Mark Scheme - PI4.1 Enthalpy Change for Solids and Solutions

1

Combustion of C and H_2 = (2 × –394) + (3 × –286)
= –1646 kJ mol^{-1} (1)

ΔH = –1646 – (–1560) = –86 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 cm^3 [1]

[If no best fit lines award 0 in (i) and accept 25 cm^3 in (ii)]

(c) Moles acid = 0.02425 (1)

Conc acid = $\frac{0.02425}{0.026}$ = 0.933 mol dm^{-3} (1) [2]

(d) Heat = 51 × 4.18 x 6.4

= 1364 J [1]

(e) ΔH = $-\frac{1364}{0.02425}$ (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 cm^3 solution [1]

(iv) 12.0 g / 100 cm^3 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-H → 412; 1 C=O → 743; 1 C-O → 360; 1 O-H → 463

Total +2850 kJ (1)

Bonds made 3 C-H → 1236; 1 C-O → 360; 3 O-H → 1389

Total -2985 kJ (1)

$\Delta H = 2850 - 2985 = -135$ kJ mol^{-1} (1) [3]

(c) Relative molecular mass is a relative quantity (based on $^1/_{12}$th of the ^{12}C atom as one unit). [1]

(d) (i) The rate of the forward reaction is equal to the rate of the backward reaction. [1]

(ii) C_2H_4O [1]

Total [12]

4 (a) (i) $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$ (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 = $\frac{22.68}{0.0176}$ $\Delta H = -1290$ (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) $C_3H_7OH + 4\frac{1}{2}O_2 \rightarrow 3CO_2 + 4H_2O$ (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]

(a) The mass of one mole of compound [1]

(b) ΔH_f = –417 kJ mol^{-1} [1]

6 (a) $\Delta H = \Delta H_2 + \Delta H_3 - \Delta H_1$ [1]

(b) $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g)$ state symbols requires [1]

7. (a) (i) M_r ($CuSO_4.5H_2O$) = 249.7 [1]

(ii) I. Moles of copper(II) sulfate

= 0.250 x 250/1000 = 6.25 x 10^{-2} moles (1)

Mass = 6.25 x 10^{-2} x 249.7 = 15.6 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 x 0.05 = 1.25 x 10^{-2} moles [1]

II. Zinc is the limiting reagent / Copper(II) sulfate is in excess [1]

III. ΔH = -(50)x 4.18 x 6.0 ÷ (6.12 x 10^{-3}) (1)

ΔH = -204902 J mol^{-1}

ΔH = -205 kJ mol^{-1} (1) [2]

IV. Enthalpy measures chemical energy, and as heat energy increases, chemical energy must decrease [1]

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9 **A [1]**