

## Suggested Problems: Chapter 16

**Problem 16.23:** For (a), we see that  $\text{Mg}(s)$  is oxidized to  $\text{Mg}^{2+}(aq)$  and that  $\text{Ni}^{2+}(aq)$  is reduced to  $\text{Ni}(s)$ . The standard state reduction potential for  $\text{Mg}^{2+}/\text{Mg}$  is  $-2.372$  V and the standard state reduction potential for  $\text{Ni}^{2+}/\text{Ni}$  is  $-0.257$  V. The standard state potential for the reaction is

$$E^\circ = E^\circ_{\text{Ni}^{2+}/\text{Ni}} - E^\circ_{\text{Mg}^{2+}/\text{Mg}} = -0.257 - (-2.372) = +2.115 \text{ V}$$

Because the potential is positive, we know that the reaction is favorable.

For (b) we see that  $\text{Cu}(s)$  is oxidized to  $\text{Cu}^{2+}(aq)$  and that  $\text{Ag}^+(aq)$  is reduced to  $\text{Ag}(s)$ . The standard state reduction potential for  $\text{Cu}^{2+}/\text{Cu}$  is  $0.34$  V and the standard state reduction potential for  $\text{Ag}^+/\text{Ag}$  is  $0.7996$  V. The standard state potential for the reaction is

$$E^\circ = E^\circ_{\text{Ag}^+/\text{Ag}} - E^\circ_{\text{Cu}^{2+}/\text{Cu}} = 0.7996 - 0.34 = +0.4596 \text{ V}$$

Because the potential is positive, we know that the reaction is favorable.

For (c), we ignore the nitrate ion,  $\text{NO}_3^-$ , as it does not undergo any reactions. We see that  $\text{Mn}(s)$  is oxidized to  $\text{Mn}^{2+}(aq)$  and that  $\text{Sn}^{2+}(aq)$  is reduced to  $\text{Sn}(s)$ . The standard state reduction potential for  $\text{Mn}^{2+}/\text{Mn}$  is  $-1.185$  V and the standard state reduction potential for  $\text{Sn}^{2+}/\text{Sn}$  is  $-0.1375$  V. The standard state potential for the reaction is

$$E^\circ = E^\circ_{\text{Sn}^{2+}/\text{Sn}} - E^\circ_{\text{Mn}^{2+}/\text{Mn}} = -0.1375 - (-1.185) = +1.0589 \text{ V}$$

Because the potential is positive, we know that the reaction is favorable.

For (d), we ignore the nitrate ion,  $\text{NO}_3^-$ , as it does not undergo any reactions. We see that  $\text{Fe}^{2+}(s)$  is oxidized to  $\text{Fe}^{3+}(aq)$  and that  $\text{Au}^{3+}(aq)$  is reduced to  $\text{Au}(s)$ . The standard state reduction potential for  $\text{Fe}^{3+}/\text{Fe}^{2+}$  is  $0.771$  V and the standard state reduction potential for  $\text{Au}^{3+}/\text{Au}$  is  $1.498$  V. The standard state potential for the reaction is

$$E^\circ = E^\circ_{\text{Au}^{3+}/\text{Au}} - E^\circ_{\text{Fe}^{3+}/\text{Fe}^{2+}} = 1.498 - (0.771) = +0.727 \text{ V}$$

Because the potential is positive, we know that the reaction is favorable.

**Problem 16.29:** The relationship between  $\Delta G^\circ$  and  $E^\circ$  is

$$\Delta G^\circ = -nFE^\circ$$

where  $n$  is then number of electrons transferred in the redox reaction and  $F$  is Faraday's constant ( $96485 \text{ J/V} \cdot \text{mol e}^-$ ). For (a) we have

$$\Delta G^\circ = -(2 \text{ mol e}^-) \times (96485 \text{ J/V} \cdot \text{mol e}^-) \times (0.000 \text{ V}) \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 0 \text{ kJ}$$

For (b) we have

$$\Delta G^\circ = -(2 \text{ mol e}^-) \times (96485 \text{ J/V} \cdot \text{mol e}^-) \times (0.434 \text{ V}) \times \frac{1 \text{ kJ}}{1000 \text{ J}} = -83.7 \text{ kJ}$$

For (c) we have

$$\Delta G^\circ = -(1 \text{ mol e}^-) \times (96485 \text{ J/V} \cdot \text{mol e}^-) \times (-2.439 \text{ V}) \times \frac{1 \text{ kJ}}{1000 \text{ J}} = +235.3 \text{ kJ}$$