

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) Reagent

Acidified
 $K_2Cr_2O_7$

Acidified
 $KMnO_4$

I_2 / NaOH

Named
RCOOH with HCl or H_2SO_4

Named
RCOCl

Allow names including potassium permanganate

Wrong or no reagent CE = 0

1

P (ketone)
no reaction
no reaction
Yellow ppt
no reaction
no reaction

Penalise incorrect formulae or incomplete reagent, such as $K_2Cr_2O_7$ or acidified dichromate, but mark on.

1

S (2° alcohol)
(orange to) green
(purple to) colourless
no reaction
fruity or sweet smell
Misty fumes

Allow no change or nvc but penalise nothing or no observation

If 2 reagents added sequentially or 2 different reagents used for P and S then CE = 0

1

(b) Tollens'
silver mirror / solid

1

Fehling's / Benedicts
red ppt

1

(c) **G**
P

If not P then no marks for clip

1

5 OR five

1

(d) $C_4H_{12}Si$

Must be molecular formula

Wrong substance CE = 0 for clip

1

Any **two** from

- One or single peak OR all (four) carbon atoms are equivalent or one

environment

1

- upfield from others or far away from others or far to right
- non toxic OR inert
- low boiling point or volatile or easy removed from sample

*Ignore and don't credit single peak linked to 12 equivalent H
or has a peak at $\delta = 0$*

but use list principle for wrong statements

1

1

(e) Figure 1 is **R**

If not R cannot score M2

M1

1

90–150 (ppm) or value in range is (two peaks for) C = C / alkene

M2

1

Figure 2 is **T**

If not T cannot score M4 or M5

M3

1

50-90 (ppm) or value in range is C—O or alcohol or ether

M4

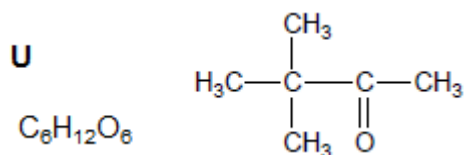
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two peaks (so not S which would have only one)

M5

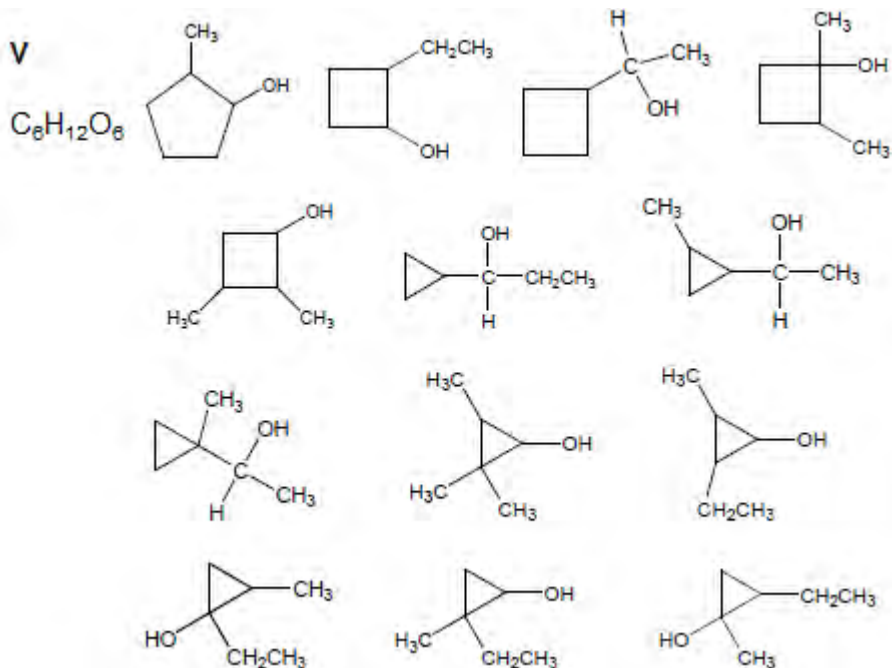
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(f)

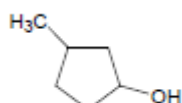


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Answers include



Not allow **S**



because **V** must be an isomer of **S**

[17]

M3.(a) (i) **M1** (Compounds / molecules with) the same structural formula

*Penalise **M1** if 'same structure' or 'different structural / displayed formula'.*

M2 with atoms / bonds / groups arranged differently in space

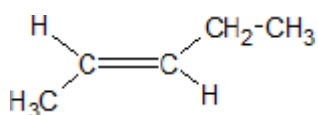
OR atoms / bonds / groups with different spatial arrangements / different orientation

Ignore references to 'same molecular formula' or 'same empirical formula'.

Mark independently.

2

(ii)



Credit C-H₃C

Credit C₂H₅

Penalise C-CH₃CH₂

- (b) **M1** Br₂ OR bromine (water) OR bromine (in CCl₄ / organic solvent)
If M1, has no reagent or an incorrect reagent, CE=0.
 Ignore 'acidified'.
- M2** Isomer 1: decolourised / goes colourless / loses its colour
For M1 penalise Br (or incorrect formula of other correct reagent), but mark on.
- M3** Isomer 2: remains orange / red / yellow / brown / the same **OR** no reaction / no (observable) change **OR** reference to colour going to the cyclopentane layer
For M1, it must be a whole reagent and / or correct formula.
If oxidation state given in name, it must be correct. If 'manganate' OR 'manganate(IV)' or incorrect formula, penalise M1, but mark on.

