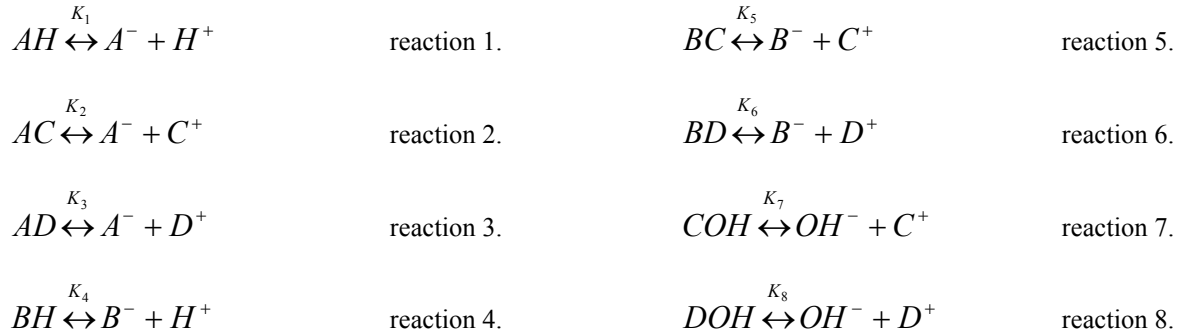


Midterm Examination
March 2, 2017
Due: Beginning of Class, Tuesday, March 7, 2017

Consider a system with three anions, A, B and OH, and three cations, C, D and H. The following reactions are possible



There are a total of fourteen species: $AH, AC, AD, BH, BC, BD, COH, DOH, A^-, B^-, C^+, D^+, H^+, OH^-$. Equilibrium coefficients govern the distribution of each of these reactions.

$K_1 = \frac{[A^-][H^+]}{[AH]}$	or	$[AH] = \frac{[A^-][H^+]}{K_1}$	equation 1.
$K_2 = \frac{[A^-][C^+]}{[AC]}$	or	$[AC] = \frac{[A^-][C^+]}{K_2}$	equation 2.
$K_3 = \frac{[A^-][D^+]}{[AD]}$	or	$[AD] = \frac{[A^-][D^+]}{K_3}$	equation 3.
$K_4 = \frac{[B^-][H^+]}{[BH]}$	or	$[BH] = \frac{[B^-][H^+]}{K_4}$	equation 4.
$K_5 = \frac{[B^-][C^+]}{[BC]}$	or	$[BC] = \frac{[B^-][C^+]}{K_5}$	equation 5.
$K_6 = \frac{[B^-][D^+]}{[BD]}$	or	$[BD] = \frac{[B^-][D^+]}{K_6}$	equation 6.
$K_7 = \frac{[OH^-][C^+]}{[COH]}$	or	$[COH] = \frac{[OH^-][C^+]}{K_7}$	equation 7.
$K_8 = \frac{[OH^-][D^+]}{[DOH]}$	or	$[DOH] = \frac{[OH^-][D^+]}{K_8}$	equation 8.

Four more equations come from molar balances on A, B, C, D.

$$[A_{Tot}] = [AH] + [AC] + [AD] + [A^-] \quad \text{equation 9.}$$

$$[B_{Tot}] = [BH] + [BC] + [BD] + [B^-] \quad \text{equation 10.}$$

$$[C_{Tot}] = [AC] + [BC] + [COH] + [C^+] \quad \text{equation 11.}$$

$$[D_{Tot}] = [AD] + [BD] + [DOH] + [D^+] \quad \text{equation 12.}$$

The pH of the solution is given, which effectively provides the values of both $[H^+]$ and $[OH^-]$.

Solve for the concentration of all fourteen species as a function of pH from 1 to 13 for the following parameter values. Both the equilibrium coefficients and the concentrations have units of $\frac{mol}{\ell}$.

$$K_1 = 10^{-1}, K_2 = 10^{-2}, K_3 = 10^{-7}, K_4 = 10^{-3}, K_5 = 10^{-4}, K_6 = 10^{-4}, K_7 = 10^{-6} \text{ and } K_8 = 10^{-4}.$$

$$[A_{Tot}] = 1.0 \cdot 10^{-3}, [B_{Tot}] = 0.5 \cdot 10^{-4}, [C_{Tot}] = 1.0 \cdot 10^{-3}, \text{ and } [D_{Tot}] = 0.5 \cdot 10^{-4}.$$