

M1.(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

3

(b) **M1** (Shake with) Br_2 **OR** bromine (water) **OR** bromine (in CCl_4 / 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 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 (stays) purple or no reaction or no (observed) change

M3 decolourised / goes colourless / loses its colour

Use iodine

M1 iodine or I_2 / KI or iodine solution

M2 no change

M3 decolourised / goes colourless / loses its colour

Use concentrated sulfuric acid

M1 concentrated H_2SO_4

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.

3

(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"

3

(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]

M2.(a) Structure for 3-methylbut-1-ene

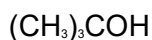


Any correct structural representation.

Credit "sticks" and require the double bond.

1

(b) Structure for 2-methylpropan-2-ol

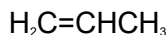


Any correct structural representation.

Credit "sticks".

1

(c) Structure for propene

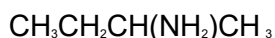


Any correct structural representation.

Credit "sticks" and require the double bond.

1

(d) Structure for 2-aminobutane



Any correct structural representation.

Credit "sticks".

1

[4]

M3.(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

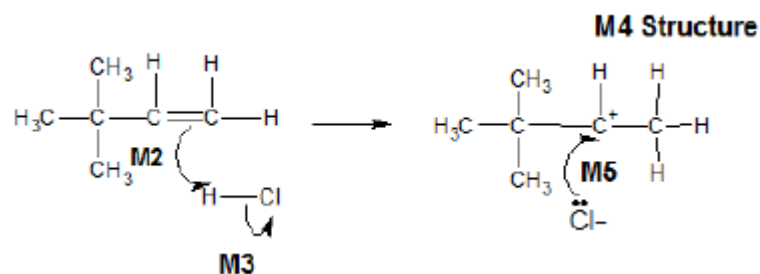
OR

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"

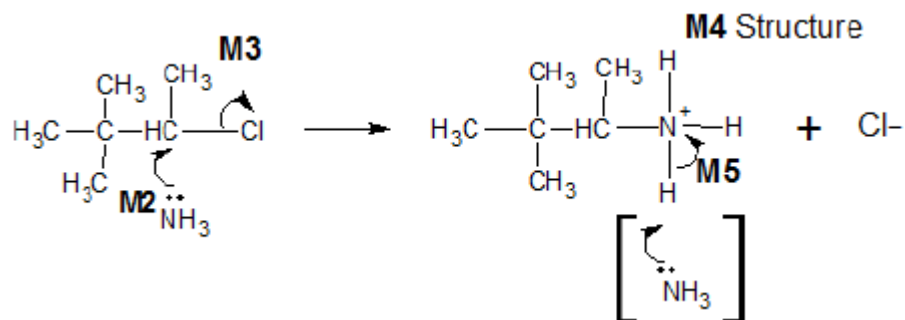
For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4**

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_N1 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 NH₃ 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)

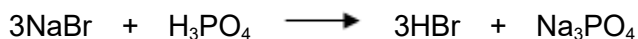
M3 not "reflux" alone

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

SO₂ and Br₂ identified

M4

Concentrated sulfuric acid

- is an oxidising agent
- oxidises the bromide (ion) or 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 SO₂ and Br₂*

- *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

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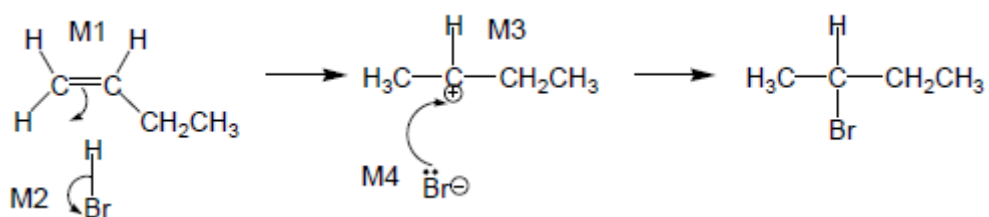
M4.C

M5.(a) HBr **OR** HCl **OR** H₂SO₄
Allow HI or HY

1

(b) Electrophilic addition

1



Allow consequential marking on acid in 12.1 and allow use of HY

4

(c) The major product exists as a pair of enantiomers

1

The third isomer is 1-bromobutane (minor product)

1

Because it is obtained via primary carbocation

1

[9]

M6.C

[1]

M7.(a) Measured volume would be greater 1

Level in burette falls as tap is filled before any liquid is delivered 1

(b) Drop sizes vary
Allow percentage error for amount of oil will be large as the amount used is so small 1

(c) Use a larger single volume of oil 1

Dissolve this oil in the organic solvent 1

Transfer to a conical flask and make up to 250 cm³ with more solvent 1

Titrate (25 cm³) samples from the flask 1

(d) Stage 1

Mass of oil = $0.92 \times (5.0 \times 10^{-2} \times 5) = 0.23$ (g) 1

Mol of oil = $0.23 / 885 = 2.6 \times 10^{-4}$ 1

Extended response calculation

To gain 4 or 5 marks, students must show a logical progression from stage 1 and stage 2 (in either order) to stage 3

Stage 2

$$\text{Mol bromine} = 2.0 \times 10^{-2} \times 39.4 / 1000 = 7.9 \times 10^{-4}$$

1

Stage 3

Ratio oil : bromine

$$2.6 \times 10^{-4} : 7.9 \times 10^{-4}$$

$$\text{Simplest ratio} = 2.6 \times 10^{-4} / 2.6 \times 10^{-4} : 7.9 \times 10^{-4} / 2.6 \times 10^{-4}$$

$$= 1 : 3$$

1

Hence, 3 C=C bonds

M5 cannot be awarded unless working for M4 is shown

1

[12]