Alternatives : potassium manganate(VII)

M1 KMnO₄ in acid **M2** colourless **M3** purple

M1 KMnO₄ in alkali / neutral **M2** brown solid **M3** purple

Credit for the use of **iodine**

M1 iodine (solution / in KI) **M2** colourless **M3** (brown) to purple (credit no change)

Credit for the use of **concentrated** H₂SO₄

M1 concentrated H₂SO₄ **M2** brown **M3** no change / colourless

Ignore 'goes clear'.

Ignore 'nothing (happens)'.

Ignore 'no observation'.

No credit for combustion observations.

3

- (c) (i) (Both infrared spectra show an absorption in range) **1620 to 1680** (cm⁻¹)
Ignore reference to other ranges (eg for C–H or C–C).

1

- (ii) The fingerprint (region) / below 1500 cm⁻¹ will be different **or** its fingerprinting will be different

OR

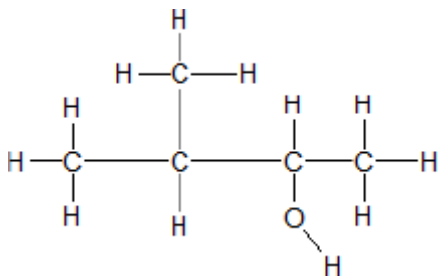
different absorptions / peaks are seen (in the region) below 1500 cm^{-1} (or a specified region within the fingerprint range)

Allow the words 'dip' OR 'spike' OR 'low transmittance' as alternatives for absorption.

QoL

1

(d)

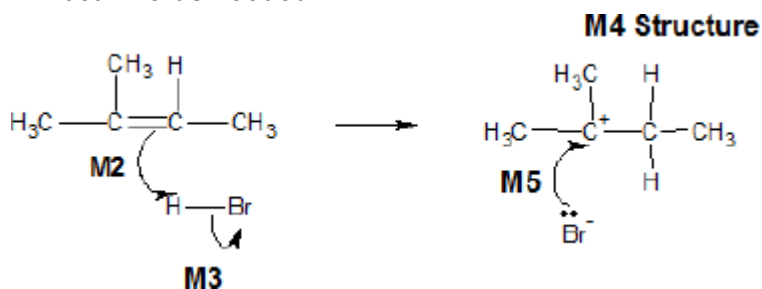


*All bonds must be drawn.
Ignore bond angles.*

1

(e) (i) **M1 Electrophilic addition**

M1 both words needed.



Penalise one mark from their total if half-headed arrows are used.

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

M2 Ignore partial negative charge on the double bond.

M3 must show the breaking of the H-Br bond

M3 Penalise incorrect partial charges on H-Br bond and penalise formal charges.

M4 is for the structure of the tertiary carbocation

Penalise M4 if there is a bond drawn to the positive charge.

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 positively charged carbon atom of either a secondary or a tertiary carbocation

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

Max 3 of any 4 marks in the mechanism for wrong organic reactant or wrong organic product (if shown) or secondary carbocation.

Max 2 of any 4 marks in the mechanism for use of bromine.

Do not penalise the correct use of 'sticks'.

NB The arrows here are double-headed

5

- (ii) **M1** Reaction goes via intermediate carbocations / carbonium ions
M1 is a lower demand mark for knowledge that carbocations are involved.

M2 (scores both marks and depends on M1)

Tertiary carbocation / carbonium ion is more stable (than the secondary carbocation / carbonium ion)

OR

Secondary carbocation / carbonium ion is less stable (than the tertiary carbocation / carbonium ion)

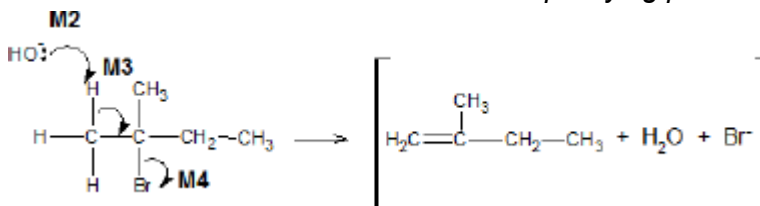
M2 is of higher demand and requires the idea that the secondary carbocation is less stable or the tertiary carbocation is more stable. Reference to incorrect chemistry is penalised.

A carbocation may be defined in terms of alkyl groups / number of carbon atoms, rather than formally stated.

2

- (f) **M1 Elimination**

M1 credit 'base elimination' but no other qualifying prefix.



Penalise one mark from their total if half-headed arrows are used.

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

Penalise **M2** if covalent KOH

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**)

M4 is independent provided it is from their original molecule **BUT penalise M2, M3 and M4 if nucleophilic substitution** shown

Award full marks for an E1 mechanism in which **M2** is on the correct carbocation

NB The arrows here are double-headed

*Penalise **M4** for formal charge on C or Br of the C–Br bond or incorrect partial charges on C–Br.*

*Penalise **M4** if an additional arrow is drawn from the Br of the C–Br bond to, for example, K⁺.*

Ignore other partial charges.

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

***Max 2 of any 3 marks in the mechanism** for wrong reactant or wrong organic product (if shown) or a correct mechanism that leads to the alkene 2-methylbut-2-ene.*

Credit the correct use of “sticks” for the molecule except for the C–H being attacked.

M5 hydroxide ion behaves as a base / proton acceptor / electron pair donor / lone pair donor

*Penalise **M5** if ‘nucleophile’.*

5

[21]