CE 311A: Environmental Quality and Pollution
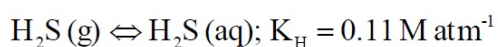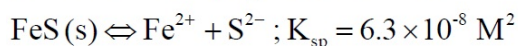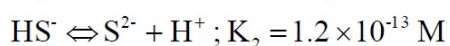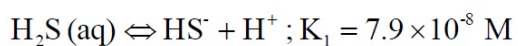## Problem Set No. 3
Due in class on or before 1/9/17

Submission by due date is voluntary and carries no marks. Submitted work will be checked and returned with solutions.

Q1) Write balanced half-cell and overall reactions for the following redox transformations:

    (a) The reduction of nitrobenzene to aniline by hydrogen sulfide assuming that elemental sulfur ($S(s)$) is formed.

    (b) The oxidation of dimethylsulfide (CH_3-S-CH_3) to dimethylsulfoxide (CH_3-SO-CH_3) by goethite ($FeOOH_{(s)}$) assuming that siderite ($FeCO_{3(s)}$) is formed.

    (c) The reduction of dichromate ion ($Cr_2O_7^{2-}$) to chromium dihydroxo complex [$Cr(OH)_2^+$] by dissolved Fe^{2+} which converts to ferric hydroxide solid [$Fe(OH)_{3(s)}$]

Q2) During midterm recess from IIT Kanpur you decide to pursue a sport: spelunking (that is, crawling through caves). So you put on appropriate outfit and begin to explore some caves in the foothills of the Himalayas. As you descend into one especially small and previously undiscovered cave, you begin to smell the rotten-egg odor characteristic of sulfide gas (H_2S). In fact, you notice that many of the rocks around you are glinting with what you recognize to be iron sulfide (FeS) crystals. Suddenly, the rock drops out from under your feet and you fall into a pool of water within cavern room. The hole you dropped through clogs with debris and closes up after you. The room contains 150 L of air containing hydrogen sulfide gas (H_2S). The water is in contact with rock containing solid FeS, and we know that sulfide is a weak acid governed by the following equilibrium relationships at 25ºC.

$$H_2S\,(aq) \Leftrightarrow HS^- + H^+\,; K_1 = 7.9 \times 10^{-8}\ M$$
$$HS^- \Leftrightarrow S^{2-} + H^+\,; K_2 = 1.2 \times 10^{-13}\ M$$
$$FeS\,(s) \Leftrightarrow Fe^{2+} + S^{2-}\,; K_{sp} = 6.3 \times 10^{-8}\ M^2$$
$$H_2S\,(g) \Leftrightarrow H_2S\,(aq);\ K_H = 0.11\ M\ atm^{-1}$$

You would like to measure the toxicity of the sulfide gas to determine whether you can expect to escape. Since you happen to be carrying some pH paper, you know that the pH of water is 9.0. Calculate the partial pressure of sulfide in the air above the pool at equilibrium.

List the dissolved species for this system and identify the components. Neglect any other species that Fe^{2+} may form with S^{2-} or OH^-. Neglect presence of other ions such as carbonate and assume the system to be dilute.

Q3) A wastewater contains 15 mg/L phenol (C_6H_6O) as a major constituent. How much Cr(VI), present as $Cr_2O_7^{2-}$, is reduced by phenol to Cr(OH)$_{3(s)}$ in a COD test? How much COD does the phenol contribute to the solution, expressed as mg O_2/L?

Hint: Starting with the balanced half-cell reactions develop the overall reaction for oxidation of phenol to carbon dioxide by dichromate.