

## Chapter 18 Multiple Choice Review Solutions

$$5. \quad \Delta S^\circ = [S^\circ_{\text{H}_2\text{SO}_4(l)}] - [S^\circ_{\text{SO}_3(g)} + S^\circ_{\text{H}_2\text{O}(l)}] = [156.9 \text{ J/mol}\cdot\text{K}] - [256.2 \text{ J/mol}\cdot\text{K} + 69.9 \text{ J/mol}\cdot\text{K}] \\ = 156.9 \text{ J/mol}\cdot\text{K} - 326.1 \text{ J/mol}\cdot\text{K} = \boxed{-169.2 \text{ J/mol}\cdot\text{K}}$$

$$6. \quad \Delta G^\circ = 0 = \Delta H_{\text{vap}} - T \Delta S_{\text{vap}} = (21.16 \text{ kJ/mol})(1000 \text{ J/kJ}) - (-35.4^\circ\text{C} + 273) \Delta S_{\text{vap}} \\ \Delta S_{\text{vap}} = \frac{2.116 \times 10^4 \text{ J/mol}}{238 \text{ K}} = \boxed{88.9 \text{ J/mol}\cdot\text{K}}$$

$$9. \quad \Delta S^\circ = [2 \Delta G^\circ_{\text{HNO}_3(l)} + \Delta G^\circ_{\text{NO}(g)}] - [3 \Delta G^\circ_{\text{NO}_2(g)} + \Delta G^\circ_{\text{H}_2\text{O}(l)}] \\ = [2(-79.9 \text{ kJ/mol}) + (86.7 \text{ kJ/mol})] - [3(51.8 \text{ kJ/mol}) + (-237.2 \text{ kJ/mol})] \\ = -73.1 \text{ kJ/mol} - (-81.8 \text{ kJ/mol}) = \boxed{+8.7 \text{ kJ/mol}}$$

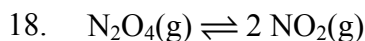
$$10. \quad \Delta G^\circ = \Delta H^\circ - T \Delta S^\circ = -199 \text{ kJ/mol} - (298 \text{ K})(-4.1 \text{ J/mol}\cdot\text{K})(1 \text{ kJ}/1000 \text{ J}) \\ = -199 \text{ kJ/mol} + 1.2 \text{ kJ/mol} = \boxed{-198 \text{ kJ/mol}}$$

$$11. \quad \Delta G^\circ = \Delta H^\circ - T \Delta S^\circ = (128.9 \text{ kJ/mol}) - (298 \text{ K}) \Delta S^\circ = 33.1 \text{ kJ/mol}; \\ \Delta S^\circ = -\frac{33.1 \text{ kJ/mol} - 128.9 \text{ kJ/mol}}{298 \text{ K}} = 0.321 \text{ kJ/mol}\cdot\text{K} \\ \Delta G^\circ = 0 = \Delta H^\circ - T \Delta S^\circ = (128.9 \text{ kJ/mol}) - (T)(0.321 \text{ kJ/mol}\cdot\text{K}) \\ T = \frac{128.9 \text{ kJ/mol}}{0.321 \text{ kJ/mol}\cdot\text{K}} = \boxed{402 \text{ K}}$$

$$13. \quad \Delta G^\circ = \Delta H^\circ - T \Delta S^\circ = (-98.2 \text{ kJ/mol}) - (298 \text{ K})(70.1 \text{ J/mol}\cdot\text{K})(1 \text{ kJ}/1000 \text{ J}) \\ = -119 \text{ kJ/mol} \\ K_p = e^{\frac{\Delta G^\circ}{RT}} = e^{\frac{(-119 \text{ kJ/mol})(1000 \text{ J}/1 \text{ kJ})}{(8.314 \text{ J/mol}\cdot\text{K})(298 \text{ K})}} = \boxed{7.2 \times 10^{20}}$$

$$14. \quad \Delta G^\circ = -RT \ln K_p = -(8.314 \text{ J/mol}\cdot\text{K})(1 \text{ kJ}/1000 \text{ J})(1500 + 273) \ln(1.4 \times 10^{-7}) \\ = -(14.7)(-15.8) = \boxed{233 \text{ kJ/mol}}$$

$$15. \quad \Delta G^\circ = -RT \ln K_p = -(8.314 \text{ J/mol}\cdot\text{K})(1 \text{ kJ}/1000 \text{ J})(298 \text{ K}) \ln(7.7 \times 10^{-13}) \\ = 69.1 \text{ kJ/mol} \\ \Delta G = \Delta G^\circ + RT \ln Q = \Delta G^\circ + RT \ln([\text{Ag}^+][\text{Br}^-]) \\ = 69.1 \text{ kJ/mol} + (8.314 \text{ J/mol}\cdot\text{K})(1 \text{ kJ}/1000 \text{ J})(298 \text{ K}) \ln(1.0 \times 10^{-2} \times 1.0 \times 10^{-3}) \\ = 69.1 \text{ kJ/mol} + (2.48 \text{ kJ/mol})(-11.51) = \boxed{40.6 \text{ kJ/mol}}$$



$$\Delta G^\circ = 2\Delta G_f^\circ(\text{NO}_2) - \Delta G_f^\circ(\text{N}_2\text{O}_4) = 2(51.8 \text{ kJ/mol}) - (98.29 \text{ kJ/mol}) = 5.3 \text{ kJ/mol}$$

