

MULTIPLE CHOICE (3pts each): Write the ONE letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

- 1.) What is the hydronium ion concentration of a solution with a pH of 3.278? 1.) B
 a.) $3.77 \times 10^{-2} \text{ M}$ b.) $5.27 \times 10^{-4} \text{ M}$ c.) $1.90 \times 10^{-11} \text{ M}$ d.) 0.516 M
 $10^{-3.278} = 5.2723 \times 10^{-4} \text{ M}$
- 2.) What is the hydroxide concentration of a solution with a pH of 3.278? 2.) C
 a.) $3.77 \times 10^{-2} \text{ M}$ b.) $5.27 \times 10^{-4} \text{ M}$ c.) $1.90 \times 10^{-11} \text{ M}$ d.) 0.516 M
 $\text{pOH} = 14 - 3.278 = 10.722$ $10^{-10.722} = 1.8967 \times 10^{-11}$
- 3.) Which response best represents the conjugate base of $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$? 3.) D
 a.) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}^{1+}$ b.) $\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}^{1-}$ c.) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}_2^{1+}$ d.) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^{1-}$
- 4.) What is the pH of a 0.00297 M solution of HNO_3 ? 4.) A
 a.) 2.527 b.) 11.473 c.) 1.264 d.) 12.736
 $-\log(0.00297) = 2.52724$
- 5.) Which of the following ions would give the most acidic solution? 5.) D
 a.) Cr^{2+} b.) Cr^{3+} c.) Fe^{2+} d.) Fe^{3+} *Smallest w/ highest charge*
- 6.) Which of the following would give the most acidic solution when dissolved in water? 6.) D
 a.) NaCl b.) NaCH_3COO c.) K_2SO_4 d.) $\text{CH}_3\text{CH}_2\text{NH}_3\text{Cl}$ *neutral*
both neutral *conjugate base* *both neutral* *conj acid*
- 7.) Which response best represents the conjugate acid of $\text{CH}_3\text{CH}_2\text{NH}_2$? 7.) B
 a.) $\text{CH}_3\text{CH}_2\text{NH}^{1-}$ b.) $\text{CH}_3\text{CH}_2\text{NH}_3^{1+}$ c.) $\text{CH}_4\text{CH}_2\text{NH}_2^{1+}$ d.) $\text{CH}_2\text{CH}_2\text{NH}_2^{1-}$
- 8.) What is the pH of a $6.24 \times 10^{-5} \text{ M}$ solution of KOH ? 8.) C
 a.) 4.205 b.) 2.102 c.) 9.795 d.) 11.897
 $\text{pOH} = -\log(6.24 \times 10^{-5}) = 4.2048$ $\text{pH} = 14 - 4.2048 = 9.79518$
- 9.) Which of the following would be the best conjugate base for a buffer containing hydrofluoric acid (HF)? 9.) A
 a.) KF b.) NaCl c.) $\text{NaCH}_3\text{CH}_2\text{COO}$ d.) NH_4Cl
need F^-
- 10.) What is the K_a for the conjugate acid of a base with $K_b = 7.95 \times 10^{-7}$? 10.) A
 a.) 1.26×10^{-8} b.) 7.95×10^7 c.) 7.95×10^{-21} d.) 1.26×10^6
 $K_a = \frac{1 \times 10^{-14}}{7.95 \times 10^{-7}} = 1.25786 \times 10^{-8}$

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! SHOW ALL WORK. If your work is in a different location, you must make a note of this in the given work area for the problem in order for the work to be considered for partial credit. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1.) You are given a 0.397M solution of KNO_2 .

a.) Based on the formula, would you expect this solution to be acidic or basic?

Answer: Basic

b.) Briefly explain your answer to part a. Your explanation must be based on the formula, not the calculations in part c.

NO_2^- is the conjugate base of the weak acid HNO_2 .

c.) What is the pH of the solution (K_a for HNO_2 is 7.2×10^{-4})?

$$K_b = \frac{1 \times 10^{-14}}{7.2 \times 10^{-4}} = 1.3889 \times 10^{-11}$$

Answer: 8.37

$$1.3889 \times 10^{-11} = \frac{x^2}{0.397}$$

$$\text{pOH} = -\log(2.348 \times 10^{-6}) = 5.6293$$

$$x^2 = 5.51389 \times 10^{-12}$$

$$\text{pH} = 14 - 5.6293 = 8.3707$$

$$x = 2.348 \times 10^{-6} = [\text{OH}^-]$$

2.) Given a $6.97 \times 10^{-4}\text{M}$ solution of $\text{Ba}(\text{OH})_2$.

a.) What is the $[\text{OH}^-]$ concentration?

Answer: $1.39 \times 10^{-3}\text{M}$

$$6.97 \times 10^{-4}\text{M Ba}(\text{OH})_2 \left(\frac{2\text{OH}^-}{1\text{Ba}(\text{OH})_2} \right) = 1.394 \times 10^{-3}\text{M}$$

b.) What is the pH?

