Solutions

Each answer shows the steps, then the **result**.

2.1

- $\Delta G = \Delta H - T\Delta S$

2.2

- Yes ($\Delta G < 0$)

2.3

- Gibbs equation:

$$\Delta G = \Delta H - T\Delta S = -50\ \text{kJ} - (300\ \text{K})(0.100\ \text{kJ K}^{-1}) \quad \text{M1}$$

- $\Delta G = \mathbf{-80}$ kJ

3.1 B

- negative

3.2

(a)

- High temperature (both positive)

(b)

- set $\Delta G = \Delta H - T\Delta S = 0$ and solve for T:

$$T = \frac{\Delta H}{\Delta S} = \frac{30\ \text{kJ}}{0.10\ \text{kJ K}^{-1}}$$

- $T = \mathbf{300}$ K

3.3

- Favorable at **low** temperature – with $\Delta S < 0$, the $-T\Delta S$ term is positive and grows with T; only at low T is it small enough for the negative ΔH to dominate and keep $\Delta G < 0$

3.4

(a)

- $\Delta G^\circ = \sum \Delta G_f^\circ(\text{products}) - \sum \Delta G_f^\circ(\text{reactants}) = 2(51.3) - [2(86.6) + 0]$ (ΔG_f° of the element O_2 is 0)
- $\Delta G^\circ = \mathbf{-70.6}$ kJ mol^{-1}

(b)

- freezing releases energy ($\Delta H < 0$) but makes the water more ordered ($\Delta S < 0$)
- in $\Delta G = \Delta H - T\Delta S$ the $-T\Delta S$ term is positive and grows with T; below 0°C it is smaller than $|\Delta H|$, so $\Delta G < 0$, while above 0°C it is larger and $\Delta G > 0$

3.5 A

- both terms make ΔG positive: $\Delta H > 0$ and $-T\Delta S > 0$ at every temperature