Chemistry 1B, Fall 2015 Quiz #6A KEY

You must show your work for full credit.

Exp 5 Questions

1. An ammonia buffer is made by adding 15.0 mL of 0.100 M NH_3 solution to 35.0 mL of 0.120 M NH_4Cl. For the following calculations, you can assume that this buffer behaves as a traditional buffer. $K_a(NH_4^+ \text{ ion}) = 5.6 \times 10^{-10}$.

a) Calculate the pH of this solution. (**2 pt**)

$pH = pK_a + \log([NH_3]/[NH_4^+])$ or $= pK_a + \log[n(NH_3)/n(NH_4^+)]$ (moles used so we don't need to recalculate diluted concentrations)

*$pH = -\log(5.6 \times 10^{-10}) + \log[(0.0015 \text{ mol})/(0.0042 \text{ mol})] = 9.25 + \log(0.357) = 9.25 - 0.45 =$ **8.80***

*using 1st equation and dilution, $pH = 9.25 + \log[(0.0300 \text{ M})/(0.084 \text{ M})] = 9.25 + \log(0.357) =$ **8.80***

Can also use the K_a equation directly as in lab manual

b) Now 5.0 mL of 0.100 M NaOH is added to the buffer. What is the new pH? Be sure to show the reaction that happens from addition of NaOH. (**3 pts**)

Added OH^- reacts with the acid form in the reaction shown below. Since the equilibrium constant ($1/K_b$) strongly favors the products, OH^- will be used up converting NH_4^+ to NH_3. This can be expressed quantitatively by making a mole table (see below), which first requires a calculation of the moles of OH^- added. Moles(OH^-) = (0.0050L)(0.100 mol/L) = 0.0005 mol

	$OH^-(aq)$ +	$NH_4^+(aq) \leftrightarrow$	$NH_3(aq) + H_2O(l)$
initially:	0.0005	0.0042	0.0015
change:	-0.0005	-0.0005	+0.0005
full right:	0	0.0037	0.0020

*Now, the H-H equation can be used: $pH = pK_a + \log[n(NH_3)/n(NH_4^+)] = 9.25 - 0.54 =$ **8.98***

c) The original buffer (no addition of NaOH) is diluted to a total of 100.0 mL. What is the new pH? Explain your answer. (**1 pt**)

***pH = 8.80** (or same answer as in a)). Dilution reduces NH_3 and NH_4^+ by the same factor – the ratio of concentrations stays the same.*

Solubility problem

2. Chromate, CrO_4^{2-}, is a toxic form of chromium (in the +6 oxidation state). It is desired to separate CrO_4^{2-} from SO_4^{2-} in a mixture that contains CrO_4^{2-} and SO_4^{2-} at concentrations of 0.080 and 0.020 M, respectively. The K_{sp} values for $SrCrO_4$ and $SrSO_4$ are 3.6×10^{-5} and 3.44×10^{-7}, respectively.

a) Which ion will precipitate first as Sr^{2+} is added? (**1 pt**)

We can calculate $[Sr^{2+}]$ when each ion first precipitates. $K_{sp}(SrCrO_4) = [Sr^{2+}][CrO_4^{2-}]$ or solving for $[Sr^{2+}]$, $[Sr^{2+}] = 3.6 \times 10^{-5}/[CrO_4^{2-}] = 4.5 \times 10^{-4}$ M. For $[SO_4^{2-}]$, $[SO_4^{2-}] = 3.44 \times 10^{-7}/0.020 = 1.72 \times 10^{-5}$ M. Since Sr^{2+} precipitates out at a lower concentration for SO_4^{2-}, ***SO_4^{2-} precipitates first**.*

Note: can also compare K_{sp} (not always accurate but reasonable in this case).

(continued on back)

b) Perform calculations to show whether it is possible to isolate CrO_4^{2-} from 99% of the SO_4^{2-} present by Sr^{2+} addition (assume no dilution occurs in the Sr^{2+} addition). (Hint: 99% removal means 1% left). (**3 pts**)

Having done the calculations in part a), we can use $[Sr^{2+}]$ *at the start of* CrO_4^{2-} *precipitation to determine the equilibrium* $[SO_4^{2-}]$ *left at that* Sr^{2+} *level.* $K_{sp}(SrSO_4) = [Sr^{2+}][SO_4^{2-}]$ *or* $[SO_4^{2-}] = 3.44 \times 10^{-7}/4.5 \times 10^{-4} = 7.64 \times 10^{-4}$ *M*

Now we can determine what percent of the original SO_4^{2-} *is left in the solution that contains the* CrO_4^{2-} *that we are trying to isolate.*
$\% = (7.64 \times 10^{-4}\ M)*100/0.020 = 3.8\%$. *In order to meet our separation criteria, we needed to remove 99+% of sulfate and this shows that it is not possible to isolate chromate at the desired level.*
Note: one can also calculate whether at 1% of original sulfate precipitation, whether chromate would already have started precipitating. $(0.01)(0.020) = 2.0 \times 10^{-4}$ *M and then* Sr^{2+} *in equilibrium will have concentration =* $K_{sp}(SrSO_4)/[SO_4^{2-}] = 1.7 \times 10^{-3}$ *or* $Q = [Sr^{2+}][CrO_4^{2-}] = (1.7 \times 10^{-3})(0.080) = 1.4 \times 10^{-4} > K_{sp}(SrCrO_4)$. *Since Q > K, precipitation of chromate would occur before getting to 1% of the initial sulfate.*