

Problem 11-10 Equilibrium constant from standard cell potential

We can observe that on the iron nails immersed into a solution of bluestone metallic copper is deposited.

(a) Write the reaction taking place in this system.

(b) From the following set of standard cell potentials use appropriate data to calculate the equilibrium constant of this reaction at 25 °C.

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

$$E^{\ominus}(\text{Cu}^{2+}|\text{Cu}^{+}) = 0.167 \text{ V}$$

$$E^{\ominus}(\text{Cu}_2\text{S}|\text{Cu}|\text{S}^{2-}) = -0.890 \text{ V}$$

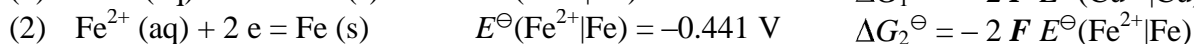
$$E^{\ominus}(\text{Fe}^{2+}|\text{Fe}) = -0.441 \text{ V}$$

$$E^{\ominus}(\text{Fe}^{3+}|\text{Fe}^{2+}) = +0.771 \text{ V}$$

$$E^{\ominus}(\text{FeS}|\text{Fe}|\text{S}^{2-}) = -0.950 \text{ V}$$

$$[K = 2.01 \cdot 10^{26}]$$

Solution:



$$\begin{aligned} \Delta G_3^{\ominus} &= \Delta G_2^{\ominus} - \Delta G_1^{\ominus} \\ -R T \ln K &= -2 F E^{\ominus}(\text{Fe}^{2+}|\text{Fe}) - [-2 F E^{\ominus}(\text{Cu}^{2+}|\text{Cu})] \end{aligned}$$

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

$$= \frac{2 \cdot 96485.3}{8.314 \cdot 298.15} \cdot [0.337 - (-0.441)]$$

$$= 60.56558415$$

$$K = 2.0105 \cdot 10^{26}$$