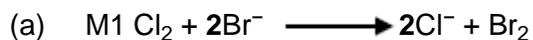


Mark schemes

1



Accept a correct equation using $\frac{1}{2} \text{Cl}_2$ but no other multiples

M2 solution goes orange / yellow (from colourless)

Ignore reference to brown colour

Penalise incorrect observations eg fumes, precipitates

2



(NaOCl)

Or a correct ionic equation

Ignore reference to "swimming pools" and to "disinfectant"

M2 bleach or kills bacteria / bacteriacide / micro-organisms / microbes

M3 sodium chlorate(I) ONLY

3



(HOCl)

*Equilibrium symbol **required** in M1*

Accept ionic RHS

M2

The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

2

- (d) M1 Silver nitrate OR AgNO₃ (with or without nitric acid)

For **M1**

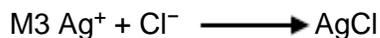
If only the formula is written then it must be correct

If both the formula and the name are written then ignore incorrect attempt at the formula, but penalise an incorrect name

M2 (depends on M1)

white precipitate / white solid

If the reagent is incomplete eg Ag⁺ ions, penalise **M1** and mark on



Penalise both **M1** and **M2** for alkaline AgNO₃ **OR** for the use of HCl to acidify the silver nitrate **OR** for Tollens' reagent

3

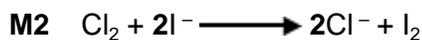
[10]

2

- (a) (i) **M1** iodine **OR** I₂ OR I₃⁻

Ignore state symbols

Credit **M1** for "iodine solution"



OR



Penalise multiples in M2 except those shown

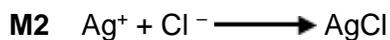
M2 accept correct use of I₃⁻

M3 redox or reduction-oxidation or displacement

3

- (ii) **M1** (the white precipitate is) silver chloride

M1 must be named and for this mark ignore incorrect formula



For **M2** ignore state symbols

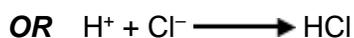
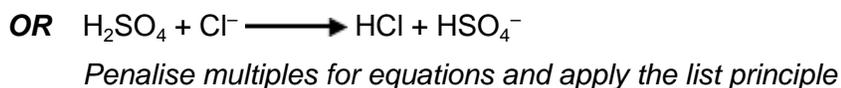
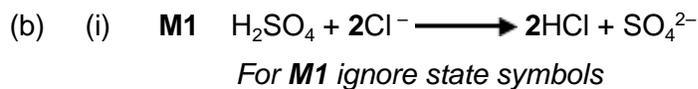
Penalise multiples

M3 (white) precipitate / it dissolves

OR colourless solution

Ignore references to "clear" alone

3



M2 hydrogen chloride **OR** HCl **OR** hydrochloric acid

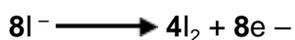
2

(ii) **M1 and M2 in either order**

For M1 and M2, ignore state symbols and credit multiples

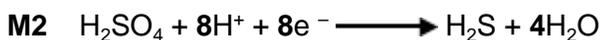


OR

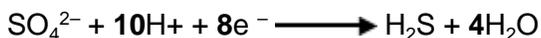


Do not penalise absence of charge on the electron

Credit electrons shown correctly on the other side of each equation



OR



Additional equations should not contradict

M3 oxidising agent / oxidises the iodide (ions)

OR

electron acceptor

M4 sulfur **OR** S **OR** S₂ **OR** S₈ **OR** sulphur

4

(iii) **M1** The NaOH / OH⁻ / (sodium) hydroxide reacts with / neutralises the H⁺ / acid / HBr (lowering its concentration)

OR a correct neutralisation equation for H⁺ or HBr with NaOH or with hydroxide ion

Ignore reference to NaOH reacting with bromide ions

Ignore reference to NaOH reacting with HBrO alone

M2 **Requires a correct statement for M1**

The (position of) equilibrium moves / shifts(from L to R)

- to replace the H⁺ / acid / HBr that has been removed / lost
- **OR** to increase the H⁺ / acid / HBr concentration
- **OR** to make more H⁺ / acid / HBr / product(s)
- **OR** to oppose the loss of H⁺ / loss of product(s)
- **OR** to oppose the decrease in concentration of product(s)
In M2, answers must refer to the (position of) equilibrium shifts / moves and is not enough to state simply that it / the system / the reaction shifts to oppose the change.

