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.) 3.77×10^{-2} M b.) 5.27×10^{-4} M c.) 1.90×10^{-11} M d.) 0.516 M

$10^{-3.278} = 5.2723\times10^{-4}$ M

2.) What is the hydroxide concentration of a solution with a pH of 3.278? 2.) C

a.) 3.77×10^{-2} M b.) 5.27×10^{-4} M c.) 1.90×10^{-11} M d.) 0.516 M

pOH = 14 − 3.278 = 10.722 $10^{-10.722} = 1.8967\times10^{-11}$

3.) Which response best represents the conjugate base of $CH_3CH_2CH_2COOH$? 3.) D

a.) $CH_3CH_3CH_2COOH^{1+}$ b.) $CH_2CH_2CH_2COOH^{1-}$ c.) $CH_3CH_2CH_2COOH_2^{1+}$ d.) $CH_3CH_2CH_2COO^{1-}$

4.) What is the pH of a 0.00297M 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 (both neutral) b.) $NaCH_3COO$ (conj base → neutral) c.) K_2SO_4 (both neutral) d.) $CH_3CH_2NH_3Cl$ (conj acid → neutral)

7.) Which response best represents the conjugate acid of $CH_3CH_2NH_2$? 7.) B

a.) $CH_3CH_2NH^{1-}$ b.) $CH_3CH_2NH_3^{1+}$ c.) $CH_4CH_2NH_2^{1+}$ d.) $CH_2CH_2NH_2^{1-}$

8.) What is the pH of a 6.24×10^{-5} M solution of KOH? 8.) C

a.) 4.205 b.) 2.102 c.) 9.795 d.) 11.897

pOH = $-\log(6.24\times10^{-5}) = 4.2048$ pH = 14 − 4.2048 = 9.7952

9.) Which of the following would be the best conjugate base for a buffer containing hydrofluoric acid (HF)? 9.) A

a.) KF (need F^-) b.) NaCl c.) $NaCH_3CH_2COO$ d.) NH_4Cl

10.) What is the K_a for a the conjugate acid of a base with $K_b = 7.95\times10^{-7}$? 10.) A

a.) 1.26×10^{-8} b.) 7.95×10^{7} c.) 7.95×10^{-21} d.) 1.26×10^{6}

$K_a = \frac{1\times10^{-14}}{7.95\times10^{-7}} = 1.25786\times10^{-8}$

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})?

$K_b = \frac{1\times10^{-14}}{7.2\times10^{-4}} = 1.3889\times10^{-11}$ Answer: 8.37

$1.3889\times10^{-11} = \frac{x^2}{0.397}$

$x^2 = 5.51389\times10^{-12}$

$x = 2.348\times10^{-6} = [OH^-]$

$pOH = -\log(2.348\times10^{-6}) = 5.6293$

$pH = 14 - 5.6293 = 8.3707$

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

a.) What is the $[OH^-]$ concentration? Answer: 1.39×10^{-3} M

$6.97\times10^{-4}\,M\,Ba(OH)_2\left(\frac{2OH^-}{1Ba(OH)_2}\right) = 1.394\times10^{-3}\,M$

b.) What is the pH? Answer: 11.144

$pOH = -\log(1.394\times10^{-3}) = 2.8557$

$pH = 14 - 2.8557 = 11.1443$

c.) What is the $[H_3O^+]$ concentration? Answer: 7.17×10^{-12} M

$10^{-11.1443} = 7.17299\times10^{-12}\,M$

3.) A solution of aspirin ($C_8H_7O_2COOH$, $K_a = 3.2\times10^{-4}$) has a pH = 2.18.

a.) What is the molarity of the solution? Answer: 0.14 M

$[H_3O^+] = 10^{-2.18} = 6.6069\times10^{-3}\ M$

$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

C	0	0
−X	+X	+X
C−X	X	X

$X = 6.6069\times10^{-3}\ M$

$3.2\times10^{-4} = \frac{[6.6069\times10^{-3}]^2}{C-6.6069\times10^{-3}}$

$\frac{3.2\times10^{-4}(C-6.6069\times10^{-3})}{3.2\times10^{-4}} = \frac{4.36516\times10^{-5}}{3.2\times10^{-4}}$

