CHEM 1423
Chapter 21
Homework Questions

TEXTBOOK HOMEWORK

21.5 Consider the following balanced redox reaction:
$16\ H^+(aq) + 2\ MnO_4^-(aq) + 10\ Cl^-(aq) \rightarrow 2\ Mn^{2+}(aq) + 5\ Cl_2(g) + 8\ H_2O(l)$

(a) Which species is being oxidized?
(b) Which species is being reduced?
(c) Which species is the oxidizing agent?
(d) Which species is the reducing agent?
(e) From which species to which does electron transfer occur?
(f) Write the balanced molecular equation, with K^+ and $SO4^{2-}$ as the spectator ions.

21.9 Balance the following skeleton reactions and identify the oxidizing and reducing agents:

(a) $Sb + NO_3^- \rightarrow Sb_4O_6 + NO \quad (acid)$

(b) $Mn^{2+} + BiO_3^- \rightarrow MnO_4^- + Bi^{3+} \quad (acid)$

(c) $Fe(OH)_2 + Pb(OH)_3^- \rightarrow Fe(OH)_3 + Pb \quad (basic)$

21.27 In basic solution, Se^{2} and SO_3^{2-} ions react spontaneously:

$$2\,Se^{2-} + 2\,SO_3^{2-} + 3\,H_2O \rightarrow 2\,Se + 6\,OH^- + S_2O_3^{2-} \qquad E^o_{cell} = 0.35V$$

(a) Write the balanced half-reactions for the process
(b) Using Appendix D to find E_{O3}^o, calculate E_{Se}^o

21.33 Balance each skeleton reaction, calculate E°cell, and state whether the reaction is spontaneous:

(a) $Ag + Cu^{2+} \rightarrow Ag^+ + Cu$

(b) $Cd + Cr_2O_7^{2-} \rightarrow Cd^{2+} + Cr^{3+}$

(c) $Ni^{2+} + Pb \rightarrow Ni + Pb^{2+}$

21.36 Use the following half-reactions to write three spontaneous reactions, calculate E°cell for each reaction, and rank the strengths of the oxidizing and reducing agents:

(1) $Au^{+}(aq) + e^{-}$ □ $Au(s)$ E° = 1.69 V

(2) $N_2O(g) + 2\ H^{+}(aq) + 2\ e^{-}$ □ $N_2(g) + H_2O(l)$ E° = 1.77 V

(3) $Cr^{3+}(aq) + 3\ e^{-}$ □ $Cr(s)$ E° = -0.74 V

21.45 What is the value of the equilibrium constant for the reaction between each pair at 25°C? (a) Ni(s) and Ag1(aq)

(b) Fe(s) and Cr31(aq)

21.50 What are E°cell and □G° of a redox reaction at 25°C for which n = 2 and K = 0.065?

21.52 A voltaic cell consists of an Mn|Mn2^{+} half-cell and a Pb|Pb2^{+} half-cell. Calculate $[Pb^{2+}]$ when $[Mn^{2+}]$ is 1.4 M and Ecell is 0.44 V.

21.76 Electrolysis of molten $MgCl_2$ is the final production step in the isolation of magnesium from seawater by the Dow process. Assuming that 45.6 g of Mg metal forms,
(a) How many moles of electrons are required?
(b) How many coulombs are required?
(c) How many amps will produce this amount in 3.50 h?

21.80 How many seconds does it take to deposit 65.5 g of Zn on a steel gate when 21.0 A is passed through a $ZnSO_4$ solution?

21.84 Zinc plating (galvanizing) is an important means of corrosion protection. Although the process is done customarily by dipping the object into molten zinc, the metal can also be electroplated from aqueous solutions. How many grams of zinc can be deposited on a steel tank from a $ZnSO_4$ solution when a 0.855 A current flows for 2.50 days?

SUPPLEMENTARY HOMEWORK

S1. Which one of these changes describes an oxidation half-reaction?

a. decrease in oxidation number

b. loss of electrons

c. electrons as reactants

d. reactant acting as an oxidizing agent

e. pure oxygen becoming oxide ion

S2. If cadmium metal and the Fe(III) ion are mixed in aqueous solution, a solution containing Cd(II) and Fe(II) results. The balanced equation for this process is

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

b. $Cd(s) + 2\,Fe^{3+}(aq) \rightarrow 2\,Fe^{2+}(aq) + Cd^{2+}(aq)$.

c. $2\,Cd(s) + Fe^{3+}(aq) \rightarrow Fe^{2+}(aq) + 2\,Cd^{2+}(aq)$.

d. $2\,Cd(s) + Fe^{3+}(aq) \rightarrow 2\,Fe^{2+}(aq) + Cd^{2+}(aq)$.

e. $2\,Cd(s) + Fe^{3+}(aq) \rightarrow Fe^{2+}(aq) + 2\,Cd^{2+}(aq)$.