M3 The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

3

[15]

3

[1]

4

A

[1]

5

(a) **M1** acidified potassium dichromate or $K_2Cr_2O_7 / H_2SO_4$

OR $K_2Cr_2O_7 / H^+$ **OR** acidified $K_2Cr_2O_7$

M2 (orange to) green solution **OR** goes green

M3 (solution) remains orange or no reaction or no (observed) change

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent e.g. "dichromate" or "dichromate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*For **M2** ignore dichromate described as "yellow" or "red"*

*For **M3** ignore "nothing (happens)" or "no observation"*

Alternative using $KMnO_4 / H_2SO_4$

M1 acidified potassium manganate(VII) / potassium permanganate or $KMnO_4 / H_2SO_4$

OR $KMnO_4 / H^+$ **OR** acidified $KMnO_4$

M2 colourless solution **OR** goes colourless

M3 (solution) remains purple or no reaction or no (observed) change

*For **M1***

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green*

(b) **M1** (Shake with) Br₂ **OR** bromine (water) **OR** bromine (in CCl₄ / organic solvent)

M2 (stays) orange / red / yellow / brown / the same

OR no reaction **OR** no (observed) change

M3 decolourised / goes colourless / loses its colour / orange to colourless

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent (e.g. Br), **penalise M1 only and mark on***

*No credit for combustion observations; **CE = 0***

*For **M2** in every case*

Ignore “nothing (happens)”

Ignore “no observation”

Ignore “clear”

OR as alternatives

Use KMnO₄ / H₂SO₄

M1 acidified potassium manganate(VII) / potassium permanganate **OR**
KMnO₄ / H₂SO₄

OR KMnO₄ / H⁺ **OR** acidified KMnO₄

M2 (stays) purple or no reaction or no (observed) change

M3 decolourised / goes colourless / loses its colour

Use iodine

M1 **iodine** or I₂ / KI or iodine solution

M2 no change

M3 decolourised / goes colourless / loses its colour

Use concentrated sulfuric acid

M1 concentrated H₂SO₄

M2 no change

M3 brown

*For **M1**, it must be a whole reagent and / or correct formula*

*For **M1** penalise incorrect attempt at correct formula, but mark **M2** and **M3***

With potassium manganate(VII)

*If incomplete / inaccurate attempt at reagent e.g. “manganate” or “manganate(IV)” or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline / neutral KMnO_4 for possible full marks but **M3** gives brown precipitate or solution goes green*

Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent as those used for other reagents.

(c) **M1** Any soluble chloride including hydrochloric acid (ignore concentration)

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 Any soluble iodide including HI

M2 yellow precipitate or yellow solid / yellow suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 Any soluble bromide including HBr

M2 cream precipitate or cream solid / cream suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 NaOH or KOH or any soluble carbonate

M2 brown precipitate or brown solid / brown suspension with NaOH / KOH
(white precipitate / solid / suspension with carbonate)

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If no reagent or incorrect reagent or insoluble chloride in **M1**, **CE = 0**
and no marks for **M1**, **M2** or **M3***

Allow chlorine water

*If incomplete reagent (e.g. chloride ions) or inaccurate attempt at
formula of chosen chloride, or chlorine, **penalise M1 only and
mark on***

*For **M2** require the word "white" and some reference to a solid.
Ignore "cloudy solution" OR "suspension" (similarly for the
alternatives)*

*For **M3***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear" on its own

Ignore "dissolves"

(d) **M1** Any soluble sulfate including (dilute or aqueous) sulfuric acid

M2 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

M3 white precipitate or white solid / white suspension

*If no reagent or incorrect reagent or insoluble sulfate in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

Accept $MgSO_4$ and $CaSO_4$ but not barium, lead or silver sulfates

*If concentrated sulfuric acid or incomplete reagent (e.g. sulfate ions) or inaccurate attempt at formula of chosen sulfate, **penalise M1 only and mark on***

*For **M3** (or **M2** in the alternative) require the word “white” and some reference to a solid.*

