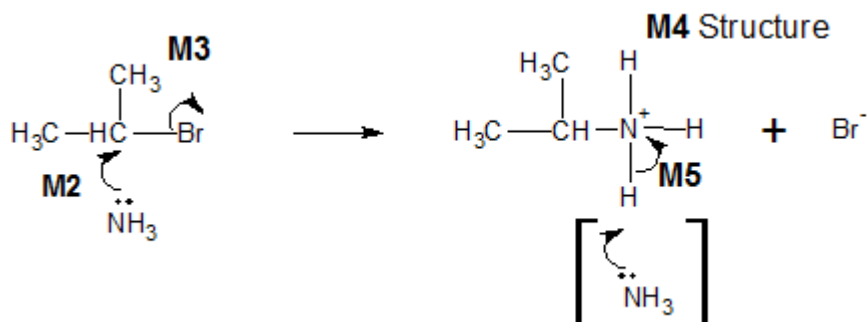
**NB** These are double-headed arrows

5

(b) **M1** Nucleophilic substitution

*For M1, both words required*

*Accept phonetic spelling*



**For the mechanism**

*Penalise M2 if NH<sub>3</sub> is negatively charged*

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

*Penalise M3 for formal charge on C of the C–Br or incorrect partial charges on C–Br*

*Penalise M3 for an additional arrow from the Br to something else*

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 their original molecule

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

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

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

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

**Maximum any 3 of 4 marks for the mechanism** for  
wrong organic reactant **OR** wrong organic product if shown

Award full marks for an S<sub>N</sub>1 mechanism in which **M2** is the attack of the ammonia on the intermediate carbocation

Accept the correct use of "sticks"

**NB These are double-headed arrows**

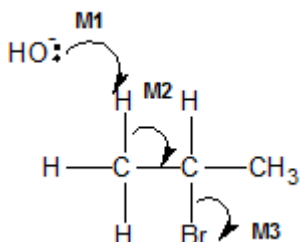
5

- (c) M1 (addition) polymerisation OR poly-addition  
Ignore "additional"  
Credit polyprop-1-ene and polypropylene

M2 poly(propene) / polypropene  
Penalise "condensation polymerisation"

2

(d)



Penalise **M1** if covalent KOH

M1 must show an arrow from the lone pair on the oxygen of a negatively charged hydroxide ion to a correct H atom

Penalise **M3** for formal charge on C of C-Br or incorrect partial charges on C-Br.

M2 must show an arrow from a correct C-H bond adjacent to the C-Br bond to the appropriate C-C bond. Only award if an arrow is shown attacking the H atom of a correct C-H bond in **M1**

Ignore other partial charges

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

M3 is independent provided it is from their original molecule, but **CE=0** if nucleophilic substitution

**Maximum any 2 of 3 marks** for wrong organic reactant

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

Accept the correct use of "sticks" for the molecule except for

the C–H being attacked

**NB These are double-headed arrows**

3

[15]

**M3.(a)** (Compounds with the) same molecular formula but different structural / displayed / skeletal formula

1

(b) (basic) elimination

1

Mechanism points:

Correct arrow from lone pair on :OH<sup>-</sup> to H on C adjacent to C–Br

1

Correct arrow from C–H bond to C–C

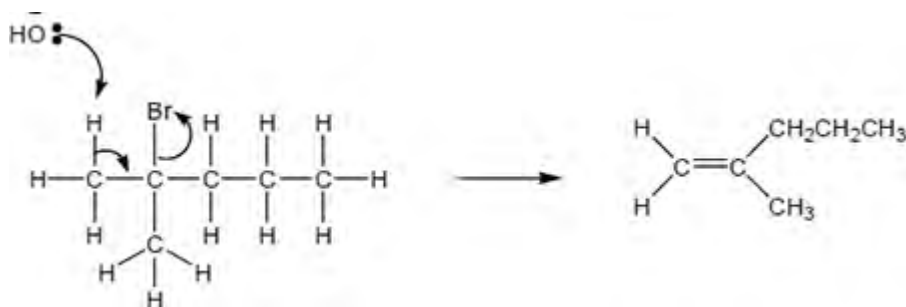
1

Correct arrow from C–Br bond to Br

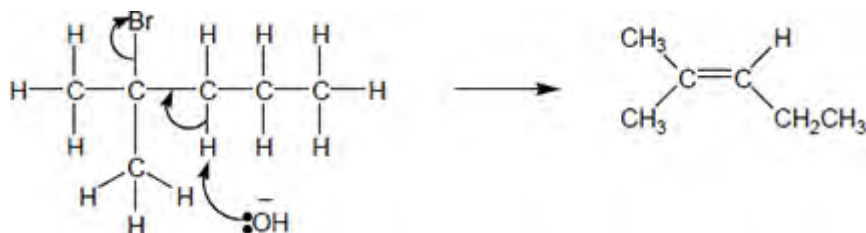
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Structure of chosen product