S3. Which cell notation represents a battery constructed using zinc and iron, with electrons flowing from zinc to iron?

a. $Fe^{3+}(aq) \mid Fe^{2+}(aq) \parallel Zn(s) \mid Zn^{2+}(aq)$

b. $Fe^{3+}(aq) \mid Fe(s) \parallel Zn(s) \mid Zn^{2+}(aq)$

c. $Zn(s) \mid Zn^{2+}(aq) \parallel Fe^{3+}(aq) \mid Fe^{2+}(aq)$

d. $Zn(s) \mid Zn^{2+}(aq) \parallel Fe^{3+}(aq) \mid Fe(s)$

e. $Zn(s)\ |\ Zn^{2+}(aq)\ ||Fe(s)\ |\ Fe^{3+}(aq)$

S4.Consider the cell reaction

$Sn(s) + Cu^{2+}(aq) \rightarrow Sn^{2+}(aq) + Cu(s)$.

The value of E^o_{cell} is 0.447 V at 25°C. Calculate the value of ΔG° and K for this cell.

S5. The value of E_{cell} at 25°C for the cell shown below is +1.27 V. What is the value of E^o_{cell}?

$Cd(s)\ |\ Cd^{2+}(0.10\ M)\ ||\ Ag^{+}(2.0\ M)\ |\ Ag(s)$

S6. The value of E^o_{cell} for the cell shown below is + 1.41 V.

$Al(s)\ |\ Al^{3+}(aq)\ ||\ Ni^{2+}(aq)\ |\ Ni(s)$

What is the value of E_{cell} at 25°C if the concentration of $Al^{3+}(aq)$ is 0.050 M, and of $Ni^{2+}(aq)$, 2.0 M?

S7. The EPA recommended maximum concentration of Zn^{2+} [M(Zn) = 65.4 g/mol] in drinking water is 5. mg/L. The amount of Zn in a sample of water can be determined by measuring the voltage of an electrochemical cell in which the reference electrode (cathode) has a standard concentration [say, 0.20 M $Zn(NO_3)_2$] and the sample electrode (anode) has the water sample. This cell can be designated as: $Zn(s)|Zn^{2+}(xx\ M)||Zn^{2+}(0.20\ M)|Zn(s)$.

The cell potential was measured as +0.078 V. Determine the concentration of Zn^{2+} in the sample, in mg/L.

S8. An electrochemical cell is prepared with 0.50 M $Pb(NO_3)_2(aq)$ in the reference compartment (cathode) and a saturated solution of lead iodate, $Pb(IO_3)_2(aq)$, in the sample compartment (anode). The measured cell voltage is: 0.120 V.

Calculate the Solubility Product, K_{sp}, of $Pb(IO_3)_2$.

S9. An electrochemical cell is prepared with 0.25 M $AgNO_3$(aq) in the reference compartment (cathode) and a saturated solution of silver phosphate, Ag_3PO_4(aq), in the sample compartment (anode). The measured cell voltage is: 0.195 V.

Calculate the Solubility Product, K_{sp}, of Ag_3PO_4.

S10. A current of 2.5 A (1 Ampere = 1 C/s) is passed through a solution of Copper(II) Bromide for a period of 24.0 hours.

How many grams of Cu(s) will be plated out?

S11 on next page

ELECTROLYSIS (Table for S11)

Note: As discussed in class, you may assume that the reduction and oxidation potentials are approximately the same in the molten salt as in aqueous solution.

Some Reduction Potentials

$2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$ $\quad E^o_{red} = -0.83$ V

$Mn^{2+} + 2\ e^- \rightarrow Mn$ $\quad E^o_{red} = -1.18$ V

$Zn^{2+} + 2\ e^- \rightarrow Zn$ $\quad E^o_{red} = -0.76$ V

$Al^{3+} + 3\ e^- \rightarrow Al$ $\quad E^o_{red} = -1.66$ V

$Na^+ + 3\ e^- \rightarrow Na$ $\quad E^o_{red} = -2.71$ V

$Fe^{2+} + 2\ e^- \rightarrow Fe$ $\quad E^o_{red} = -0.44$ V

Some Oxidation Potentials

$2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^-$ $\quad E^o_{oxid} = -1.23$ V

$2\ I^- \rightarrow I_2 + 2\ e^-$ $\quad E^o_{oxid} = -0.54$ V

$2\ Br^- \rightarrow Br_2 + 2\ e^-$ $\quad E^o_{oxid} = -1.07$ V

$2\ F^- \rightarrow F_2 + 2\ e^-$ $\quad E^o_{oxid} = -2.87$ V

S11. For each of the systems below, name (1) the products of electrolysis and the electrode [Positive Anode or Negative Cathode) at which they form, (2) The minimum voltage required for the electrolysis, (3) the balanced net electrolysis rection.

(a) Molten AlF_3(liq)

(b) A mixture of molten NaI(liq) and molten $ZnBr_2$(liq)

(c) An aqueous solution of MnF_2(aq)

(d) An aqueous solution of FeI_2(aq)

(e) An aqueous solution of NaI(aq)

(f) An aqueous solution of ZnF_2(aq)