Ignore “cloudy solution” OR “suspension”

*For **M2** (or **M3** in the alternative)*

Ignore “nothing (happens)”

Ignore “no observation”

Ignore “clear” on its own

Ignore “dissolves”

OR as an alternative

M1 NaOH or KOH

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, **penalise M1 only and mark on***

*If **M1** uses NH_3 (dilute or concentrated) **penalise M1 only and mark on***

3

[12]

6

(a) Cross between the Na cross and the Mg cross

1

(b) $Al(g) \rightarrow Al^+(g) + e^-$

$Al(g) - e^- \rightarrow Al^+(g)$

$Al(g) + e^- \rightarrow Al^+(g) + 2e^-$

One mark for state symbols consequential on getting equation correct.

Electron does not have to have the – sign on it

Ignore (g) if put as state symbol with e^- but penalise state symbol mark if other state symbols on e^-

2

- (c) 2nd/second/2/II
Only 1
- (d) Paired electrons in (3)p orbital
Penalise wrong number
If paired electrons repel allow M2 1
- repel 1
- (e) Neon/Ne
No consequential marking from wrong element 1
- $1s^22s^22p^6/[He]2s^22p^6$
Allow capital s and p
Allow subscript numbers 1
- (f) Decreases
CE if wrong 1
- Atomic radius increases/electron removed further from nucleus
or nuclear charge/electron in higher energy level/Atoms
get larger/more shells
Accept more repulsion between more electrons for M2
Mark is for distance from nucleus
Must be comparative answers from M2 and M3
CE M2 and M3 if mention molecules
Not more sub-shells 1
- As group is descended more shielding 1

[11]

7

- (a) Q is calcium or magnesium 1
- bromide 1
- R is aluminium 1
- chloride 1

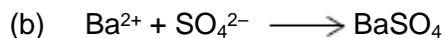
S is iron(III)

1

sulfate

1

Mark this question independently



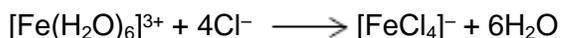
1



1



1



1

[10]

8

(a) (i) **M1 0**

M2 (+) 5

Accept Roman V for M2

2



Accept multiples

1



For M1, ignore state symbols

Credit multiples

Accept $2\frac{1}{2}\text{I}_2 + \frac{1}{2}\text{I}_2$ as alternative to 3I_2

Electrons must be cancelled

M2 NaIO_3 **OR** IO_3^- **OR** iodate ions **OR** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept "the iodine in iodate ions" but NOT "iodine" alone

Accept "the iodine / I in iodate ions" but NOT "iodine" alone

2

(c) (i) Iodine **OR** I_2

Insist on correct name or formula

1



Ignore state symbols



Credit multiples

Do not penalise absence of charge on the electron

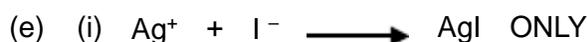
1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1



Ignore state symbols

No multiples

1

(ii) The (yellow) precipitate / solid / it does not dissolve / is insoluble

ignore "nothing (happens)"

OR turns to a white solid

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test

Ignore reference to "false positive"

- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test

Do not penalise an incorrect formula for an ion that is written in addition to the name.

- remove (other) ions that react with the silver nitrate

- react with / remove carbonate / hydroxide / sulfite (ions)

If only the formula of the ion is given, it must be correct

1

(f) (i) An electron donor

Penalise "electron pair donor"

OR (readily) donates / loses / releases / gives (away) electron(s)

Penalise "loss of electrons" alone

Accept "electron donator"

1

(ii) $\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Cl}^-$

Ignore state symbols

Do not penalise absence of charge on electron

Credit $\text{Cl}_2 \longrightarrow 2\text{Cl}^- - 2\text{e}^-$

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

*CE=0 for the clip if "iodine ions / chlorine ions" **QoL***

Iodide ions / they are larger / have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

*CE=0 for the clip if "iodide ions are bigger molecules / atoms" **QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

2

[15]

9

- (a) Iodine has more electrons / iodine is bigger (atom or molecule) / iodine has bigger M_r / bigger surface area