$C-6.6069\times10^{-3} = 1.36411\times10^{-1}$

$+6.6069\times10^{-3} \quad +6.6069\times10^{-3}$

$C = 0.143018\ M$

b.) What is the percent ionization? Answer: 4.690

$\%\ \text{ionization} = \left(\frac{[H_3O^+]}{[HA]}\right)\times100$

$= \left(\frac{6.6069\times10^{-3}\ M}{0.143018\ M}\right)\times100 = 4.619639\%$

4.) Given 25.00mL of a 0.365M 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 0.400M HCl, what is the pH after 18.24mL has been added? Strong acid & strong base

Answer: 12.626

Initial mol KOH:

$0.365\ \frac{mol}{L}\times0.02500L = 9.125\times10^{-3}\ mol$

Mol HCl added:

$0.400\ \frac{mol}{L}\times0.01824L = 7.296\times10^{-3}\ mol$

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

$7.296\times10^{-3}\ mol\ HCl\left(\frac{1\ mol\ KOH}{1\ mol\ HCl}\right) = 7.296\times10^{-3}\ mol\ KOH$ neutralized

KOH left over

$9.125\times10^{-3}\ mol - 7.296\times10^{-3}\ mol = 1.829\times10^{-3}\ mol$

Total volume: $0.02500L + 0.01824L = 0.04324L$

$\frac{1.829\times10^{-3}\ mol}{0.04324L} = 4.22988\times10^{-2}\ M$ KOH = $4.22988\times10^{-2}\ M$ $[OH^-]$

$pOH = -\log(4.22988\times10^{-2}) = 1.37367$

$pH = 14 - 1.37367 = 12.62633$

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

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

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

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

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

$pH = 14 - 2.52653$

$= 11.47347$

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

Answer: 4.951

Initial moles base:

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

equivalence pt: mol added HCl = initial moles Base = 1.25×10^{-2} mol

$NH_3(aq) + HCl(aq) \longrightarrow NH_4^+(aq) + Cl^-(aq)$ 1:1 ratio

all used up; all used up; 1.25×10^{-2} mol produced

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

$0.02500L + 0.03125L = 0.05625L$

$[NH_4^+] = \frac{0.0125 mol}{0.05625L} = 0.22222M$

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

$K_a = \frac{x^2}{0.2222M} = 5.6497 \times 10^{-10}$

$x^2 = 1.25549 \times 10^{-10}$

$x = 1.1205 \times 10^{-5} = [H_3O^+]$

$pH = -\log(1.1205 \times 10^{-5})$

$= 4.9506$

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

$pH = pKa + \log\left(\frac{[A^-]}{[HA]}\right)$

$pKa = -\log(6.3 \times 10^{-5}) = 4.20066$

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

$= 4.20066 - 4.13927 = 4.15927$

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

1:1 ratios; ↳ reduce A^-, increase HA

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

Answer: 4.11

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

0.250L + 0.250L = 0.500L

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

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

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

$= 4.20066 - 0.094677 = 4.10598$

7.) Given a 0.300M solution of ethylamine ($CH_3CH_2NH_2$, $K_b = 5.6 \times 10^{-4}$).

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

$CH_3CH_2NH_2(aq) + H_2O(l) \rightleftharpoons CH_3CH_2NH_3^+(aq) + OH^-(aq)$

b.) What is the pH of the solution? Answer: 12.11

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

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

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

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

$pH = 14 - 1.887395 = 12.1126$

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

↳ common ion effect

Answer: 1.12×10^{-3} M

$CH_3CH_2NH_2(aq) + H_2O(l) \rightleftharpoons CH_3CH_2NH_3^+(aq) + OH^-(aq)$

0.300		0	0.150
$-x$		$+x$	$+x$
$0.300 - x \rightarrow$ ignore		x	$0.150 + x \rightarrow$ ignore

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

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

$x = 1.12 \times 10^{-3}$ M $= [CH_3CH_2NH_3^+]$