CH302 Practice Quiz 5 on Complex Equilibria

1. Na_2SO_3 is the basic salt of sulfurous acid which is a weak diprotic acid. If $K_{a1} = 1.5 \times 10^{-2}$ and $K_{a2} = 1.2 \times 10^{-7}$, what is the pH concentration in a sulfite, SO3=, solution that is 0.025M?

1. 9.6 **correct**
2. 4.4
3. 10.1
4. 9.0

$SO_3^=$ is the unprotonated base with K_{a2} far away from Kw or K_{a1}. So can do simple weak base.

$OH^- = (K_b C_b)^{1/2} = \left[\left(\frac{10^{-14}}{1.2\times10^{-7}}\right)(0.025)\right] = 4.6\times10^{-5}$

so pOH = 4.3 pH = 9.7

2. What is the pH of a 0.5M solution of an acid with $K_a = 1.2 \times 10^{-1}$?

1. 0.71 **correct**
2. 3.05
3. 6.8
4. 11.08

① Note this is a weak acid
② You can't use $(KC)^{1/2}$ because K is > 10^{-4}
③ must use quadratic $K_a = \frac{x^2}{.5-x} = 1.2\times10^{-1}$

$x = .195 = H^+$

pH = 0.71

3. What is the pH of 0:15 M $Na_2HPO_4(aq)$ if $K_{a1} = 7.6 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$ and $K_{a3} = 2.1 \times 10^{-13}$?

1. 9.93 **correct**
2. 8:31
3. 7.82
4. 6.92
5. 3.02

① polyprotic acid
② amphiprotic form ~~Na_2~~ $HPO_4 \rightarrow HPO_4^-$
③ equation is pH = (pK + pK)/2 $pK_2 = 7.2$ $pK_3 = 12.7$
④ use $K_{a2} + K_{a3}$ $pH = \frac{7.2+12.7}{2} = 9.95$

4. Write the charge balance equation for a dilute aqueous solution of $HClO_2$.

1. $[ClO_2^-] = [OH^-] + [H_3O^+]$
2. $[H_3O^+] = [OH^-]$
3. $[H_3O^+] = [ClO_2^-]$
4. $[H_3O^+] = [ClO_2^-] + [OH^-]$ **correct**
5. $[HClO_2]_{initial} = [ClO_2^-]$
5. $[HClO_2]_{initial} = [HClO_2] + [ClO_2^-]$

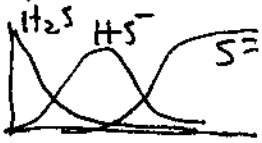
① $HClO_2$ is weak acid $HClO_2 \rightleftharpoons H^+ + ClO_2^-$
② H_2O in solution makes $H^+ + OH^-$
③ put all + ions on left, − ions on right

$[H^+] = [ClO_2^-] + [OH^-]$

5 For a solution labeled 0.10 M $Na_2S(aq)$,"

1. $[S^=] >$ 0.10 M.
2. $[S^=] > [HS^-]$ correct
3. $[S^=] = [HS^-]$
4. [OH-] = 0.10 M.
5. [OH-] > 0.10 M.

Draw α diagram



1. $S^=$ > .1 not possible, some forms HS^- so < .1
2. $S^= > HS^-$ since it is weak and starts as $S^=$, then $S^= > HS^-$
3. only $S^=$ to start so no source of HS^- to make equal
4. OH^- is small because $S^=$ is weak, it is << .1
5. see #4

6 A weakly basic solution with a pH near 7 is formed when a solution of 1×10^{-7} moles of NH_3 is added to 1 liter of water. How many equations must be solved in order to accurately calculate all the unknown concentrations formed at equilibrium in solution?

1. 1
2. 2
3. 3
4. 4 **correct**
5. 5
6. 6
7. 7

NH_3, NH_4^+, H^+, OH^- are the four species in solution at equilibrium. To solve need 4 equations.

7. What is the concentration of sulfate ion in 0.1 M H_2SO_4? K_{a1} is strong and K_{a2} = 1:2 a 10^{-2}.

1. 9.8 x 10^{-3} M **correct**
2. 1:2 x 10^{-3} M
3. 4:0 x 10^{-2} M
4. 1:0 x 10^{-3} M
5. 4:0 x 10^{-2} M

Step 1: $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$

.1	0	0
−.1	+.1	+.1
0	+.1	+.1

Step 2: $HSO_4^- \rightleftharpoons H^+ + SO_4^=$

.1	.1	0
−x	+x	x
.1−x	.1+x	x

$K_a = 1.2 \times 10^{-2} = \frac{(x)(.1+x)}{(.1-x)}$

solve quadratic $x = SO_4^= = 9.8 \times 10^{-3}$

8. There are three sources of protons to be considered in calculating the pH of a solution formed when equal volumes of 1 x 10^{-9} M HCl and 1 x 10^{-9} M acetic acid (HAc) are added to water. Assume a K_a of 1:8 x 10^{-5} for acetic acid. Rank from most to least, the concentration of protons contributed at equilibrium from HCl, HAc and H2O.

1. HCl, HAc, H_2O
2. HAc, HCl, H_2O
3. HAc, H_2O, HCl
4. H_2O, HCl, HAc **correct**
5. HCl, H_2O, HAc

1×10^{-9} M HCl ⟶ 1×10^{-9} H^+ in sol'n

55.4 M H_2O ⟶ 1×10^{-7} H^+ in sol'n

1×10^{-9} M acetic acid ⟶ $< 1 \times 10^{-9}$ H^+ in sol'n because it is weak

So H_2O > HCl > HAc in generating H^+