ELECTROCHEMISTRY: CHEMICAL CHANGE AND ELECTRICAL WORK

Chapter 21 Outline

Text Problems: # 5, 9, 27, 33, 36, 45, 50, 52, 76, 80, 84
+ Supplementary Questions (attached)

Text Sample Problems: The text has a number of excellent sample problems (solved in detail) in each section. I would recommend that you study these problems + the "follow up" problems, which have brief solutions at the end of the chapter.

Sect.	Title and Comments	Required?
1.	Redox Reactions and Electrochemical Cells	YES
2.	Voltaic Cells Using Spontaneous Reactions to Generate Electrical Energy We won't stress Active vs. Inactive Electrodes	YES
3.	Cell Potential: Output of a Voltaic Cell	YES
4.	Free Energy and Electrical Work We will add a discussion on the application of concentration cells to study (a) sample impurities, and (b) solubility equilibria We won't cover the subsection on "Changes in Potential During Cell Operation"	YES
5.	Electrochemical Processes in Batteries	A LITTLE
6.	Corrosion: An Environmental Voltaic Cell	MAYBE
7.	Electrolytic Cells: Using Electrical Energy to Drive Nonspontaneous Reactions	YES

Chapter 21

Supplementary Homework Questions

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. $Fe^{3+}(aq)\,|\,Fe^{2+}(aq)\,\|\,Zn(s)\,|\,Zn^{2+}(aq)$
- b. $Fe^{3+}(aq)\,|\,Fe(s)\,\|\,Zn(s)\,|\,Zn^{2+}(aq)$
- c. $Zn(s)\,|\,Zn^{2+}(aq)\,\|\,Fe^{3+}(aq)\,|\,Fe^{2+}(aq)$
- d. $Zn(s)\,|\,Zn^{2+}(aq)\,\|\,Fe^{3+}(aq)\,|\,Fe(s)$
- 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 $\Delta G°$ and K for this cell.

S5. The value of E_{cell} at 25^{o}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^{o}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

$2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^-$	$E^o_{red} = -0.83$ V
$Mn^{2+} + 2\ e^- \rightarrow Mn$	$E^o_{red} = -1.18$ V
$Zn^{2+} + 2\ e^- \rightarrow Zn$	$E^o_{red} = -0.76$ V
$Al^{3+} + 3\ e^- \rightarrow Al$	$E^o_{red} = -1.66$ V
$Na^+ + 3\ e^- \rightarrow Na$	$E^o_{red} = -2.71$ V
$Fe^{2+} + 2\ e^- \rightarrow Fe$	$E^o_{red} = -0.44$ V

Some Oxidation Potentials

$2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^-$	$E^o_{oxid} = -1.23$ V
$2\ I^- \rightarrow I_2 + 2\ e^-$	$E^o_{oxid} = -0.54$ V
$2\ Br^- \rightarrow Br_2 + 2\ e^-$	$E^o_{oxid} = -1.07$ V
$2\ F^- \rightarrow F_2 + 2\ e^-$	$E^o_{oxid} = -2.87$ 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)

Answers to the Supplementary Homework Questions are posted on the course web site. Questions about these Problems will be answered in Recitation