

CH302 Spring 2007 Worksheet 6+

1. How many mL of a 0.1 M solution of $\text{Ca}(\text{OH})_2$ are required to neutralized 200 mL of a 0.2 M solution of HNO_3 ?

200 mL of a .2M solution of HNO_3 will have $(.2\text{L})(.2 \text{ mol/L}) = 0.04 \text{ moles H}^+$
to get .04 moles OH^- you'll need 200 mL
 $(V)(.1\text{moles Ca}(\text{OH})_2/\text{L})(2 \text{ moles OH}^-/1 \text{ moles Ca}(\text{OH})_2) = 0.04 \text{ moles of OH}^-$
 $V = .2\text{L}$ or 200 mL

2. The pK_a of the amino acid aspartic acid is 4. In a solution in which the $\text{pH} = 7.5$ what fraction of the aspartic acid is protonated?

- A. 0.03%
- B. 7%
- C. 23.4%
- D. 72%
- E. 99.5%

$\text{pK}_a = \text{pH} - \log([\text{A}^-]/[\text{HA}]) \quad 4 = 7.5 - \log([\text{A}^-]/[\text{HA}]) \quad [\text{A}^-]/[\text{HA}] = 3162$
 $[\text{HA}]/([\text{HA}]+[\text{A}^-]) = 1/3163 = 0.0003$ or .03%

alternatively you know the pH is more than 3 pH units away from the pK so the protonated must be less than .1%.

3. At what pH would the aspartic acid be 50% protonated?

When the $\text{pH} = \text{pK}_a$ the concentration of $[\text{A}^-] = [\text{HA}]$ so $\text{pH} = 4$

4. The K_{sp} of magnesium hydroxide is 1.8×10^{-11} . What is the pH of saturated solution of magnesium hydroxide in 0.01 M HCl?

First you can neutralized the acid with the $\text{Mg}(\text{OH})_2$. You'll need 0.5 moles of $\text{Mg}(\text{OH})_2$ for every mole of HCl. The $[\text{H}^+] = 10^{-2}$ so the $[\text{Mg}^{2+}] = 5 \times 10^{-3}$. $\text{K}_{\text{sp}} = [\text{Mg}^{2+}][\text{OH}^-]^2$
 $[\text{OH}^-] = \sqrt{\text{K}_{\text{sp}}/[\text{Mg}^{2+}]} = \sqrt{((1.8 \times 10^{-11})/(5 \times 10^{-3}))} = 6 \times 10^{-5}$
 $\text{pOH} = 4.22 \quad \text{pH} = 9.78$

5. The K_a of formic acid is 1.8×10^{-4} . Suggest a means (concentrations of formic acid and sodium formate) to make a buffer solution with a pH of 4.

To get the $\text{pH} = 4$ you need a ratio of $[\text{A}^-]/[\text{HA}]$ of 1.8

$$K_a = [H^+][A^-]/[HA] = 10^{-4}[A^-]/[HA] = 1.8 \times 10^{-4} \quad [A^-]/[HA] = 1.8$$

Any ratio would work however, the higher the concentrations the better.

180 mL of 1M formate and 100 mL of 1 M formic acid

or

500 ml of .18M formate and 500 mL of 0.1 M formic acid

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6. Does 1 L of your proposed buffer system have the capacity to remain a buffer if you add 10 mL of 1M HCl?

Taking the last example, the concentration of formate in the final 1L solution is .09 and the formic acid is .05 M. There are .09 moles of formate in the solution and .05 moles of formic acid. Adding .01L of a 1M HCl solution will add $(.01L)(1 \text{ mol/L}) = .01$ moles of H^+ . This can be neutralized by the formate yielding a final solution with .08 moles of formate, .06 moles of formic acid. Yes the system will remain buffered. The pH will change slightly. The final pH would be

$$[H^+] = K_a[HA]/[A^-] = (1.8 \times 10^{-4})(.06)/(.08) = 1.35 \times 10^{-4} \quad pH = -\log(1.35 \times 10^{-4}) = 3.87$$

7 If you mix the following four solutions what is the pH of the final solution. 100 mL of 1M HCl, 200 mL of 1 M NaOH, 100 mL of 0.4 M HF, and 400 mL of 0.1 M NaF. The K_a for HF is 7.2×10^{-4} .

There are many ways to think about how to neutralize this solution. The easiest is to first look at the strong acid and strong base. 100 mL of 1 M HCl + 200 mL of 1 M NaOH has $(.1L)(1 \text{ mol/L}) = .1 \text{ M } H^+$ and $(.2L)(1 \text{ mol/L}) = .2 \text{ OH}^-$. The mixture will have .1 moles of OH^- and a volume of 300 mL.

The HF and NaF will make a buffer solution with $(.1L)(.4 \text{ mol/L}) = .04 \text{ mol HF}$ and $(.4L)(.1 \text{ mol/L}) = .04 \text{ mole NaF}$.

Adding the .1 mole OH^- to this solution will neutralize all the HF to F^- leaving .06 moles of OH^- in a total volume of 300 mL + 500 mL = 800 mL. $[OH^-] = .06 \text{ mol}/.8L = 7.5 \times 10^{-2}$ pOH = 1.12 the pH = 12.88

8. You attempt to dissolve 0.25 g of $PbCl_2$ in 50 mL of water. You find that all but 0.03 g dissolves.

What is solubility of $PbCl_2$ in water in units of $g L^{-1}$?

$$.25 - .03 = .22 \text{ g dissolve}$$

$$(.22 \text{ g})/(.05\text{L}) = 4.4 \text{ g/L}$$

What is the solubility product for PbCl_2 ?

If 4.4 g dissolve in 1 L the concentration of PbCl_2 is $(4.4 \text{ g}/278.1 \text{ g mol}^{-1}) = 0.0158 \text{ mol}$

$$[\text{Pb}^{2+}] = .0158 \text{ mol Pb}^{2+}/1\text{L} = .0158 \text{ M}$$

$$[\text{Cl}^-] = 2 \times .0158 \text{ mol Cl}^-/1\text{L} = .0316 \text{ M}$$

$$K_{\text{sp}} = [\text{Pb}^{2+}][\text{Cl}^-]^2 = (.0158)(.0316)^2 = 1.58 \times 10^{-5}$$