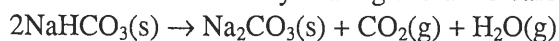


Key

6. Sodium carbonate can be made by heating sodium bicarbonate:

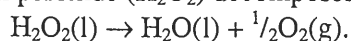


Given that $\Delta H^\circ = 128.9 \text{ kJ/mol}$ and $\Delta G^\circ = 33.1 \text{ kJ/mol}$ at 25°C , above what minimum temperature will the reaction become spontaneous?

$$\begin{aligned}\Delta G &= \Delta H - T\Delta S \\ 33.1 &= 128.9 - 298\Delta S \\ \Delta S &= 0.322 \text{ kJ/mol}\cdot\text{K}\end{aligned}$$

$$\begin{aligned}\Delta G &= \Delta H - T\Delta S \\ 0 &= 128.9 - T(0.322) \\ T &= 401 \text{ K} \\ &\text{or } 128^\circ\text{C}\end{aligned}$$

7. Hydrogen peroxide (H_2O_2) decomposes according to the equation



Calculate K_p for this reaction at 25°C . ($\Delta H^\circ = -98.2 \text{ kJ/mol}$, $\Delta S^\circ = 70.1 \text{ J/K}\cdot\text{mol}$)

$$\begin{aligned}\Delta G^\circ &= -98.2 - 298(0.0701) \\ \Delta G^\circ &= -119 \text{ kJ}\end{aligned}$$

$$\begin{aligned}\Delta G^\circ &= -RT \ln K \\ \ln K &= \frac{\Delta G^\circ}{RT} = \frac{-119 \times 10^3}{8.314 \times 298}\end{aligned}$$

$$\ln K = 48.007 \quad K = 7.5 \times 10^{20}$$

8. At 1500°C the equilibrium constant for the reaction $\text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{g})$ has the value $K_p = 1.4 \times 10^{-7}$. Calculate ΔG° for this reaction at 1500°C .

$$\begin{aligned}\Delta G^\circ &= -RT \ln K \\ \Delta G^\circ &= (-8.314)(1733) \ln 1.4 \times 10^{-7} = 232632 \text{ J} \\ &233 \text{ kJ}\end{aligned}$$

9. Assuming ΔS° and ΔH° do not vary with temperature, at what temperature will the reaction shown below become spontaneous?



$$\begin{aligned}\Delta G &= \Delta H - T\Delta S \\ 0 &= 131.3 - T(0.1336) \\ T &= 983 \text{ K}\end{aligned}$$

$$\begin{aligned}T &> 983 \text{ K} \\ &\text{or } > 710^\circ\text{C}\end{aligned}$$

10. For the reaction $\text{H}_2\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$, $\Delta H^\circ = -106 \text{ kJ/mol}$ and $\Delta S^\circ = 58 \text{ J/K}\cdot\text{mol}$ at 25°C . Calculate ΔG° for this reaction at this temperature.

$$\begin{aligned}\Delta G &= \Delta H - T\Delta S \\ &= -106 - 298(0.058)\end{aligned}$$

$$= -123 \text{ kJ}$$