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 pH of a 3.44×10^{-3}M solution of HNO_3? ← strong acid 1.) A

a.) 2.463 b) 11.537 c.) 2.162 d.) 1.232

$pH = -\log(3.44\times10^{-3}) = 2.46344$

2.) How many equivalence points would you see in the complete titration of a solution of H_3PO_4? ← 3 protons 2.) C

a.) one b.) two c.) three d.) four

3.) What is the hydroxide ion concentration of a solution with a pH of 5.247? 3.) B

a.) 5.66×10^{-6}M b.) 1.77×10^{-9}M c.) 5.66×10^{6}M d.) 1.77×10^{9}M

$pOH = 14 - 5.247 = 8.753$ $[OH^-] = 10^{-8.753} = 1.766\times10^{-9}$ M

4.) Which of the following would produce the most acidic solution? 4.) D

a.) $NaNO_2$ b.) NaCl c.) $MnBr_2$ d.) $NiBr_2$

Na^+ neutral NO_2^- base Cl^- neutral Mn^{2+} acidic Br^- neutral Ni^{2+} acidic Br^- neutral Ni^{2+} is smaller than Mn^{2+}

5.) Which of the following salts would be the best conjugate base for a buffer made with HF? ← want F^- 5.) A

a.) KF b.) NaCl c.) Li_2SO_4 d.) $NaNO_2$

6.) Which response represents the most appropriate answer for the pH of a strong monoprotic acid with a concentration of 4.56×10^{-3}M? 6.) B

a.) 2.34 b.) 2.341 c.) 2.3 d.) 2.3410

3 sig figs 3 sig figs

7.) What is the hydronium ion concentration of a solution with a pH of 5.247? 7.) A

a.) 5.66×10^{-6}M b.) 1.77×10^{-9}M c.) 5.66×10^{6}M d.) 1.77×10^{9}M

$[H_3O^+] = 10^{-5.247} = 5.6624\times10^{-6}$ M

8.) What is the most correct formula for the conjugate acid of $(CH_3)_2CHNH_2$? 8.) D

a.) $(CH_3)_2CH_2NH_2^+$ b.) $(CH_3)_2CHNH^-$ d.) $(CH_3)_2CHNH_2^-$ d.) $(CH_3)_2CHNH_3^+$

9.) Which is the most correct formula for the conjugate base of $(CH_3)_2CHCOOH$? 9.) C

a.) $(CH_3)_2CHCOOH_2^+$ b.) $(CH_3)_2CHCOOH^+$ c.) $(CH_3)_2CHCOO^-$ d.) $(CH_3)_2CCOOH^-$

10.) What is the pH of a 6.94×10^{-6}M solution of $Ba(OH)_2$? ← strong base 10.) D

a.) 4.858 b.) 8.841 c.) 5.159 d.) 9.142

2024S_D

$6.94\times10^{-6}\text{ M}\left(\frac{2OH^-}{1Ba(OH)_2}\right)$

$= 1.388\times10^{-5}\text{ M} = [OH^-]$

$pOH = -\log(1.388\times10^{-5})$

$= 4.85761$

$pH = 14 - 4.85761 = 9.1424$

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! ALL WORK MUST BE SHOWN TO RECEIVE FULL CREDIT. 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.) Calculate the pH of the following solutions.

a.) A 0.525M solution of a weak acid with a $K_a = 4.72 \times 10^{-5}$.

Answer: 2.303

$K_a = \frac{x^2}{[0.525]} = 4.72 \times 10^{-5}$

$\sqrt{x^2} = \sqrt{2.478 \times 10^{-5}}$

$x = 4.97795 \times 10^{-3} = [H_3O^+]$

$pH = -\log(4.97795 \times 10^{-3}) = 2.30295$

b.) A 0.450M solution of a weak base with a $K_b = 4.72 \times 10^{-5}$.

Answer: 11.664

$K_b = \frac{x^2}{0.450} = 4.72 \times 10^{-5}$

$\sqrt{x^2} = \sqrt{2.124 \times 10^{-5}}$

$x = 4.608687 \times 10^{-3} = [OH^-]$

$pOH = -\log(4.608687 \times 10^{-3}) = 2.336423$

$pH = 14 - 2.336423 = 11.663577$

2.) Calculate the K_a for a 0.631M weak acid with a percent ionization of 14.5%.

Answer: 1.55×10^{-2}

$[H_3O^+] = .145(0.631) = 9.1495 \times 10^{-2} M = x$

$K_a = \frac{x^2}{0.631 - x} = \frac{(9.1495 \times 10^{-2})^2}{0.631 - 9.1495 \times 10^{-2}}$

$= \frac{8.371335 \times 10^{-3}}{0.539505}$

$= 1.551607 \times 10^{-2}$

3.) What concentration of sodium benzoate would be needed to make a buffer with a pH of 4.16 that contains 0.240M benzoic acid ($K_a = 6.5\times10^{-5}$)?

