

1

(ii) to speed up the reaction

OR

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

OR

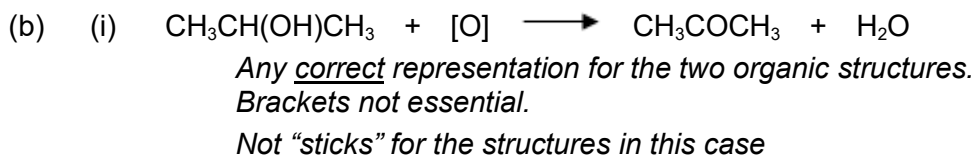
release / contain / provides an enzyme

Ignore "fermentation"

Ignore "to break down the glucose"

Not simply "enzyme" on its own

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(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**

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

OR

$$\underline{\text{Sum of bonds broken} - \text{Sum of bonds formed} = \Delta H}$$

OR

$$2B(\text{C-C}) + B(\text{C=O}) + 6B(\text{C-H}) + 4B(\text{O=O}) \text{ (LHS)}$$

$$- 6B(\text{C=O}) - 6B(\text{O-H}) \text{ (RHS)} = \underline{\Delta H}$$

M2 (also scores **M1**)

$$2(348) + 805 + 6(412) + 4(496) \text{ [LHS} = \mathbf{5957}]$$

$$(696) \quad (2472) \quad (1984)$$

$$- 6(805) - 6(463) \text{ [RHS} = \mathbf{(-) 7608}] = \Delta H$$

$$(4830) \quad (2778)$$

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

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(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]

M2.(a) (i) M1 c(oncetrated) phosphoric acid / c(onc.) H₃PO₄
OR c(oncetrated) sulfuric acid / c(onc.) H₂SO₄

*In M1, the acid must be concentrated.
Ignore an incorrect attempt at the correct formula that is
written in addition to the correct name.*

M2 Re-circulate / re-cycle the (unreacted) ethene (and steam) / the reactants

OR pass the gases over the catalyst several / many times

In M2, ignore "remove the ethanol".

Credit "re-use".

2

- (ii) M1
(By Le Chatelier's principle) the equilibrium is driven / shifts / moves to the right / L to R / forwards / in the forward direction

M2 depends on a correct statement of M1

The equilibrium moves / shifts to

- oppose the addition of / increased concentration of / increased moles / increased amount of water / steam
- to decrease the amount of steam / water

Mark M3 independently

M3 Yield of product / conversion increase **OR** ethanol increases / goes up / gets more

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- (iii) M1 Poly(ethene) / polyethene / polythene / HDPE / LDPE

M2 At higher pressures

More / higher cost of electrical energy to pump / pumping cost

OR

Cost of higher pressure equipment / valves / gaskets / piping etc.

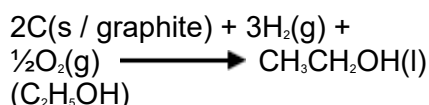
OR expensive equipment

Credit all converse arguments for M2

2

- (b) M1 for balanced equation

M2 for state symbols in a correctly balanced equation



Not multiples but credit correct state symbols in a correctly balanced equation.

Penalise C₂H₆O but credit correct state symbols in a correctly

balanced equation.

2

- (c) (i) M1 The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / element

*If standard enthalpy of formation **CE=0***

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

- (ii) M1

Correct answer gains full marks

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

Credit 1 mark for (+) 1279 (kJ mol⁻¹)

OR

$$\underline{\text{Sum of bonds broken} - \text{Sum of bonds formed} = \Delta H}$$

OR

$$B(\text{C-C}) + B(\text{C-O}) + B(\text{O-H}) + 5B(\text{C-H}) + 3B(\text{O=O}) \text{ (LHS)}$$

$$- 4B(\text{C=O}) - 6B(\text{O-H}) \text{ (RHS)} = \underline{\Delta H}$$

M2 (also scores **M1**)

$$348+360+463+5(412)+3(496) \text{ [LHS = 4719]}$$

$$(2060) \quad (1488)$$

$$- 4(805) - 6(463) \text{ [RHS = - 5998]} = \Delta H$$

$$(3220) \quad (2778)$$

OR using only bonds broken and formed (**4256 - 5535**)

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; this would score 2 marks (**M1** and **M2**)*

- *If no AE, check for a correct method; this requires either a correct cycle with 2C and 6H and 7O OR a clear statement of **M1** which could be in words and scores only **M1***

M3

$$\Delta H = \underline{- 1279} \text{ (kJ mol}^{-1}\text{)}$$

Allow a maximum of one mark if the only scoring point is LHS = 4719 OR RHS = 5998

Award 1 mark for +1279

Candidates may use a cycle and gain full marks

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- (d) (i) Reducing agent OR reductant OR electron donor
OR to reduce the copper oxide
Not "reduction".
Not "oxidation".
Not "electron pair donor".

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- (ii) CH_3COOH

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[17]

M3.(a) $q = 500 \times 4.18 \times 40$

Do not penalise precision.

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$= 83600 \text{ J}$

Accept this answer only.

Ignore conversion to 83.6 kJ if 83600 J shown.

Unit not required but penalise if wrong unit given.

Ignore the sign of the heat change.

An answer of 83.6 with no working scores one mark only.

An answer of 83600 with no working scores both marks.

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(b) Moles $(= 83.6 / 51.2) = 1.63$

Using 77400 alternative gives 1.51 mol

Allow (a) in kJ / 51.2

Do not penalise precision.

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Mass $= 1.63 \times 40(.0) = 65.2 \text{ (g)}$

Allow 65.3 (g)

Using 77400 alternative gives 60.4 to 60.5
Allow consequential answer on M1.
1 mark for M_r (shown, not implied) and 1 for calculation.
Do not penalise precision.

2

(c) Molarity = $1.63 / 0.500 = 3.26 \text{ mol dm}^{-3}$

Allow (b) $M1 \times 2$

Using 1.51 gives 3.02

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(d) Container splitting and releasing irritant / corrosive chemicals

*Must have reference to both aspects; splitting or leaking (can be implied such as contact with body / hands) **and** hazardous chemicals.*

Allow 'burns skin / hands' as covering both points

Ignore any reference to 'harmful'.

Do not allow 'toxic'.

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(e) (i) $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$

Allow fractions / multiples in equation.

Ignore state symbols.

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(ii) Iron powder particle size could be increased / surface area lessened

Decrease in particle size, chemical error = 0 / 3

Change in oxygen, chemical error = 0 / 3

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Not all the iron reacts / less reaction / not all energy released / slower release of energy / lower rate of reaction

Mark points M2 and M3 independently.

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Correct consequence of M2

An appropriate consequence, for example

- too slow to warm the pouch effectively*

- *lower temperature reached*
- *waste of materials*

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- (f) (i) Conserves resources / fewer disposal problems / less use of landfill / fewer waste products

Must give a specific point.

Do not allow 'does not need to be thrown away' without qualification.

Do not accept 'no waste'.

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- (ii) Heat to / or above 80 °C (to allow thiosulfate to redissolve)

Accept 'heat in boiling water'.

If steps are transposed, max 1 mark.

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Allow to cool before using again

Reference to crystallisation here loses this mark.

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[14]