Chapter 6: Enthalpy changes

Homework marking scheme

1 **a** **i** relative formula mass of $MgCO_3$ = 84.3 [1]

$m = n \times M_r = 0.05 \times 84.3 = 4.22$ g, to 3 significant figures. [1]

ii number of moles of acid = 2 × 0.05 = 0.1 mol [1]

volume, $V = \frac{n}{C} = \frac{0.1}{2} = 0.05\ \text{dm}^3$ or $50\ \text{cm}^3$ [1]

iii 0.05 mol = 0.05 × 40.3 = 2.02 g (to 3 significant figures) or 2.015 g [1]

iv Place **excess** (or any volume greater than 50 cm^3) of 2 mol dm^{-3} HCl in polystyrene beaker (or insulated calorimeter). [1]

Measure the initial temperature of the acid. [1]

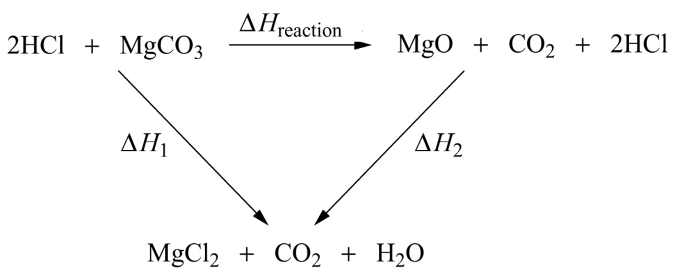
Add the $MgCO_3$ and stir until all the solid has dissolved/reaction stopped. [1]

Measure the final temperature of the reaction mixture. [1]

Use the equation:

heat change = mass of water × specific heat capacity of water × change in temperature [1]

b

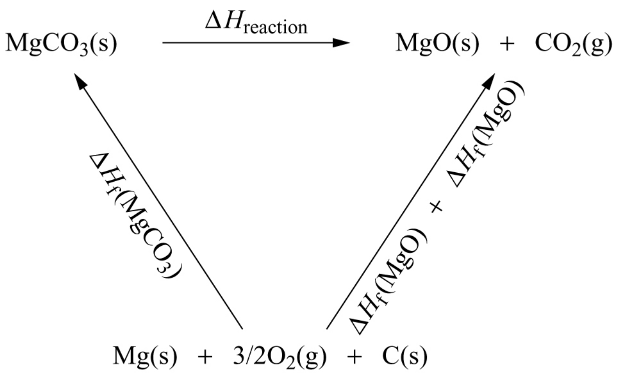


three correct corners of the cycle [1]

three arrows in correct directions [1]

correct labelling of the arrows. [1]

c **i**



three correct corners of the cycle [1]

three arrows in correct directions [1]

correct labelling of the arrows. [1]

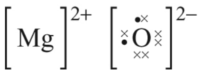
ii $\Delta H_{\text{reraction}} + \Delta H_f(MgCO_3) = \Delta H_f(MgO) + \Delta H_f(CO_2)$ or

$\Delta H_{\text{reraction}} = [\Delta H_f(MgO) + \Delta H_f(CO_2)] - \Delta H_f(MgCO_3)$ [1]

$\Delta H_{\text{reraction}} = -601.7 + (-393.5) - (-1095.8)$ [1]

= +101 kJ mol^{-1} (lose 1 mark if give +100.6 kJ mol^{-1} because question states to 3 s.f.) [1]

d **i**



correct charges on the two ions [1]

zero electrons on the Mg^{2+} (or eight electrons, all dots) and eight electrons on the oxygen [1]

two different electrons on the oxygen in different pairs, as in diagram. [1]

ii The magnesium loses its two outer electrons and this removes one energy level, therefore, smaller radius of atom. [1]

Attractive positive charge on nucleus distributed over fewer electrons. [1]

The oxygen gains two electrons and the attractive positive charge on the nucleus is distributed over more electrons. [1]

Therefore, **less attractive force per electron** and radius increases. [1]

2 **a** $C_6H_6 \rightarrow 3C_2H_2$ [1]

b **i** Use either a Hess's cycle or the expression

$\Delta H_{reaction}$ = sum of bond energies (products) – sum of bond energies (reactants) [1]

$\Delta H_{reaction}$ = (6 × C–C/C=C (benzene) + 6 × C–H) – (3 × C≡C + 6 × C–H)

The 6 × C–H cancel, leaving

$\Delta H_{reaction} = 6 \times 520 - 3 \times 840$ [1]

$= +600$ kJ mol^{-1} [1]

ii $C_2H_2 + 5/2O_2 \rightarrow 2CO_2 + H_2O$ [1]

iii bonds broken: 1 × C≡C = +840

2 × C–H = 2 × 410

5/2 O=O = 2.5 × 497 [1]

total = +2902.5 kJ mol^{-1}

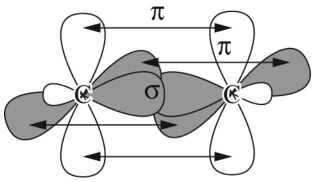
bonds made: 4 × C=O = 4 × 740 = +2960 and 2 × O–H = 2 × 460 [1]

total = +3880 kJ mol^{-1}

$\Delta H_{reaction} = +2902.5 - 3880$ [1]

$\Delta H_{reaction} = -978$ kJ mol^{-1} [1]

c



sigma bond between the carbon atoms [1]

pi bond above and below the plane of the molecule [1]

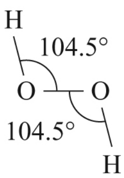
pi bond in the plane of the molecule. [1]

d There are four pairs of electrons round each carbon (three pairs shared between the carbon atoms, and one pair per carbon shared with a hydrogen atom). [1]

But two of these are multiple bonds and do not contribute to the shape. [1]

This leaves one pair of electrons shared between the carbon atoms and therefore the shape is linear. [1]

e



drawing the atoms with some resemblance to the correct structure [1]

correct bond angles. [1]