

M1.(a) Structure for 3-methylbut-1-ene

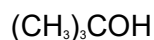


Any correct structural representation.

Credit "sticks" and require the double bond.

1

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

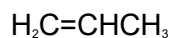


Any correct structural representation.

Credit "sticks".

1

(c) Structure for propene

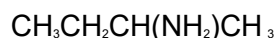


Any correct structural representation.

Credit "sticks" and require the double bond.

1

(d) Structure for 2-aminobutane



Any correct structural representation.

Credit "sticks".

1

[4]

M2. Acidified potassium dichromate

Accept words or formulae.

Accept acidified potassium permanganate.

Accept Lucas reagent (conc HCl, ZnCl₂) (cloudy in 5 mins for 2°, instantly for 3°).

Mark on for incomplete reagent.

Incorrect reagent CE = 0 / 3

Inclusion of Tollen's etc with acidified potassium dichromate is incorrect reagent.

Not no reaction.

Either

Obs with 2-methylpropan-2-ol

No visible change

1

Obs with butan-2-ol

Orange to green (both colours needed)

1

or

Obs with 2-methylpropan-2-ol orange

Obs with butan-2-ol green

[3]

M3.(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

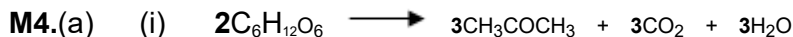
M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*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]



Or multiples

1

(ii) to speed up the reaction

OR

(provide a) catalyst or catalyses the reaction or biological catalyst

OR

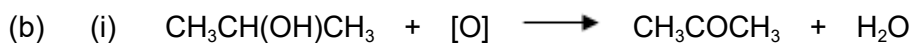
release / contain / provides an enzyme

Ignore "fermentation"

Ignore "to break down the glucose"

Not simply "enzyme" on its own

1



Any correct representation for the two organic structures.

Brackets not essential.

Not "sticks" for the structures in this case

1

(ii) Secondary (alcohol) OR 2° (alcohol)

1

(c) **M1** $q = m c \Delta T$

OR $q = 150 \times 4.18 \times 8.0$

Award full marks for correct answer

*In **M1**, do not penalise incorrect cases in the formula*

M2 = (±) 5016 (J) **OR** 5.016 (kJ) **OR** 5.02 (kJ)
(also scores M1)

M3 This mark is for dividing correctly the number of kJ by the number of moles and arriving at a final answer in the range shown.
Using 0.00450 mol

therefore $\Delta H = - \underline{1115}$ (kJ mol⁻¹)

OR $- \underline{1114.6}$ to $- \underline{1120}$ (kJ mol⁻¹)

Range (+)1114.6 to (+)1120 gains 2 marks

BUT – 1110 gains 3 marks and +1110 gains 2 marks

AND – 1100 gains 3 marks and +1100 gains 2 marks

Award full marks for correct answer

*In **M1**, do not penalise incorrect cases in the formula*

*Penalise **M3** ONLY if correct numerical answer but sign is incorrect; **(+)1114.6 to (+)1120 gains 2 marks***

*Penalise **M2** for arithmetic error and mark on*

If $\Delta T = 281$; score $q = m c \Delta T$ only

*If $c = 4.81$ (leads to 5772) penalise **M2** ONLY and mark on for **M3** = - 1283*

*Ignore incorrect units in **M2***

*If units are given in **M3** they must be either kJ or kJ mol⁻¹ in this case*

3

(d) **M1** The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / element

M2 is burned / combusts / reacts completely in oxygen
OR
burned / combusted / reacted in excess oxygen

M3 with (all) reactants and products / (all) substances in standard / specified states

OR

(all) reactants and products / (all) substances in normal states under standard conditions / 100 kPa / 1 bar and specified T / 298 K

*For **M3***

Ignore reference to 1 atmosphere

3

(e) **M1**

$\sum B(\text{reactants}) - \sum B(\text{products}) = \Delta H$

OR

Sum of bonds broken – Sum of bonds formed = ΔH

OR

$2B(C-C) + B(C=O) + 6B(C-H) + 4B(O=O)$ (LHS)