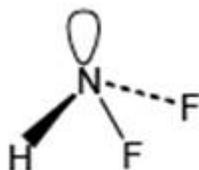
1

Stronger / more van der Waals forces / vdw / London / temporarily induced dipole / dispersion forces between molecules

1

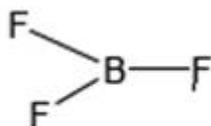
*Stronger VdW intermolecular forces = M^2
If stated VdW between atoms lose M^2*

- (b) (i)



Mark is for 3 bp and 1 lp attached to N (irrespective of shape)

1



Mark is for 3 bp and 0 lp attached to B (irrespective of shape)

1

NHF_2 shape - pyramidal / trigonal pyramid

Accept tetrahedral / triangular pyramid

1

BF_3 shape - trigonal planar

Not triangular or triangular planar

1

- (ii) 107°

Allow $106-108^\circ$

1

- (c) Hydrogen bonds

Allow H-Bonds

Not just Hydrogen

Apply list principle eg Hydrogen bonding and dipole-dipole = 0

1

(d) Coordinate / dative covalent / dative

If covalent mark on

If ionic / metallic CE = 0

1

Lone pair / both electrons/ 2 electrons on N(HF₂) donated (to BF₃)

Direction of donation needed here

1

[10]

10

(a) Ca(OH)₂ OR Mg(OH)₂

Ignore name

Could be ionic

1

(b) NaF or sodium fluoride

OR

NaCl or sodium chloride

Either formula or name can score

Do not penalise the spelling “fluoride”

When both formula and name are written,

- *penalise contradictions*
- *if the attempt at the correct **formula** is incorrect, ignore it and credit **correct name** for the mark unless contradictory*
- *if the attempt at the correct name is incorrect, ignore it and credit **correct formula** for the mark unless contradictory*

1

(c) NaClO OR NaOCl

Ignore name (even when incorrect)

The correct formula must be clearly identified if an equation is written

1

(d) **Br₂** (ONLY)

Only the correct formula scores;

penalise lower case “b”, penalise upper case “R”, penalise superscript

Ignore name

The correct formula must be clearly identified if an equation is written

1

(e) **M1** S OR S₈ OR S₂

M2 I₂ (ONLY)

Ignore names

penalise lower case "i" for iodine,

penalise superscripted numbers

Mark independently

The correct formula must be clearly identified in each case if an equation is written

2

(f) (i) CH₃CH₂CH=CH₂

Structure of but-1-ene. Ignore name

Credit "sticks" for C-H bonds

1

(ii) CH₃CH₂CH₂CH₂OH

Structure of butan-1-ol. Ignore name

Credit "sticks" for C-H bonds

1

(iii) CH₃CH₂CH₃

Structure of propane. Ignore name

Ignore calculations and molecular formula

Credit "sticks" for C-H bonds

Ignore the molecular ion

1

(iv) CH₃CH₂Br OR C₂H₅Br

Structure of bromoethane.

Ignore name and structure of nitrile

Credit "sticks" for C-H bonds

1

[10]

11

- (a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

M2 $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$ (Also scores M1 unless contradicted)

M3 sodium chloride OR NaCl

For M2

Accept multiples

Ignore state symbols

Allow crossed out nitrate ions, but penalise if not crossed out

3

- (ii) The silver nitrate is acidified to

- react with / remove ions that would interfere with the test
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
- remove (other) ions that react with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)
Ignore reference to “false positive”

1

- (iii) **M1 and M2 in either order**

M1 Fluoride (ion) OR F

- M2**
- Silver fluoride / AgF is soluble / dissolves (in water)
 - no precipitate would form / no visible / observable change
*Do not penalise the spelling “fluoride”,
Penalise “fluride” once only
Mark M1 and M2 independently*

2



(or the ions together)

M2 white precipitate / white solid / white suspension

M3 Barium meal or (internal) X-ray or to block X-rays

M4 BaSO₄ / barium sulfate is insoluble (and therefore not toxic)

For M1, ignore state symbols

Allow crossed out sodium ions, but penalise if not crossed out

For M2, ignore "milky"

If BaSO₃ OR BaS used in M1 and M4, penalise once only

For M3 Ignore radio-tracing

For M4 NOT barium ions

NOT barium

NOT barium meal

NOT "It" unless clearly BaSO₄

4

(c) **M1** $2(12.00000) + 4(1.00794) = 28.03176$

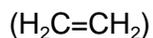
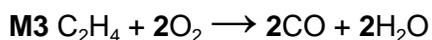
M2 Ethene and CO or "they" have an imprecise **M_r** of 28.0 / 28

OR

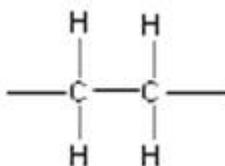
Ethene and CO or "they" have the same M_r to one d.p.