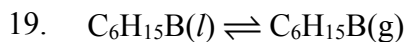
$$\Delta H^\circ = 2\Delta H_f^\circ(\text{NO}_2) - \Delta H_f^\circ(\text{N}_2\text{O}_4) = 2(33.85 \text{ kJ/mol}) - (9.66 \text{ kJ/mol}) = 58.04 \text{ kJ/mol}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ; T = 25^\circ\text{C} + 273 = 298\text{K}, \text{ so } 5.3 \text{ kJ/mol} = 58.04 \text{ kJ/mol} - (298\text{K})\Delta S^\circ$$

$$\Delta S^\circ = \frac{58.04 \text{ kJ/mol} - 5.3 \text{ kJ/mol}}{298 \text{ K}} = 0.177 \text{ kJ/mol} \cdot \text{K}$$

$$\text{At eq. } \Delta G^\circ = 0 = 58.04 \text{ kJ/mol} - T(0.177 \text{ kJ/mol} \cdot \text{K})$$

$$\text{So } T = \frac{58.04 \text{ kJ/mol}}{0.177 \text{ kJ/mol} \cdot \text{K}} = 328 \text{ K}; T = 328 \text{ K} - 273 = 55^\circ\text{C}$$



$$\Delta G^\circ = \Delta G_f^\circ[\text{C}_6\text{H}_{15}\text{B}(\text{g})] - \Delta G_f^\circ[\text{C}_6\text{H}_{15}\text{B}(\text{l})] = (16.1 \text{ kJ/mol}) - (9.4 \text{ kJ/mol}) = 6.7 \text{ kJ/mol}$$

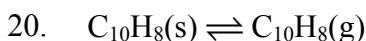
$$\Delta H^\circ = \Delta H_f^\circ[\text{C}_6\text{H}_{15}\text{B}(\text{g})] - \Delta H_f^\circ[\text{C}_6\text{H}_{15}\text{B}(\text{l})] = (-157.7 \text{ kJ/mol}) - (-194.6 \text{ kJ/mol}) = 36.9 \text{ kJ/mol}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ; T = 25^\circ\text{C} + 273 = 298\text{K}, \text{ so } 6.7 \text{ kJ/mol} = 36.9 \text{ kJ/mol} - (298\text{K})\Delta S^\circ$$

$$\Delta S^\circ = \frac{36.9 \text{ kJ/mol} - 6.7 \text{ kJ/mol}}{298 \text{ K}} = 0.101 \text{ kJ/mol} \cdot \text{K}$$

$$\text{At eq. } \Delta G^\circ = 0 = 36.9 \text{ kJ/mol} - T(0.101 \text{ kJ/mol} \cdot \text{K})$$

$$\text{So } T = \frac{36.9 \text{ kJ/mol}}{0.101 \text{ kJ/mol} \cdot \text{K}} = 365 \text{ K}; T = 365 \text{ K} - 273 = 92^\circ\text{C}$$



$$\Delta G^\circ = \Delta G_f^\circ[\text{C}_{10}\text{H}_8(\text{g})] - \Delta G_f^\circ[\text{C}_{10}\text{H}_8(\text{s})] = (224.1 \text{ kJ/mol}) - (201.6 \text{ kJ/mol}) = 22.5 \text{ kJ/mol}$$

$$\Delta H^\circ = \Delta H_f^\circ[\text{C}_{10}\text{H}_8(\text{g})] - \Delta H_f^\circ[\text{C}_{10}\text{H}_8(\text{s})] = (150.6 \text{ kJ/mol}) - (78.5 \text{ kJ/mol}) = 72.1 \text{ kJ/mol}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ; T = 25^\circ\text{C} + 273 = 298\text{K}, \text{ so } 22.5 \text{ kJ/mol} = 72.1 \text{ kJ/mol} - (298\text{K})\Delta S^\circ$$

$$\Delta S^\circ = \frac{72.1 \text{ kJ/mol} - 22.5 \text{ kJ/mol}}{298 \text{ K}} = 0.166 \text{ kJ/mol} \cdot \text{K}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ; T = 35^\circ\text{C} + 273 = 308\text{K},$$

$$\Delta G^\circ = 72.1 \text{ kJ/mol} - (308 \text{ K})(0.166 \text{ kJ/mol} \cdot \text{K}) = 21.0 \text{ kJ/mol}$$

$$\Delta G^\circ = -RT \ln K$$

$$\text{So } 21.0 \text{ kJ/mol} = -(8.31 \text{ J/mol} \cdot \text{K})(1 \text{ kJ}/1000 \text{ J})(308\text{K}) \ln K$$

$$\ln K = \frac{-21.0}{(8.31)(1/1000)(308)} = -8.19; K = e^{-8.19} = 2.8 \times 10^{-4}$$

$$K = P_{\text{C}_{10}\text{H}_8} = 2.8 \times 10^{-4} \text{ atm} \times 760 \text{ mm Hg/atm} = 0.21 \text{ mm Hg}$$