Exam 3: Redox and misc.
CE 353, Spring '00

Name:

Some Useful Equations and Constants

$pe^{O} = \left(\frac{1}{n}\right)(\log K)$

$\frac{2.3RT}{F} = 0.059$ at 25^{O} C

$p\varepsilon = F E_H / (2.3 R T) = 16.9 E_H$ at 25^{o} C

$E_H^{O} = \left(\frac{0.059}{n}\right)\log K = 0.59\, pe^{O}$

$pe^{O} = F E_H^{O} / (2.3 R T) = 16.9 E_H^{O}$ at 25^{O} C

R = 8.314 Joule / (mole K)

$p\varepsilon^{o} = -\Delta G^{o} / (2.3\, n R T)$

F = 96,493 coulomb / eq (or joule / (volt eq))

1. (12 pts) Draw the structure of the following chemicals.

a) cis-dichloroethene

b) 3,4,4'-trichlorobiphenyl

c) vinyl chloride

d) toluene

2. (13 pts)

a) Name 4 inorganic compounds that can act as final electron acceptors for biological respiration by facultative or anaerobic organisms.

b) Write the complete half-reaction for each (one has more than one: write one).

c) One of your 4 could be sulfate (SO_4^{2-}) to hydrogen sulfide (as HS^-). Combine this half reaction with the oxidation of glucose ($C_6H_{12}O_6$) to carbon dioxide (CO_2) to construct a completely balanced oxidation-reduction reaction.

3. (10 pts) Construct a balanced oxidation-reduction reaction for the oxidation of ammonia (as NH_3) to nitrate ion through the reduction of manganese oxide, $(MnO_2)_s$, to manganese II, $(Mn^{2+})_{aq}$. (Hint: start by writing 2 complete half-reactions)

4. (5 pts) Balance the following half reactions with other species and electrons.

$$CCl_3CCl_3 \Leftrightarrow CH_3CH_3 + Cl^-$$

(hexachloroethane)

5. (10 pts) The following is a list of solubility products for various metal sulfides:

Reaction	log K_{sp} at 25^0 C
FeS_s ? Fe^{2+} + S^{2-}	-18.1
ZnS_s ? Zn^{2+} + S^{2-}	-24.7
CdS_s ? Cd^{2+} + S^{2-}	-27.0
PbS_s ? Pb^{2+} + S^{2-}	-27.5
CuS_s ? Cu^{2+} + S^{2-}	-36.0
HgS_s ? Hg^{2+} + S^{2-}	-52.7

a) Which metal sulfide is the most soluble?

b) Which metal sulfide is the least soluble?

c) For any saturated solution of any of these metal sulfides, does the solubility of the metal ion increase or decrease as a function of pH? (Hint: assume no aqueous complexes occur, and recall the pK_a of HS^- is 13.9)

6. (5 pts) What does it mean 'to *poise* a solution'? Give an example of such a solution.

7. (15 pts) An cation exchange resin has an exchange capacity of 1.5 meq / mL resin.

a) At saturation, how many moles of Cu^{2+} can a 50 L column of resin hold if copper is the only cation on the resin?

b) How many grams of copper is this? (Cu = 63.54 g / mol)

c) How many grains is this? (Hint: 1 pound = 453.59 grams, 12 ounces = 1 pound, 20 pennyweight = 1 ounce, 24 grains = 1 pennyweight)

d) If an industrial wastewater contains 10^{-4} M Cu^{2+}, and complete exchange with sodium (initially on the resin) occurs, what volume of wastewater (L) can be treated before theoretical breakthrough (*i.e.*, resin saturation) occurs?

8. (20 pts) Develop (derive) the line for a pe-pH predominance diagram that indicates where equal concentrations of SO_4^{2-} and HS^- exist for a total sulfur concentration (= SO_4^{2-} + HS^-) of 10^{-4} M.

SO_4^{2-} + 10 H^+ + 8 e^- ? H_2S_{aq} + 4 H_2O $E_H°$ = 0.303 Volts

H_2S_{aq} ? H^+ + HS^- $K_a = 10^{-7}$ M

9. (10 pts) What is the pe of water in equilibrium with air at pH = 5?

	$E_H°$ (Volts)	pe°
Recall: $O_{2,g}$ + 4 H^+ + 4 e^- ? 2 H_2O	+ 1.23	20.8
2 H_2O + 2 e^- ? $H_{2,g}$ + OH^-	-0.83	-14.0

and air in 21% O_2