Chapter 6: Enthalpy changes

Homework questions

1 Magnesium oxide is an industrially important chemical obtained by heating magnesium carbonate. It is widely used in lining furnaces and as an insulating material in cables.
The equation for the thermal decomposition of magnesium carbonate is as follows:
$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$
A group of students were given the task of finding the standard enthalpy change of reaction (ΔH^{θ}_r) for this reaction. This enthalpy change cannot be measured directly. Their instructions were to carry out the reactions between magnesium carbonate and magnesium oxide separately with 2 mol dm^{-3} hydrochloric acid according to the following equations:
$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$ ΔH_1
$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ ΔH_2

a **i** The students were instructed to weigh out 0.05 mol of magnesium carbonate. What mass of magnesium carbonate is this? [2]

ii The hydrochloric acid should be in excess. What volume of the acid would contain exactly the amount required to react with 0.05 mol of magnesium carbonate? [2]

iii What mass of magnesium oxide would they need to weigh out to make it a fair test? [1]

iv Give a brief description of the procedure carried out by the students to measure the enthalpy changes ΔH_1 and ΔH_2. Give details of any formulae and calculations used. [5]

b Construct a Hess' cycle that would enable the students to find the standard enthalpy change for the decomposition of magnesium carbonate using the data obtained by the students. [3]

c To check the accuracy of their results the students consulted their data books and found the following values for the standard enthalpy change of formation of each of the compounds involved in the reaction:
$\Delta H^{\theta}_f(MgCO_3) = -1095.8$ kJ mol^{-1}
$\Delta H^{\theta}_f(MgO) = -601.7$ kJ mol^{-1}
$\Delta H^{\theta}_f(CO_2) = -393.5$ kJ mol^{-1}

i Construct a Hess' cycle to find the standard enthalpy change of reaction for the decomposition of magnesium carbonate. [3]

ii Calculate the standard enthalpy change of reaction, giving your answer to 3 significant places. Show all working. [3]

d **i** Draw a dot-and-cross diagram for magnesium oxide, showing the outer electrons only. [3]

ii The oxide and magnesium ions are **isoelectronic** but the oxide ion is larger than the magnesium ion. Explain why. [4]

Total = 26

2 Benzene (C_6H_6) undergoes pyrolysis to give ethyne (C_2H_2). There are no other products.

a Write the equation for the reaction. [1]

b A number of bond energies are shown in the table below.

Substance	Bond energy / kJ mol^{-1}
C≡C	840
C=C	610
C–C/C=C (benzene)	520
C–C	350
C–H	410
O=O	497
C=O	740
O–H	460

i Calculate the enthalpy of reaction for the conversion of benzene to ethyne. [3]

ii Write the equation for the complete combustion of 1 mol of ethyne. [1]

iii Calculate the standard enthalpy of combustion of ethyne. Give your answer to 3 significant figures. [4]

c Draw a molecule of ethyne, showing how the orbitals on each carbon overlap to form the carbon–carbon triple bond. [3]

d Explain why a molecule of ethyne is linear. [3]

e Hydrogen peroxide, H_2O_2, can be written H–O–O–H. Draw a molecule of hydrogen peroxide, showing the bond angles present. [2]

Total = 17