Answer: 11.144

$$\text{pOH} = -\log(1.394 \times 10^{-3}) = 2.8557$$

$$\text{pH} = 14 - 2.8557 = 11.1443$$

c.) What is the $[\text{H}_3\text{O}^+]$ concentration?

Answer: $7.17 \times 10^{-12}\text{M}$

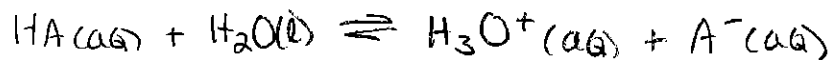
$$10^{-11.1443} = 7.17299 \times 10^{-12}\text{M}$$

3.) A solution of aspirin ($C_8H_7O_2COOH$, $K_a = 3.2 \times 10^{-4}$) has a $pH = 2.18$.

a.) What is the molarity of the solution?

Answer: 0.14 M

$$[H_3O^+] = 10^{-2.18} = 6.6069 \times 10^{-3} M$$



$$\begin{array}{c} C \\ -x \\ \hline C-x \end{array}$$

$$\begin{array}{c} 0 \\ +x \\ \hline x \end{array}$$

$$\begin{array}{c} 0 \\ +x \\ \hline x \end{array}$$

$$x = 6.6069 \times 10^{-3} M$$

$$3.2 \times 10^{-4} = \frac{[6.6069 \times 10^{-3}]^2}{C - 6.6069 \times 10^{-3}}$$

$$\frac{3.2 \times 10^{-4} (C - 6.6069 \times 10^{-3})}{3.2 \times 10^{-4}} = \frac{4.36516 \times 10^{-5}}{3.2 \times 10^{-4}}$$

$$C - 6.6069 \times 10^{-3} = 1.36411 \times 10^{-1}$$

$$C = 0.143018 M$$

Answer: 4.6%

b.) What is the percent ionization?

$$\% \text{ ionization} = \left(\frac{[H_3O^+]}{[HA]} \right) \times 100$$

$$= \left(\frac{6.6069 \times 10^{-3} M}{0.143018 M} \right) \times 100 = 4.61963\%$$

4.) Given 25.00 mL of a 0.365 M solution of KOH.

a.) What is the pH of the solution?

Answer: 13.562

$$pOH = -\log(0.365) = 0.437707$$

$$pH = 14 - 0.437707 = 13.5623$$

b.) If the KOH solution is titrated with 0.400 M HCl, what is the pH after 18.24 mL has been added? Strong acid & strong base

Answer: 12.626

Initial mol KOH:

$$0.365 \frac{\text{mol}}{L} \times 0.02500 L = 9.125 \times 10^{-3} \text{ mol}$$

$$pOH = -\log(4.22988 \times 10^{-2}) = 1.37367$$

Mol HCl added:

$$0.400 \frac{\text{mol}}{L} \times 0.01824 L = 7.296 \times 10^{-3} \text{ mol}$$

$$pH = 14 - 1.37367 = 12.62633$$

more KOH than HCl $HCl + KOH \rightarrow KCl + H_2O$

$$7.296 \times 10^{-3} \text{ mol HCl} \left(\frac{1 \text{ mol KOH}}{1 \text{ mol HCl}} \right) = 7.296 \times 10^{-3} \text{ mol KOH neutralized}$$

KOH left over

$$9.125 \times 10^{-3} \text{ mol} - 7.296 \times 10^{-3} \text{ mol} = \frac{1.829 \times 10^{-3} \text{ mol}}{0.04324 L} = 4.22988 \times 10^{-2} M$$

KOH =

$$4.22988 \times 10^{-2} M$$

CHM112 2023S

$[OH^-]$

Version D

$$\begin{array}{r} \text{Total volume: } 0.02500 L \\ + 0.01824 L \\ \hline 0.04324 L \end{array}$$

5.) Given 25.00mL of a 0.500M solution of ammonia (NH_3 , $K_b = 1.77 \times 10^{-5}$)

weak base

a.) What is the pH of the solution?

Answer: 11.473

$$1.77 \times 10^{-5} = \frac{x^2}{0.500}$$

$$x^2 = 8.85 \times 10^{-6}$$

$$x = 2.974895 \times 10^{-3} \text{ M} = [\text{OH}^-]$$

$$\text{pOH} = -\log(2.974895 \times 10^{-3}) = 2.52653$$

$$\text{pH} = 14 - 2.52653$$

$$= 11.47347$$

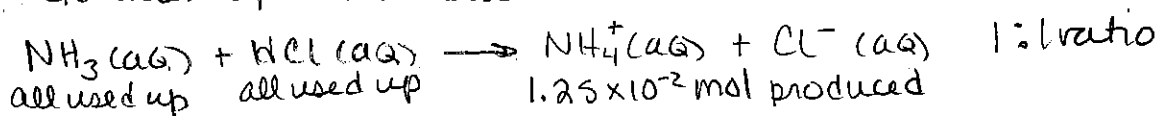
b.) If the solution of ammonia is titrated with 0.400M HCl, what is the pH at the equivalence point? weak base w/ strong acid