$- 6B(C=O) - 6B(O-H)$ (RHS) = ΔH

M2 (also scores **M1**)

$2(348)+805+6(412)+4(496)$ [LHS = **5957**]

(696) (2472) (1984)

$- 6(805) - 6(463)$ [RHS = (-) **7608**] = ΔH

(4830) (2778)

OR using only bonds broken and formed (**5152 – 6803**)

M3

$\Delta H = -1651$ (kJ mol⁻¹)

Candidates may use a cycle and gain full marks.

Correct answer gains full marks

Credit 1 mark for (+) 1651 (kJ mol⁻¹)

For other incorrect or incomplete answers, proceed as follows

- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication / addition error; this would score 2 marks (M1 and M2)*
- *If no AE, check for a correct method; this requires either a correct cycle with 4O₂, 3CO₂ and 3H₂O OR a clear statement of M1 which could be in words and scores **only M1***

Allow a maximum of one mark if the only scoring point is LHS = 5957 (or 5152) OR RHS = 7608 (or 6803)

Award 1 mark for + 1651

3

(f) **For the two marks M1 and M2, any two from**

- heat loss or not all heat transferred to the apparatus or heat absorbed by the apparatus or (specific) heat capacity of the apparatus not considered
- incomplete combustion / not completely burned / reaction is not complete
- The idea that the water may end up in the gaseous state (rather than liquid)
- reactants and / or products may not be in standard states.
- MBE data refers to gaseous species but the enthalpy of combustion refers to liquids in their standard states / liquid propanone and liquid water in standard states
- MBE do not refer to specific compounds OR MBE values vary with different compounds / molecules OR are average / mean values taken from a range of compounds / molecules

Apply the list principle but ignore incomplete reasons that contain correct chemistry

Ignore "evaporation"

Ignore "faulty equipment"

Ignore "human error"

Not enough simply to state that "MBE are mean / average values"

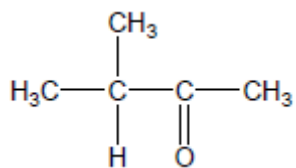
2

[15]

M5.(a) 3-methylbutan-2-ol

1

(b)



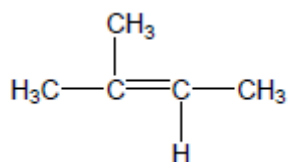
Allow $(\text{CH}_3)_2\text{CHCOCH}_3$

1

(c) Elimination

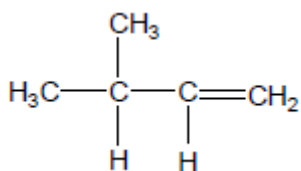
1

(d)



Allow $(\text{CH}_3)_2\text{C}=\text{CHCH}_3$

1



Allow $(\text{CH}_3)_2\text{CHCH}=\text{CH}_2$

1

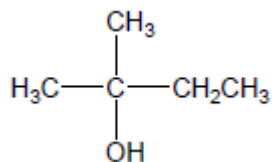
(e) Position

1

(f) C B A

1

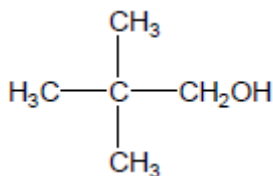
(g)



Allow $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}_2\text{CH}_3$

1

(h)



Allow $(\text{CH}_3)_3\text{CCH}_2\text{OH}$

1

[9]

M6.A

[1]

M7.(a) H_2SO_4

Allow H_3PO_4 or HCl

1

(b) Dichromate / Cr(VI) reduced or Cr(III) formed.

Allow Cr^{6+} and Cr^{3+}

1

(c) The alcohol is flammable

Allow enables temperature to be controlled

1

(d) Tollens'

1

Silver mirror
OR Fehling's
Red precipitate
OR Benedict's
Red precipitate

1
[5]