Electrochemistry

Use data from Table 21-1 as needed in the following problems. Assume that all half-cells are under standard conditions.

1. For each of these pairs of half-reactions, write a balanced equation for the overall cell reaction and calculate the standard cell potential, E^0_{cell}.

a. $Cs^+(aq) + e^- \rightarrow Cs(s)$

$Cu^+(aq) + e^- \rightarrow Cu(s)$

Cell reaction:

$E^0_{cell} =$

b. $Hg^{2+}(aq) + 2e^- \rightarrow Hg(l)$

$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$

Cell reaction:

$E^0_{cell} =$

c. $Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$

$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$

Cell reaction:

$E^0_{cell} =$

d. $Br_2(g) + 2e^- \rightarrow 2Br^-(aq)$

$Au^+(aq) + e^- \rightarrow Au(s)$

Cell reaction:

$E^0_{cell} =$

e. $Be^{2+}(aq) + 2e^- \rightarrow Be(s)$

$Tl^{3+}(aq) + 3e^- \rightarrow Tl(s)$

Cell reaction:

$E^0_{cell} =$

f. $NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$

$In^{3+}(aq) + 3e^- \rightarrow In(s)$

Cell reaction:

$E^0_{cell} =$

g. $H_3PO_4(aq) + 2H^+(aq) + 2e^- \rightarrow H_3PO_3(aq) + H_2O(l)$

$SeO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow H_2SeO_3(aq) + H_2O(l)$

Cell reaction:

$E^0_{cell} =$

h. $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

$2CO_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2C_2O_4(aq)$

Cell reaction:

$E^0_{cell} =$

2. Calculate the standard cell potential, E^0_{cell}, for a cell composed of a $Sn|Sn^{2+}$ half-cell and each of these half-cells.

a. $Pd|Pd^{2+}$

$E^0_{cell} =$

b. $Hf|Hf^{4+}$

$E^0_{cell} =$

c. $Cl_2|Cl^-$

$E^0_{cell} =$

d. $Pb|Pb^{2+}$

$E^0_{cell} =$

3. Which of the following cells will produce the highest voltage?

$Mn|Mn^{2+}\|Zn^{2+}|Zn$

$Zn|Zn^{2+}\|Ni^{2+}|Ni$

$Ni|Ni^{2+}\|Cu^{2+}|Cu$

4. For each of these overall cell reactions, write the oxidation and reduction half-reactions, calculate the standard cell potential, E^0_{cell}, and determine if the reaction is spontaneous or not.

a. $Fe^{3+}(aq) + Co^{2+}(aq) \rightarrow Fe^{2+}(aq) + Co^{3+}(aq)$

Oxidation half-reaction:

Reduction half-reaction:

$E^0_{cell} =$

Spontaneous?

b. $Fe^{3+}(aq) + Cu^{+}(aq) \rightarrow Fe^{2+}(aq) + Cu^{2+}(aq)$

Oxidation half-reaction:

Reduction half-reaction:

$E^0_{cell} =$

Spontaneous?

c. $3Ni^{2+}(aq) + 2Rh(s) \rightarrow 3Ni(s) + 2Rh^{3+}(aq)$

Oxidation half-reaction:

Reduction half-reaction:

$E^0_{cell} =$

Spontaneous?

d. $2Na^{+}(aq) + 2Hg(l) + 2I^{-}(aq) \rightarrow 2Na(s) + Hg_2I_2(s)$

Oxidation half-reaction:

Reduction half-reaction:

$E^0_{cell} =$

Spontaneous?

e. $O_2(g) + 2H_2SO_3(aq) \rightarrow 2SO_4{}^{2-}(aq) + 4H^{+}(aq)$

Oxidation half-reaction:

Reduction half-reaction:

$E^0_{cell} =$

Spontaneous?

5. Suppose a battery-powered device requires a minimum voltage of 9.0 V to run. How many lead–acid cells would be needed to run the device? (Remember that a standard automobile battery contains six lead–acid cells connected in one package.) The overall reaction of a lead–acid cell is

$Pb(s) + PbO_2(s) + 4H^{+}(aq) + 2SO_4{}^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

6. What is the minimum voltage that must be applied to a Down's cell to cause the electrolysis of molten sodium chloride? The net cell reaction is

$2Na^{+}(l) + 2Cl^{-}(l) \rightarrow 2Na(l) + Cl_2(g)$

7. One way to determine the metallic composition of an alloy is to use electroplating. Suppose an electrolytic cell is set up with solution of nickel ions obtained from a 6.753-g sample of a nickel alloy. The cell also contains a platinum electrode that has a mass of 10.533 g. Electric current is used to reduce the nickel ions to nickel metal, which is deposited on the platinum electrode. After being plated with nickel, the platinum electrode has a mass of 15.042 g. What is the percentage of nickel in the alloy?