1



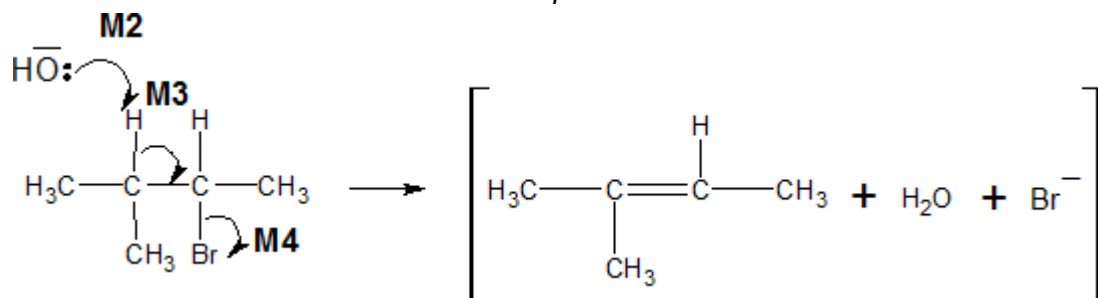
**OR**



[6]

**M4.(a) (i) M1 Elimination**

**M1** Credit "base elimination" but no other prefix.



Penalise **M2** if covalent KOH

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

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

Ignore other partial charges

M3 must show an arrow from a correct C-H bond adjacent to the C-Br bond to a correct C-C bond. Only award if an arrow is shown attacking the H atom of a correct adjacent C-H bond in **M2**

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

M4 is independent provided it is from their original molecule, **BUT CE=0 for the mechanism (penalise M2, M3 and M4 only) if nucleophilic substitution mechanism is shown**

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

Credit the correct use of "sticks" for the molecule except for the C-H being attacked

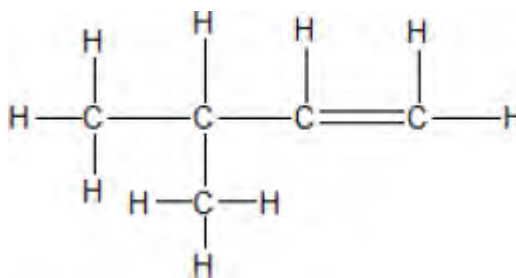
Award full marks for an E1 mechanism in which **M4** is on the correct carbocation

Penalise **M4**, if an additional arrow is drawn from Br eg to K<sup>+</sup>

**NB These are double-headed arrows**

4

(ii) Displayed formula for 3-methylbut-1-ene



*All bonds and atoms must be drawn out, but ignore bond angles*

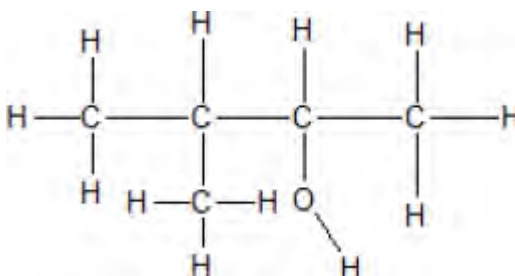
1

(iii) Position(al) (isomerism or isomer)

*Penalise any other words that are written in addition to these.*

1

(b) (i) Displayed formula for 3-methylbutan-2-ol



*All bonds and atoms must be drawn out, but ignore bond angles.*

1

(ii) Any **one** from

- Lower / decreased temperature **OR** cold
- Less concentrated (comparative) **OR** dilute KOH
- Water (as a solvent) / (aqueous conditions)  
*Ignore "pressure".*

1

(iii) Nucleophilic substitution

*Both words needed - credit phonetic spelling.*

1



- (iv) (Strong / broad) absorption / peak in the range **3230 to 3550**  $\text{cm}^{-1}$  or specified value in this range or marked correctly on spectrum

*Allow the words “dip” **OR** “spike” **OR** “trough” **OR** “low transmittance” as alternatives for absorption.*

1

[10]