Further Exercises

Chapter 2

W1. Calculate the change in work, w, for a system that releases 750 J of heat in a process for which the internal energy increases by 220 J.

W2. Starting from the definition of enthalpy, $H = U + pV$, derive a relation between the two heat capacities, C_p and C_v, for an ideal gas.

W3. A 8.0 g sample of methane occupies 10.0 dm^3 at 325 K. Calculate the work done when the gas expands isothermally against a constant external pressure of 2.0 bar until its volume has increased by 5.0 dm^3. How much work would be done if the expansion occurred reversibly.

W4. The reaction used to inflate car 'air bags' is the decomposition of sodium azide, NaN_3

$$NaN_3\,(s) \rightarrow Na\,(s) + 1.5\,N_2\,(g) \qquad \Delta_r H^o = -21.7\ kJ\ mol^{-1}$$

Assuming an airbag needs 60 dm^3 of gas to inflate at 25°C, calculate:

(a) the mass of NaN_3 required to produce this volume of gas.

(b) the volume of gas produced by this mass on a cold day when the temperature in the car might be 10 °C.

(c) the enthalpy change when the airbag is inflated at 298 K.

W5. Calculate how much heat is required to convert 5 g of ice at 0 °C to steam at 100 °C. What happens to the H_2O molecules at each stage?

W6. Calcium carbonate occurs in several forms, including calcite and aragonite. If $\Delta_f H$ = – 1206.9 kJ mol^{-1} for calcite and $\Delta_f H$ = – 1207.1 kJ mol^{-1} for aragonite, calculate the enthalpy change for the transition from calcite to aragonite.

W7. Using the data in Appendix 1, calculate the enthalpy change at 25 ºC for:

$$CO_{(g)} + H_2O_{(g)} \rightarrow CO_{2(g)} + H_{2(g)}$$

W8. At 298 K, the standard enthalpy change of combustion of hydrogen is -285.8 kJ mol^{-1}. The corresponding values for graphite and methanol are –393.5 kJ mol^{-1} and –727.0 kJ mol^{-1} respectively. Calculate the standard enthalpy change of formation of methanol.

W9. The complete combustion of ethane releases 1558.8 kJ mol^{-1} at 25 °C. Calculate ΔH°(combustion) at 100 °C.

C_p / J K^{-1} mol^{-1} : $C_2H_{6(g)}$ 52.6 : $O_{2(g)}$ 29.4 : $CO_{2(g)}$ 37.1 : $H_2O_{(l)}$ 75.3

W10. A piece of apple weighing 2.5 g was burned in oxygen in a bomb calorimeter and produced a temperature rise of 2.05 K. In the same calorimeter, the combustion of 0.316 g of benzoic acid produced a temperature rise of 3.24 K. $\Delta_c U$ for benzoic acid is − 3251 kJ mol^{-1}. If the average mass of an apple is 175 g, how much energy in (a) kJ and (b) Calories comes from an apple?

W11. A bomb calorimeter was calibrated by igniting a 0.7807 g sample of benzoic acid in excess oxygen. The temperature of the calorimeter rose by 1.940 K from 298 K. The internal energy of combustion of benzoic acid is -3251 kJ mol^{-1}. Combustion of 0.9008 g of α-D-glucose gave a temperature rise of 1.311 K in the calorimeter.

Using this information, together with data from Appendix 1, find the enthalpy of formation of α-D-glucose at 298 K and the enthalpy of combustion at the human body temperature of 37 ºC.