Energetics [S]

1. The neutralisation of hydrochloric acid by potassium hydroxide is exothermic.

   $HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$

   a. Define the term *exothermic*: **[1]**

   b. In an experiment to determine ΔH for this reaction, $25cm^3$ of 1M HCl was added to $25cm^3$ of KOH. The temperature of the mixture rose from 24.5°C to 29.5°C.

      i. Calculate the energy used to heat the mixture if the specific heat capacity of water is 4.2 J/K/g: **[1]**

      ii. Calculate the number of moles of hydrochloric acid neutralized: **[1]**

      iii. Hence calculate the energy change per mole (ΔH) for this reaction: **[2]**

      iv. Suggest a reason why your value for ΔH is inaccurate and explain whether it is higher or lower than the true value: **[3]**

2. The thermal decomposition of copper(II) carbonate is strongly endothermic:

   $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$ $\Delta H = +605$ kJ/mol

   Draw an energy profile for this reaction: **[4]**

3. Calculate ΔH for the complete combustion of ethanol using the following bond energy data: **[3]**

   $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

C-H +412 kJ/mol	C=O +799 kJ/mol	C-C +346 kJ/mol
O=O +494 kJ/mol	O-H +459 kJ/mol	C-O +358 kJ/mol

Energetics [S]

1. The neutralisation of hydrochloric acid by potassium hydroxide is exothermic.

   $HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$

   a. Define the term *exothermic*: **[1]**

      releases/gives out (heat) energy [1]

   b. In an experiment to determine ΔH for this reaction, $25cm^3$ of 1M HCl was added to $25cm^3$ of KOH. The temperature of the mixture rose from 24.5°C to 29.5°C.

      i. Calculate the energy used to heat the mixture if the specific heat capacity of water is 4.2 J/K/g: **[1]**

         E = mcΔT = 50 * 4.2 * 5 = 1050 J [1]

      ii. Calculate the number of moles of hydrochloric acid neutralized: **[1]**

         moles = conc. * volume = 1 * (25/1000) = 0.025 mol [1]

      iii. Hence calculate the energy change per mole (ΔH) for this reaction: **[2]**

         ΔH = E(in kJ)/moles = 1.050/0.025 = - 42 kJ/mol

         [1] for number, [1] for minus sign and units

      iv. Suggest a reason why your value for ΔH is inaccurate and explain whether it is higher or lower than the true value: **[3]**

         Heat energy is lost to the surroundings… [1]

         … so the water temperature doesn't rise as much as it should … [1]

         … so our value is lower than expected [1]

2. The thermal decomposition of copper(II) carbonate is strongly endothermic:

   $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$ $\Delta H = +605$ kJ/mol

   Draw an energy profile for this reaction: **[4]**

   vertical energy/H axis labeled [1]

   products energy level higher than reactants [1]

   reactants and products identified on their energy levels with correct formulae [1]

   ΔH labeled as difference between energy levels [1]

3. Calculate ΔH for the complete combustion of ethanol using the following bond energy data: **[3]**

   $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

C-H +412 kJ/mol	C=O +799 kJ/mol	C-C +346 kJ/mol
O=O +494 kJ/mol	O-H +459 kJ/mol	C-O +358 kJ/mol

bonds broken = 1(C-C) + 5(C-H) + 1(C-O) + 1(O-H) + 3(O=O)

= +1(+346) + 5(+412) + 1(+358) + 1(+459) + 3(+494) = +4705 kJ/mol [1]

Bonds made = 4(C=O) + 6(O-H)

= 4(-799) + 6(-459) = -5950 kJ/mol [1]

ΔH = +4705 – 5950 = -1245 kJ/mol