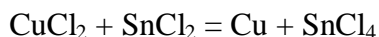


Problem 11-11 Equilibrium constant from standard potentials

Calculate the equilibrium constant of the reaction



at the temperature of 25 °C. Choose the data suitable for this calculation:

$$E^\ominus(\text{Cu}^{2+}|\text{Cu}) = 0.337 \text{ V}$$

$$E^\ominus(\text{Sn}^{2+}|\text{Sn}) = -0.140 \text{ V}$$

$$E^\ominus(\text{CuCl}|\text{Cu}|\text{Cl}^-) = +0.137 \text{ V}$$

$$E^\ominus(\text{Cu}^+|\text{Cu}) = 0.521 \text{ V}$$

$$E^\ominus(\text{Sn}^{4+}|\text{Sn}^{2+}) = +0.150 \text{ V}$$

$$E^\ominus(\text{Cl}_2|\text{Cl}^-) = +1.360 \text{ V}$$

$$[K = 2.1 \cdot 10^6]$$

Solution:

$$(1) \quad \text{Cu}^{2+}(\text{aq}) + 2 \text{ e} = \text{Cu}(\text{s}) \quad E^\ominus(\text{Cu}^{2+}|\text{Cu}) = 0.337 \text{ V} \quad \Delta G_1^\ominus = -2 F E^\ominus(\text{Cu}^{2+}|\text{Cu})$$

$$(2) \quad \text{Sn}^{4+}(\text{aq}) + 2 \text{ e} = \text{Sn}^{2+}(\text{aq}) \quad E^\ominus(\text{Sn}^{4+}|\text{Sn}^{2+}) = -0.15 \text{ V} \quad \Delta G_2^\ominus = -2 F E^\ominus(\text{Sn}^{4+}|\text{Sn}^{2+})$$

$$(3) \quad \text{CuCl}_2(\text{aq}) + \text{SnCl}_2(\text{aq}) = \text{Cu}(\text{s}) + \text{SnCl}_4(\text{aq}) \quad \Delta G_3^\ominus = -R T \ln K$$

$$\Delta G_3^\ominus = \Delta G_2^\ominus - \Delta G_1^\ominus$$
$$-R T \ln K = -2 F E^\ominus(\text{Cu}^{2+}|\text{Cu}) - [-2 F E^\ominus(\text{Sn}^{4+}|\text{Sn}^{2+})]$$

$$\ln K = \frac{2F}{RT} \cdot [E^\ominus(\text{Cu}^{2+}|\text{Cu}) - E^\ominus(\text{Sn}^{4+}|\text{Sn}^{2+})]$$

$$= \frac{2 \cdot 96485.3}{8.314 \cdot 298.15} \cdot [0.337 - 0.15]$$

$$= 14.557538$$

$$K = 2.1 \cdot 10^6$$