OR

These may be shown by two clear, simple sums identifying both compounds



M4 Displayed formula



M5 Type of polymer = Addition (polymer)

M1 must show working using 5 d.p. for hydrogen

Penalise “similar” or “close to”, if this refers to the imprecise value in M2, since this does not mean “the same”

For M3, accept $\text{CH}_2=\text{CH}_2$ OR CH_2CH_2

For M4, all bonds must be drawn out including those on either side of the unit.

Penalise “sticks”

*Ignore brackets around **correct** repeating unit but penalise “n”*

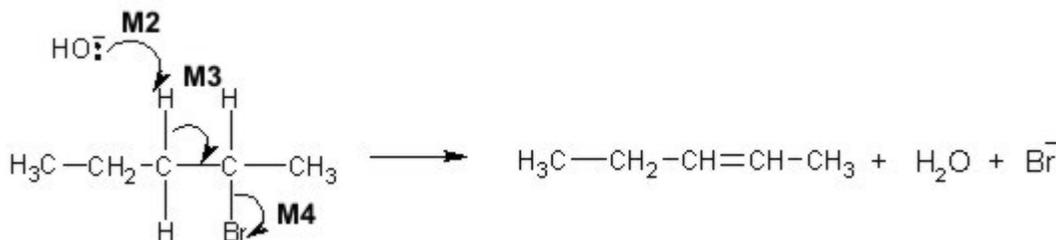
Penalise “additional”

5

[15]

12

(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**

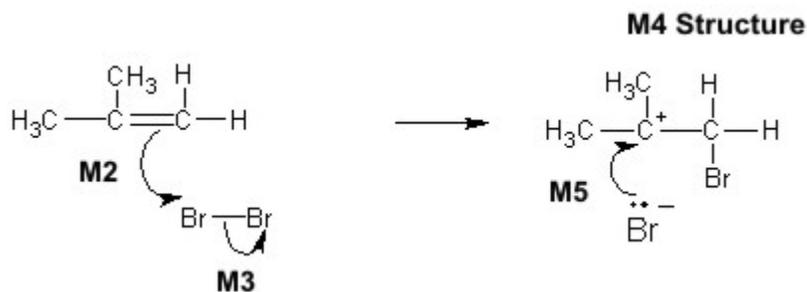


Penalise C_3H_7

Accept correct "sticks"

1

(b) **M1 Electrophilic addition**



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

Max any 3 of 4 marks for the mechanism for

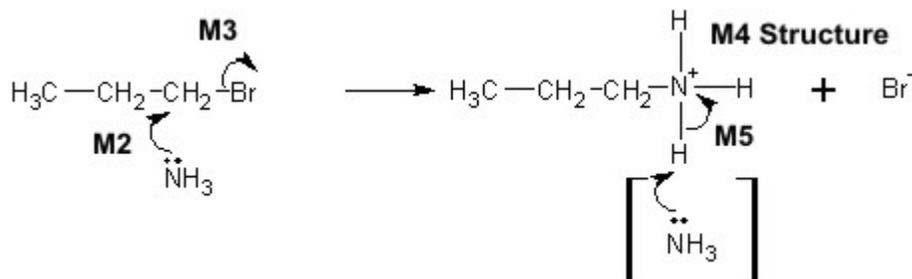
wrong organic reactant or wrong organic product (if shown) or primary carbocation.

If HBr is used, max 2 marks for their mechanism

Accept the correct use of "sticks"

5

(c) **M1** Nucleophilic substitution



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 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_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 NH₃ 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 **for the mechanism** for wrong organic reactant (or wrong organic product if shown)*

Accept the correct use of "sticks"

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