

Mark Scheme - 3.6 Enthalpy Change for Solids and Solutions

1. Combustion of C and H₂ = (2 × -394) + (3 × -286)
= -1646 kJ mol⁻¹ (1)
- $\Delta H = -1646 - (-1560) = -86 \text{ kJ mol}^{-1}$ (1) [2]
- 2.
- (a) Otherwise a temperature change would occur on adding the acid which had nothing to do with the reaction [1]
- (b) (i) Best fit lines (1)
Temperature rise = 6.4 °C (1)
(Take value from candidate's best fit lines) [2]
- (ii) Volume of acid = 26.0 cm³ [1]
[If no best fit lines award 0 in (i) and accept 25 cm³ in (ii)]
- (c) Moles acid = 0.02425 (1)
Conc acid = $\frac{0.02425}{0.026} = 0.933 \text{ mol dm}^{-3}$ (1) [2]
- (d) Heat = 51 × 4.18 × 6.4
= 1364 J [1]
- (e) $\Delta H = \frac{-1364}{0.02425}$ (1)
= -56.2 kJ mol⁻¹ (1) [2]
- (f) Pipette / burette [1]
- (g) No further reaction occurs (1)
The excess acid cools the solution (1) [2]
- (h) Heat/ energy is lost to the environment (1)
Insulation is improved e.g. lid on the polystyrene cup (1) [2]

Total [14]

3.

- (a) (i) I burette / (graduated) pipette [1]
II volumetric / graduated / standard flask [1]
- (ii) 0.0064 [1]
- (iii) 1.20 g / 100 cm³ solution [1]
- (iv) 12.0 g / 100 cm³ solution [1]
- (b) (i) The catalyst is in a different physical state to the reactants. [1]
- (ii) Bonds broken 2 H-H → 872 1 C-O → 360
 1 C-H → 412 1 O-H → 463
 1 C=O → 743
- Total +2850 kJ (1)
- Bonds made 3 C-H → 1236
 1 C-O → 360
 3 O-H → 1389
- Total -2985 kJ (1)
- $\Delta H = 2850 - 2985 = -135 \text{ kJ mol}^{-1}$ (1) [3]
- (c) Relative molecular mass is a relative quantity (based on $\frac{1}{12}$ th of the ¹²C atom as one unit). [1]
- (d) (i) The rate of the forward reaction is equal to the rate of the backward reaction. [1]
- (ii) C₂H₄O [1]
- Total [12]**

4. (a) (i) $2\text{C}(\text{s}) + 3\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{l})$ (state symbols needed)
 C(s) allowed as C(gr) or C(graphite) [1]
- (ii) (if these elements were reacted together) other products would form/
 carbon does not react with hydrogen and oxygen under standard
 conditions [1]
- (b) (i) energy = $100 \times 4.2 \times 54 = 22680$ [1]
- (ii) moles ethanol = $0.81/46 = 0.0176$ (1)
 energy change = $\frac{22.68}{0.0176}$ $\Delta\text{H} = -1290$ (1)
 -ve sign and correct to 3 sf (1) [3]
- (c) internet value numerically larger (1)
 heat losses / incomplete combustion / thermal capacity of calorimeter
 ignored (1) no credit for energy loss [2]
- (d) (i) $\text{C}_3\text{H}_7\text{OH} + 4\frac{1}{2}\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$ (ignore state symbols) [1]
- (ii) negative enthalpy change means energy in bonds broken is less than
 that in bonds made [1]
- (iii) more bonds broken and made in propanol and therefore more energy
 released [1]
- (e) any 4 from:
 both conserve carbon / non-renewable fuel sources / fossil fuels / use
 renewable sources
 (these gas / liquid) suitable for different uses e.g. ethanol to fuel cars
 atom economy gasification is less (some C lost as CO_2) / CO_2 produced in
 gasification is a greenhouse gas
 CO is toxic
 gasification at high temperature / enzymes need low temperature
 enzyme approach therefore saves fuel / gasification needs more energy [4]
 3 max if any reference to destruction of ozone layer
 QWC [2]
 The candidate has selected a form and style of writing that is appropriate to
 purpose and complexity of the subject matter (1)
 Answer has suitable structure (1)

Total [17]

5. enthalpy changes = -110 [1]
6. (a) The mass of one mole of compound [1]
- (b) $\Delta H_f = -417 \text{ kJ mol}^{-1}$ [1]
7. (a) $\Delta H = \Delta H_2 + \Delta H_3 - \Delta H_1$ [1]
- (b) $\frac{1}{2}\text{N}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g})$ state symbols requires [1]
8. (a) (i) $M_r(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 249.7$ [1]
- (ii) I. Moles of copper(II) sulfate
 $= 0.250 \times 250/1000 = 6.25 \times 10^{-2}$ moles (1)
 Mass = $6.25 \times 10^{-2} \times 249.7 = 15.6 \text{ g}$ (1) [2]
- II. 1 mark each for:
- Weighing method
 - Dissolve copper sulfate in a smaller volume of distilled water
 - Transfer to 250.0 cm^3 volumetric / standard flask
 - Use of funnel
 - Wash funnel / glass rod / beaker with distilled water into volumetric flask
 - Add distilled water up to mark
 - Shake solution / mix thoroughly 5 max [5]
- QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate* [1]

- (b) (i) Powder has a greater surface area (1) so gives a higher rate of reaction (1) [2]
- (ii) Extrapolate lines from start (level at 21.3°C) and end (through points at 180-270 seconds) (1)
- Temperature rise = 6.0°C (Range 5.8-6.2°C) (1) [2]
- (iii) I. Moles = $0.250 \times 0.05 = 1.25 \times 10^{-2}$ moles [1]
- II. Zinc is the limiting reagent / Copper(II) sulfate is in excess [1]
- III. $\Delta H = -(50) \times 4.18 \times 6.0 \div (6.12 \times 10^{-3})$ (1)
- $\Delta H = -204902 \text{ J mol}^{-1}$
- $\Delta H = -205 \text{ kJ mol}^{-1}$ (1) [2]
- IV. Enthalpy measures chemical energy, and as heat energy increases, chemical energy must decrease [1]
- Total [18]

9. A [1]