Homework #9

Pr#1 (5.76) Osmotic pressure of sea water.

1 kg of seawater has volume $1\,l = 10^{-3}\,m^3$

The total mass of solute is 35g and the average atomic mass of sodium and clorine is $\langle\mu\rangle = \frac{23+35.5}{2} = 29.2$ g/mole.

Then the number of moles in solute is

$$n_B = \frac{35\,g}{29.2\,g/mole} = 1.12\ mol.$$

a) $P_2 - P_1 = \frac{n_B \cdot RT}{V} = \frac{1.12 \cdot 8.3 \cdot 300}{10^{-3}} = 3\times10^6\,Pa \simeq 30\,atm.$

b) $P\Delta V = 3000\,J$. (work needed to desalinate 1 kg of see water)

to evaporate water you need $2260\,kJ/kg$

Problem #2 (5.86) (HW #9)

The table on page 405 gives giver ΔH° for production of 1 mole of ammonia (from elemental constitutes N_2 and H_2, and at 298 K) as.

$$\Delta H = \sum_{products} \Delta H - \sum_{reagents} \Delta H = -46.11 \text{ kJ}$$

For two moles of ammonia we just multiply this number by 2. Then using equation

$$\ln k(T_2) - \ln k(T_1) = \frac{\Delta H^\circ}{RT}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$ we find

(this is a functional form not a product)

$$\ln k(773k) = \ln(\underbrace{5.9\times 10^5}_{\text{k at room temperature}}) + \frac{-92.2\times 10^3}{8.3}\left(\frac{1}{298} - \frac{1}{773}\right) =$$

$$= 13.29 - 22.94 = -9.65$$

$$k = \exp(-9.65) = 6.4\times 10^{-5}$$

experimental 6.9×10^{-5}

Problem #3 (5.87) HW # 9.

(a) The law of mass action for the first dissociation reaction is.

$$\frac{m_{H^+} \cdot m_{HSO_4^-}}{m_{H_2SO_4}} = 10^2 \text{ (from problem statement)}$$

Since the equilibrium constant is so huge compare to that for dissosiation of water we can neglect any H^+ ions that come from water dissosiation and assume that molalities of H^+ and HSO_4^- are equal

$$m^2_{HSO_4^-} = 10^2 \, m_{H_2SO_4} \qquad m_{HSO_4^-} = 10\sqrt{m_{H_2SO_4}}$$

Let's try some numbers'

if $m_{H_2SO_4} = 1$ $m_{HSO_4^-} = 10$ that means 90% of the acid is dissociated. The lower molalities of H_2SO_4 will give even larger percentage of dissociation. Conclusion in all solutions we are likely to encounter, the reaction will come almost to completion.

(b) The law of mass action for the second dissociation reaction is

$$\frac{m_{H^+} \cdot m_{SO_4^{2-}}}{m_{HSO_4^-}} = 10^{-1.9} = 0.013$$

Let's assume that the reaction went to completetion than for every SO_4^{-2} ion we have 2 H^+ ions.

$$m_{HSO_4^{-1}} = \frac{10^{-4} \cdot 5\times10^{-5}}{0.013} = 4\times10^{-7}$$

$$\boxed{\frac{(m_{H^+}+x)(x)}{(5\times10^{-5}-x)} = 10^{-2}}$$

x - must be closed to 5×10^{-5} to satisfy this eq.

This number is much smaller than $m_{SO_4^{2-}} = 5\times10^{-5}$ so we may safely assume that the second reaction went to completion.

The molality of H^+ $m_{H^+} = 10^{-4}$ and water with this concentration of H^+ has $pH = 4$

(c) Dissociation of water

$$m_{H^+} \cdot m_{OH^-} = 10^{-14} \qquad \text{if } m_{H^+} = 10^{-4}$$

$m_{OH^-} = 10^{-10}$ negligible to the concentrations of other ions.

(d)

$$m_{HSO_4^-} = m_{SO_4^{-2}}$$

$$\frac{m_{H^+}\, m_{SO_4^{2-}}}{m_{HSO_4^{-1}}} = m_{H^+} = 10^{-1.9} = 0.013$$

$pH = 1.2$ very strong acid.

Problem # 4 extra credit.

$$\boxed{P = P_0/2}$$