Chemistry 160, Spring 2007 Name:

Exercise 7: Free energy and electrochemistry

1. Consider the following types of galvanic cells (the page references are for the textbook where each cell's half-reactions are written):

• alkaline dry cell (p. 788)

• nickel-cadmium (NI-CAD) battery (p. 788)

• rechargeable lithium battery (p. 789)

For each cell, write the **shorthand notation** for the cell, as shown in chapter 18, and then write the **overall balanced equation** for the cell.

2. The overall reaction in the lead storage battery is

$Pb\ (s) + PbO_2\ (s) + 2\ H^+\ (aq) + 2\ HSO_4^-\ (aq) \rightarrow 2\ PbSO_4\ (s) + 2\ H_2O\ (l)$

a. For the cell reaction, $\Delta H° = -315.9$ kJ and $\Delta S° = 263.5$ J/K. Calculate $E°$ at –20.0°C. Assume $\Delta H°$ and $\Delta S°$ do not depend on temperature.

b. Calculate E at –20.0°C when $[HSO_4^-] = [H^+] = 4.5$ M.

c. Explain how this result shows that car batteries fail more often in cold weather than in warm weather.