

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

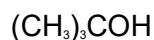


*Any correct structural representation.*

*Credit "sticks" and require the double bond.*

1

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

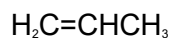


*Any correct structural representation.*

*Credit "sticks".*

1

(c) Structure for propene

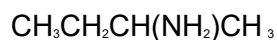


*Any correct structural representation.*

*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, ZnCl<sub>2</sub>) (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  $\text{KMnO}_4$  for possible full marks but **M2** gives brown precipitate or solution goes green*

3

(b) **M1** (Shake with)  $\text{Br}_2$  **OR** bromine (water) **OR** bromine (in  $\text{CCl}_4$  / 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  $\text{KMnO}_4$  /  $\text{H}_2\text{SO}_4$**

**M1** acidified potassium manganate(VII) / potassium permanganate **OR**  $\text{KMnO}_4$  /  $\text{H}_2\text{SO}_4$

**OR**  $\text{KMnO}_4$  /  $\text{H}^+$  **OR** acidified  $\text{KMnO}_4$

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

**M3** decolourised / goes colourless / loses its colour

**Use iodine**

**M1** iodine or  $\text{I}_2$  / KI or iodine solution

**M2** no change

**M3** decolourised / goes colourless / loses its colour

**Use concentrated sulfuric acid**

**M1** concentrated  $\text{H}_2\text{SO}_4$

**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  $\text{KMnO}_4$  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

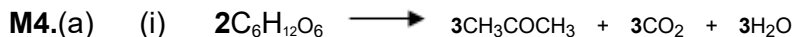
**M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*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**

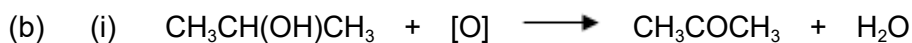
release / contain / provides an enzyme

*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<sup>-1</sup>)

**OR**  $- \underline{1114.6}$  to  $- \underline{1120}$  (kJ mol<sup>-1</sup>)

**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<sup>-1</sup> 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 =  $\Delta H$

**OR**

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

– 6B(C=O) – 6B(O–H) (RHS) =  $\Delta H$

**M2** (also scores **M1**)

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

(696)            (2472) (1984)

– 6(805) – 6(463) [RHS = (–) **7608**] =  $\Delta H$

(4830) (2778)

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

**M3**

$\Delta H = -1651$  (kJ mol<sup>-1</sup>)

**Candidates may use a cycle and gain full marks.**

*Correct answer gains full marks*

*Credit 1 mark for (+) 1651 (kJ mol<sup>-1</sup>)*

*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 4O<sub>2</sub>, 3CO<sub>2</sub> and 3H<sub>2</sub>O 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

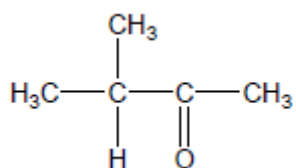
[15]



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

1

(b)



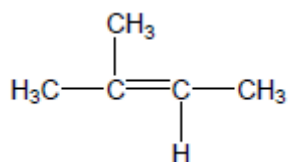
Allow  $(\text{CH}_3)_2\text{CHCOCH}_3$

1

(c) Elimination

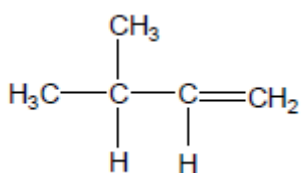
1

(d)



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

1



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

1

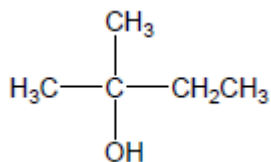
(e) Position

1

(f) C B A

1

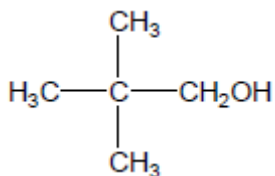
(g)



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)**  $\text{H}_2\text{SO}_4$

Allow  $\text{H}_3\text{PO}_4$  or  $\text{HCl}$

1

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

Allow  $\text{Cr}^{6+}$  and  $\text{Cr}^{3+}$

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]