This print-out should have 8 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

**ChemPrin3e T11 28**

001 10.0 points

Which of the following mixtures gives a buffer with a pH less than 7.0? For acetic acid, \( K_a = 1.8 \times 10^{-5} \) and for \( \text{NH}_3 \), \( K_b = 1.8 \times 10^{-5} \).

1. 10 mL of 0.1 M aqueous acetic acid + 10 mL of 0.1 M NaOH(aq)

2. 10 mL of 0.1 M \( \text{NH}_3 \)(aq) + 10 mL of 0.1 M HCl(aq)

3. 10 mL of 0.1 M aqueous acetic acid + 5.0 mL of 0.1 M NaOH(aq) **correct**

4. 10 mL of 0.1 M \( \text{NH}_3 \)(aq) + 5.0 mL of 0.1 M HCl(aq)

5. 10 mL of 0.1 M aqueous acetic acid + 10 mL of 0.1 M \( \text{NH}_3 \)(aq)

Explanation:

**Sparks buffer 003**

002 10.0 points

What is the pH of a solution made to be 0.5 M in HCN and 0.3 M in NaCN? \( K_a \) for HCN is \( 4 \times 10^{-10} \).

1. 9.17 **correct**

2. 6.67

3. \( 6.67 \times 10^{-10} \)

4. 9.6

5. 4.83

6. 7.33

Explanation:

**Msci 19 0730**

003 10.0 points

A 100 mL portion of 0.3 M acetic acid is being titrated with 0.2 M NaOH solution. What is the pH of the solution after 100 mL of the NaOH solution has been added? The ionization constant of acetic acid is \( 1.8 \times 10^{-5} \).

1. pH = 4

2. pH = 4.32

3. pH = 5.27

4. pH = 5.05 **correct**

5. pH = 4.71

Explanation:

\[
V_{\text{CH}_3\text{COOH}} = 100 \text{ mL} \quad [\text{CH}_3\text{COOH}] = 0.3 \text{ M} \\
V_{\text{NaOH}} = 100 \text{ mL} \quad [\text{NaOH}] = 0.2 \text{ M} \\
K_a = 1.8 \times 10^{-5} \\
\text{For CH}_3\text{COOH}, (0.3 \text{ M})(0.1 \text{ L}) = 0.03 \text{ mol} \\
\text{For NaOH}, (0.2 \text{ M})(0.1 \text{ L}) = 0.02 \text{ mol} \\
\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{NaCH}_3\text{COO}^- + \text{H}_2\text{O} \\
0.03 \text{ mol} \quad 0.02 \text{ mol} \quad 0 \text{ mol} \\
-0.02 \text{ mol} \quad -0.02 \text{ mol} \quad +0.02 \text{ mol} \\
0.01 \text{ mol} \quad 0 \text{ mol} \quad 0.02 \text{ mol} \\
\text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COO}^- + \text{H}^+ \\
0.01 \text{ mol} \quad 0.02 \text{ mol} \\
0.2 \text{ L} \quad 0.2 \text{ L} \\
0.05 \text{ M} \quad 0.1 \text{ M} \quad x \\
\text{Thus} \\
K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} \\
1.8 \times 10^{-5} = \frac{0.1 x}{0.05} \\
x = [\text{H}^+] = K_a[\text{CH}_3\text{COOH}] = 0.1(1.8 \times 10^{-5})(0.05) \\
= 9 \times 10^{-6} \\
\text{Thus} \\
pH = -\log [\text{H}^+] = 5.04576
What is the $pK_a$ of the acid titrated in this pH curve?

1. 6.8
2. 9.0
3. 5.6 correct
4. 5.9
5. 4.7

Explanation:

The ionization constants for an imaginary weak acid $H_3A$ are $K_1 = 1.0 \times 10^{-3}$, $K_2 = 1.0 \times 10^{-7}$, and $K_3 = 1.0 \times 10^{-11}$. Would a water solution of NaH$_2$A be acidic, basic, or neutral? Hint: Write the chemical equation and the equilibrium constant for the two possible reactions.

1. neutral
2. acidic because of further ionization of $H_2A^-$ correct
3. acidic because of the hydrolysis of $H_2A^-$
4. basic because of the further ionization of $H_2A^-$

What is the pH of 0.15 M NaHSO$_3$(aq) if $K_{a1} = 0.015$, $K_{a2} = 1.2 \times 10^{-7}$, $pK_{a1} = 1.81$ and $pK_{a2} = 6.91$?

1. 3.02
2. 7.82
3. 4.36 correct
4. None of these
5. 6.92

Explanation:

This is a salt of a polyprotic acid. The salt will dissociate into solution. The cation is an extremely weak acid and does not affect the equilibrium. The anion can then either protonate or deprotonate; the extent to which these processes occur is determined by the relative values of $pK_{a1}$ and $pK_{a2}$. The pH is

$$pH = \frac{1}{2}(pK_{a1} + pK_{a2})$$

$$= \frac{1}{2}(1.81 + 6.91)$$

$$= 4.36.$$  

Note the pH of a salt solution of a polyprotic acid is independent of the concentration of the salt as long as it is not extremely dilute.
What is the molar solubility of CaF$_2$? ($K_{sp} = 3.9 \times 10^{-11}$.)

1. $3.9 \times 10^{-11}$
2. $3.4 \times 10^{-4}$
3. $6.2 \times 10^{-6}$
4. $4.4 \times 10^{-6}$
5. $2.1 \times 10^{-4}$ correct

Explanation:

$$CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$$

$$K_{sp} = [Ca^{2+}][F^-]^2$$

$$3.9 \times 10^{-11} = (x)(2x)^2$$

$$= 4x^3$$

$$x = 2.1 \times 10^{-4}$$

\[n_{Cl^-} = 500 \times 1.0 = 500 \text{ mmol}\]

\[NH_3 + HCl \rightarrow NH_4^+ + Cl^-\]

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Cl$^-$ are spectator ion. $NH_4^+/NH_3$ is a buffer system. Since $[NH_3] = [NH_4^+]$ in the original buffer $pK_a = pH_{ini} = 9.25$, and

$$pH_{fin} = pK_a + \log \left(\frac{[NH_3]}{[NH_4^+]}\right)$$

$$= -\log \left(\frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}}\right) + \log \left(\frac{450}{550}\right)$$

$$= 9.16812$$

A buffer (pH 9.25) was prepared by mixing 1.00 mole of ammonia and 1.00 mole of ammonium chloride to form an aqueous solution with a total volume of 1.00 L. To 500 mL of this solution was added 50.0 mL of 1.00 M HCl. What is the pH of this solution?

1. 9.17 correct

2. 9.49

3. 9.83

4. 8.97

5. 8.71

Explanation:

$[NH_3] = 1 \text{ M}$

$[NH_4^+] = 1 \text{ M}$

$[HCl] = 1 \text{ M}$

$pH_{ini} = 9.25$

Initial condition (ini):

$n_{NH_3} = 500 \times 1.0 = 500 \text{ mmol}$

$n_{NH_4^+} = 500 \times 1.0 = 500 \text{ mmol}$

$n_{HCl} = 50 \times 1.0 = 50 \text{ mmol}$