$pH = pKa + \log\left(\frac{A^-}{HA}\right)$ Answer: 0.226M

$pKa = -\log(6.5\times10^{-5}) = 4.187$

$4.16 = 4.187 + \log\left(\frac{A^-}{0.240M}\right)$

$-0.027 = \log\left(\frac{A^-}{0.240M}\right)$

$10^{-0.027} = \frac{A^-}{0.240M}$

$0.93972 = \frac{A^-}{0.240M}$ $A^- = 0.2255\,M$

4.) a.) What is the pH of a 0.372M solution of lactic acid? (C_2H_5OCOOH, $K_a = 1.3\times10^{-4}$)

$1.3\times10^{-4} = \frac{x^2}{0.372}$

Answer: 2.16

$\sqrt{x^2} = \sqrt{4.836\times10^{-5}}$

$x = 6.9541\times10^{-3} = [H_3O^+]$

$pH = -\log(6.9541\times10^{-3}) = 2.157759$

b.) What is the pH if 25.00mL of the 0.372M lactic acid solution is titrated with 20.00mL of 0.400M KOH?

$\frac{0.372mol}{L} \times 0.02500L = 9.3\times10^{-3}mol\ HA$ Answer: 4.68

$\frac{0.400mol}{L} \times 0.02000L = 8.0\times10^{-3}mol$ Strong Base

Weak acid left over 1:1 ratio $= 8.0\times10^{-3}$ mol HA neutralized

$9.3\times10^{-3}\,mol - 8.0\times10^{-3}\,mol = \frac{1.3\times10^{-3}mol\ HA\ remaining}{(0.025L+0.020L)}$

$= 2.8889\times10^{-2}\,M\ HA$

1:1 ratio $= \frac{8.0\times10^{-3}\,mol\ A^-\ produced}{(0.025L+0.020L)}$

$= 1.7778\times10^{-1}\,M\ A^-$

→ or use H-H equation

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

2.8889×10^{-2}		0	1.7778×10^{-1}
$-X$		$+X$	$+X$
$2.8889\times10^{-2} - X \rightarrow$ ignore		X	$1.7778\times10^{-1} + X \rightarrow$ ignore

$1.3\times10^{-4} = \frac{[X][1.7778\times10^{-1}]}{[2.8889\times10^{-2}]}$ $X = 2.11248\times10^{-5} = [H_3O^+]$

$pH = -\log(2.11248\times10^{-5}) = 4.6752$

pKa = 3.7695511

5.) A 500mL buffer is made containing 0.450M formic acid ($K_a = 1.7 \times 10^{-4}$) and 0.400M potassium formate.

a.) What is the pH of this buffer? Answer: 3.72

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

$= 3.7695511 + \log\left(\frac{0.400}{0.450}\right)$

$= 3.7695511 - 0.0511525 = 3.718398$

b.) What is the pH of this buffer after 6.00mL of 0.500M HCl is added?

Answer: 3.71

$\frac{0.500 mol}{L} \times 0.006L = 0.003 mol\ HCl$

$\frac{0.450 mol}{L} \times 0.500L = 0.225 mol\ HA + 0.003 mol = \frac{0.228 mol}{0.506L} = 0.45059\ M\ HA$

$\frac{0.400 mol}{L} \times 0.500L = 0.200 mol\ A^- - 0.003 mol = \frac{0.197 mol}{0.506L} = 0.38933\ M\ A^-$

$HCl + A^- \longrightarrow HA + Cl^-$

New volume = 0.006L + 0.500L = 0.506L

$pH = 3.7695511 + \log\left(\frac{0.38933}{0.45059}\right) = 3.706609$

6.) Given 50.00mL of 0.0578M HCl

a.) What is the pH of this solution? Answer: 1.238

$-\log(0.0578) = 1.238017$

b.) What is the pH of this solution after 34.00mL of 0.100 M NaOH has been added?

Answer: 11.783

$0.0578 \frac{mol}{L} \times 0.0500L = 0.00289 mol\ Acid$

New volume!
0.0500L
+ 0.0340L
0.084L

$0.100 \frac{mol}{L} \times 0.0340L = 0.0034 mol\ Base$

more base than acid 1:1 ratio 0.00289 mol base neutralized

$0.0034 mol - 0.00289 mol = \frac{0.00051 mol\ base\ left\ over}{0.084L} = 0.006071 M\ OH^-$

$pOH = -\log(6.0714 \times 10^{-3}) = 2.216711$

$pH = 14 - 2.216711 = 11.783289$

7.) Given a 0.532M solution of KNO_2.

a.) Is this solution acidic or basic? Answer: Basic

b.) Show the reaction of KNO_2 with water.

$$NO_2^-(aq) + H_2O(\ell) \rightleftharpoons HNO_2(aq) + OH^-(aq)$$

c.) What is the pH of this solution? The K_a of HNO_2 is 4.5×10^{-4}.

Answer: 8.54

$$K_b = \frac{1.0\times10^{-14}}{4.5\times10^{-4}}$$

$$= 2.2222\times10^{-11}$$

$$2.2222\times10^{-11} = \frac{x^2}{0.532}$$

$$\sqrt{x^2} = \sqrt{1.18222\times10^{-11}}$$

$$x = 3.438346\times10^{-6} = [OH^-]$$

$$pOH = -\log(3.438346\times10^{-6}) = 5.46365$$

$$pH = 14 - 5.46365 = 8.53635$$