Initial moles base:

Answer: 4.951

$$\frac{0.500 \text{ mol}}{\text{L}} \times 0.02500 \text{ L} = 1.25 \times 10^{-2} \text{ mol}$$

equivalence pt: mol added HCl = initial moles Base = $1.25 \times 10^{-2} \text{ mol}$



$$\text{Total volume: HCl added } 1.25 \times 10^{-2} \text{ mol} \left(\frac{1 \text{ L}}{0.400 \text{ mol}} \right) = 0.03125 \text{ L}$$

$$0.02500 \text{ L} + 0.03125 \text{ L} = 0.05625 \text{ L}$$

$$[\text{NH}_4^+] = \frac{0.0125 \text{ mol}}{0.05625 \text{ L}} = 0.22222 \text{ M}$$

$$K_a = \frac{1 \times 10^{-14}}{1.77 \times 10^{-5}} = 5.6497 \times 10^{-10}$$

$$K_a = \frac{x^2}{0.2222 \text{ M}} = 5.6497 \times 10^{-10} \quad x^2 = 1.25549 \times 10^{-10} \quad \text{pH} = -\log(1.1205 \times 10^{-5}) = 4.9506$$

6.) A buffer is made up with 250.0mL of 0.550M benzoic acid ($K_a = 6.3 \times 10^{-5}$) and 250.0mL of 0.500M sodium benzoate.

a.) What is the pH of the buffer?

Answer: 4.16

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{A}^-]}{[\text{HA}]}\right) \quad \text{p}K_a = -\log(6.3 \times 10^{-5}) = 4.20066$$

$$\text{pH} = 4.20066 + \log\left(\frac{0.500}{0.550}\right)$$

$$= 4.20066 - 0.03927 = 4.15927$$

b.) What is the pH of the buffer after 0.00800mol HCl have been added?

1:1 ratios

→ reduce A^- increase HA

$$[\text{A}^-]: \frac{0.500 \text{ mol}}{\text{L}} \times 0.2500 \text{ L} = 0.125 \text{ mol}$$

Answer: 4.11

$$0.125 \text{ mol} - 0.00800 \text{ mol} = \frac{0.117 \text{ mol}}{0.500 \text{ L}} = 0.234 \text{ M}$$

$$\frac{0.250 \text{ L} + 0.250 \text{ L}}{0.500 \text{ L}}$$

$$[\text{HA}]: \frac{0.550 \text{ mol}}{\text{L}} \times 0.2500 \text{ L} = 0.1375 \text{ mol}$$

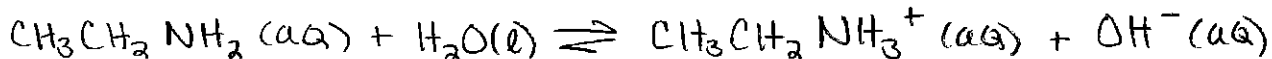
$$0.1375 \text{ mol} + 0.00800 \text{ mol} = \frac{0.1455 \text{ mol}}{0.500 \text{ L}} = 0.291 \text{ M}$$

$$\text{pH} = 4.20066 + \log\left(\frac{0.234}{0.291}\right)$$

$$= 4.20066 - 0.094677 = 4.10598$$

7.) Given a 0.300M solution of ethylamine ($\text{CH}_3\text{CH}_2\text{NH}_2$, $K_b = 5.6 \times 10^{-4}$).

a.) Write the equation showing how ethylamine reacts with water.



b.) What is the pH of the solution?

Answer: 12.11

$$5.6 \times 10^{-4} = \frac{x^2}{0.300}$$

$$\text{pOH} = -\log(1.296 \times 10^{-2}) = 1.887395$$

$$x^2 = 1.68 \times 10^{-4}$$

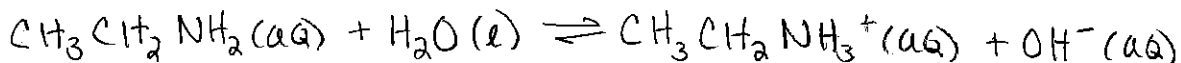
$$\text{pH} = 14 - 1.887395 = 12.1126$$

$$x = 1.296 \times 10^{-2} = [\text{OH}^-]$$

c.) What is the conjugate acid concentration [X] of a solution that is ^{0.300M}~~0.250M~~ ethylamine and 0.150M NaOH?

↳ common ion effect

Answer: $1.12 \times 10^{-3} \text{ M}$



0.300

0

0.150

-x

+x

+x

0.300 - x → ignore

x

0.150 + x → ignore

$$5.6 \times 10^{-4} = \frac{[x][0.150]}{[0.300]}$$

$$\frac{1.68 \times 10^{-4}}{0.150} = \frac{[x][0.150]}{0.150}$$

$$x = 1.12 \times 10^{-3} \text{ M} = [\text{CH}_3\text{CH}_2\text{NH}_3^+]$$