## Further Exercises

Chapter 3

W1. 2.00 mol of an ideal gas with a heat capacity of 12.5 J $mol^{-1}$ $K^{-1}$ occupies a volume of 5 $dm^3$ at 300 K. What is the entropy change if the gas is heated to 400 K while the volume doubles?

W2. What are the signs of $\Delta H$, $\Delta S$ and $\Delta G$ for the process of a solid undergoing sublimation?

W3. For the melting of potassium fluoride, KF, $\Delta_{fus}H$ = +246 J $g^{-1}$ at its melting point of 291.6 K. Calculate $\Delta_{fus}S$.

W4. Calculate $\Delta_c G^o$ for the combustion of ethane, $C_2H_{6(g)} + 3½O_{2\ (g)} \rightarrow 2\ CO_{2\ (g)} + 3\ H_2O_{\ (g)}$ at 298 K. How much of the heat produced by burning 10.00 g of ethane cannot be used to do work?

W5. The reaction of methanol, $CH_3OH_{\ (l)}$, with oxygen can be used in a fuel cell to provide electricity. Using data from Appendix 1, calculate the enthalpy change for the combustion reaction at 298 K and the maximum work that can be produced by the oxidation of 1.00 mol of methanol.

W6. Calculate the standard Gibbs energy change at 298 K for the reactions:

$$C_{(s)} + O_{2\ (g)} \rightarrow CO_{2(g)}$$

$$MgCO_{3(s)} \rightarrow MgO_{(s)} + CO_{2(g)}$$

$$C_6H_{12}O_{6\ (s)} + 6\ O_{2\ (g)} \rightarrow 6\ CO_{2\ (g)} + 6\ H_2O_{\ (g)}$$

W7. Biological cell membranes mainly consist of lipid molecules which have polar head groups and non-polar tails. The molecules in solution spontaneously align to form layers. What is the sign of the entropy change for the lipid molecules and for the whole system? Suggest why the self-assembly can be spontaneous.

W8. Calculate the standard Gibbs energy change for the hydrolysis of ATP given that:

glucose + ATP → glucose-6-phosphate + ADP   $\Delta_r G°' = -16.7$ kJ $mol^{-1}$

glucose-6-phosphate → Glucose + phosphate   $\Delta_r G°' = -13.8$ kJ $mol^{-1}$

W9. Predict the sign of $\Delta S$ for:

a) Crystallisation of salt from a solution.

b) Condensation of a vapour to a liquid.

c) Dissolving sugar in water.

d) $CO_{2(s)} \rightarrow CO_{2(g)}$

e) $H_2O_{(g)} + CaSO_{4(s)} \rightarrow CaSO_4 \bullet H_2O_{(s)}$

W10. Calculate the entropy change when 1.00 mol of water at 0 °C freezes to form ice. The $\Delta_{fus}H^{o}$ = +6.02 kJ $mol^{-1}$.

W11. Calculate the normal boiling point of ethanol given that $\Delta_{vap}H$ = +42.6 kJ $mol^{-1}$ and $\Delta_{vap}S$ = +122.0 J $K^{-1}$ $mol^{-1}$.

W12. Calculate the standard Gibbs energy change at 298 K for the reaction below using values of $\Delta_f H^{\ominus}_{298}$ and standard entropies.

$$4\,HCl_{(g)} + O_{2\,(g)} \rightarrow 2\,Cl_{2\,(g)} + 2\,H_2O_{(l)}$$

W13. The Reverse water gas shift reaction is used industrially. It is commonly operated over a catalyst at 350 °C. Calculate the standard Gibbs energy change for the reaction at this temperature and at 25 °C.

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

W14. The standard Gibbs energy change for a reaction is -332.9 kJ mol$^{-1}$ at 298 K and -339.5 kJ mol$^{-1}$ at 500 K. Estimate the standard entropy change for the reaction.