1 In an experiment, 0.750 g of benzene (C_6H_6) were completely burned in air. The heat evolved raised the temperature of 200 g of water by 43.7°C. Use this data to calculate the enthalpy of combustion of benzene (the specific heat capacity of water is 4.18 J g^{-1} K^{-1}).

$q = mc\Delta T = 200 \times 4.18 \times 43.7 = 36533$ J

$mol\ C_6H_6 = \dfrac{0.750}{78.0} = 0.009615$

$\Delta H = \dfrac{-36.533}{0.009615} = -3800$ kJ mol^{-1} (3 sf)

(4)

(BBoF 168)

2 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid was added to 25.0 cm^3 of 2.00 mol dm^{-3} ammonia solution. The temperature rose by 12.4°C. Calculate the enthalpy of neutralisation for this reaction. Assume that the density of the solution is 1.00 g cm^{-3} and the specific heat capacity of the solution is 4.18 J g^{-1} K^{-1}.

$q = mc\Delta T = 50 \times 4.18 \times 12.4 = 2592$ J

$mol\ HCl = \dfrac{25.0}{1000} \times 2.00 = 0.0500$
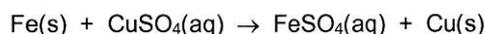
$mol\ NH_3 = \dfrac{25.0}{1000} \times 2.00 = 0.0500$

$HCl + NH_3 \rightarrow NH_4Cl$

$\Delta H = \dfrac{-2.592}{0.0500} = -51.8$ kJ mol^{-1} (3 sf)

(5)

(BBoF 169)

3 When 0.500 g of powdered iron is added to 100 cm^3 of 0.200 mol dm^{-3} copper sulphate solution in an insulated vessel, the temperature rises by 3.3°C.

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

a) Why is the iron added as a powder?

✓ bigger surface area

✓ faster reaction

(2)

b) Calculate the heat evolved in the reaction. The specific heat capacity of the solution can be taken as 4.18 J g^{-1} K^{-1}, and the heat capacity of the iron can be ignored.

$q = mc\Delta T = 100 \times 4.18 \times 3.3 = 1379$ J

(2)

c) Calculate the number of moles of iron and copper sulphate, and so state which reagent is in excess?

$mol\ Fe = \dfrac{0.500}{55.8} = 0.00896$

$mol\ CuSO_4 = \dfrac{100}{1000} \times 0.200 = 0.0200$

∴ $CuSO_4$ is in excess

(2)

d) Calculate the enthalpy change for the reaction.

$\Delta H = \dfrac{-1.379}{0.00896} = -150$ kJ mol^{-1} (2 sf)

(due to 3.3°C) (2)

(BBoF 170)

4 a) Write an equation to represent the $\Delta H°_c$ of butan-1-ol ($C_4H_9OH(l)$).

$$C_4H_9OH(l) + 6 O_2(g) \rightarrow 4 CO_2(g) + 5 H_2O(l) \tag{1}$$

b) A simple flame calorimeter was used to measure the $\Delta H°_c$ of butan-1-ol. 0.600 g of butan-1-ol was burned in a simple lamp burner under a container of water. There was 250 g of water in the container and its temperature rose by 19.4°C. Using the specific heat capacity of water as 4.18 J g^{-1} K^{-1}, calculate the enthalpy of combustion of butan-1-ol.

$q = mc\Delta T = 250 \times 4.18 \times 19.4 = 20273 \text{ J}$

$\text{mol } C_4H_9OH = \dfrac{0.600}{74.0} = 0.008108$

$\Delta H = \dfrac{-20.273}{0.008108} = -2500 \text{ kJ mol}^{-1} \quad (3sf)$ (2)

(BBoF 171)

5 When 20.0 g of ammonium nitrate dissolves in 250 cm^3 of water, the temperature falls by 5.0°C. Calculate the enthalpy change of solution of ammonium nitrate (i.e. the enthalpy change when one mole of ammonium nitrate dissolves).
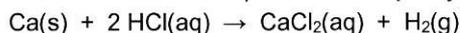
$q = mc\Delta T = 250 \times 4.18 \times 5.0 = 5225 \text{ J}$

$\text{mol } NH_4NO_3 = \dfrac{20.0}{80.0} = 0.250$

$\Delta H = \dfrac{+5.225}{0.250} = +21 \text{ kJ mol}^{-1} \quad (2 sf \text{ as } 5.0°C)$ (4)

(BBOF 173)

6 When 0.400 g of calcium reacts with 100 cm^3 of 2.00 mol dm^{-3} hydrochloric acid, the temperature rises by 12.0°C. The equation for the reaction is shown below. The specific heat capacity of the water is 4.18 J mol^{-1} K^{-1}.

$$Ca(s) + 2 HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$$

a) Calculate the heat released in the reaction.

$q = mc\Delta T = 100 \times 4.18 \times 12.0$

$= 5016 \text{ J}$ (2)

b) Calculate which reagent is in excess.

$\text{mol } Ca = \dfrac{0.40}{40.1} = 0.009975$

$\text{mol } HCl = 2.00 \times \dfrac{100}{1000} = 0.200$

$\therefore HCl \text{ is in excess as } 0.200 \text{ mol } HCl \text{ needs } 0.100 \text{ mol } Ca$ (3)

c) Calculate the enthalpy change for this reaction per mole of calcium reacting.

$\Delta H = \dfrac{-5.016}{0.009975} = -503 \text{ kJ mol}^{-1} \quad (3sf)$ (2)

(BBoF 180)