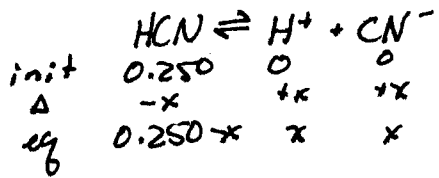


f) 0.250 mol/dm³ HCN - weak acid



$$6.2 \times 10^{-10} = \frac{(x)(x)}{(0.250-x)}$$

$$6.2 \times 10^{-10} = \frac{x^2}{0.250}$$

$$1.55 \times 10^{-10} = x^2$$

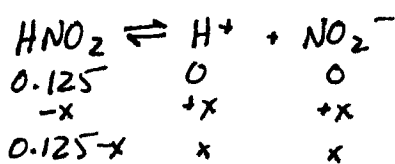
$$x = 1.2 \times 10^{-5}$$

$$K_a = \frac{[\text{H}^+][\text{CN}^-]}{[\text{HCN}]}$$

i) hydronium ion concentration $1.2 \times 10^{-5} \text{ M}$ iii) pH 4.9

ii) hydroxide ion concentration $8.0 \times 10^{-10} \text{ M}$ iv) pOH 9.1

g) 0.125 mol/dm³ HNO₂ - weak acid



$$7.2 \times 10^{-4} = \frac{(x)(x)}{(0.125-x)}$$

$$7.2 \times 10^{-4} = \frac{x^2}{0.125}$$

$$9.0 \times 10^{-5} = x^2$$

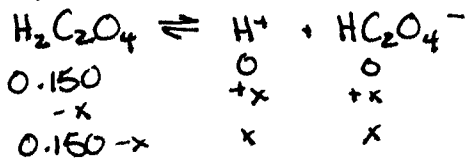
$$x = 9.5 \times 10^{-3}$$

$$K_a = \frac{[\text{H}^+][\text{NO}_2^-]}{[\text{HNO}_2]}$$

i) hydronium ion concentration $9.5 \times 10^{-3} \text{ M}$ iii) pH 2.0

ii) hydroxide ion concentration $1.1 \times 10^{-12} \text{ M}$ iv) pOH 12

h) 0.150 mol/dm³ HOOC₂COOH - weak acid



$$(5.4 \times 10^{-2})(0.150-x) = x^2$$

$$0.0081 - 0.054x = x^2$$

$$0 = x^2 + 0.054x - 0.0081$$

$$K_a = \frac{[\text{H}^+][\text{HC}_2\text{O}_4^-]}{[\text{H}_2\text{C}_2\text{O}_4]}$$

$$5.4 \times 10^{-2} = \frac{(x)(x)}{(0.150-x)}$$

$$x = \frac{-0.054 \pm \sqrt{(0.054)^2 - (4)(1)(-0.0081)}}{2(1)}$$

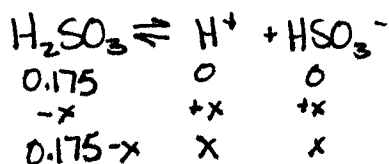
$$x = \frac{-0.054 \pm 0.188}{2}$$

$$x = -0.12 \text{ or } \underline{\underline{0.067}}$$

i) hydronium ion concentration 0.067 M iii) pH 1.2

ii) hydroxide ion concentration $1.5 \times 10^{-13} \text{ M}$ iv) pOH 13

i) $0.175 \text{ mol/dm}^3 \text{ H}_2\text{SO}_3$ - weak acid



$$K_a = \frac{[\text{H}^+][\text{HSO}_3^-]}{[\text{H}_2\text{SO}_3]}$$

$$1.3 \times 10^{-2} = \frac{(x)(x)}{(0.175-x)}$$

$$(0.013)(0.0175-x) = x^2$$

$$0.002275 - 0.013x = x^2$$

$$0 = x^2 + 0.013x - 0.002275$$

$$x = \frac{-0.013 \pm \sqrt{(0.013)^2 - (4)(1)(-0.002275)}}{2(1)}$$

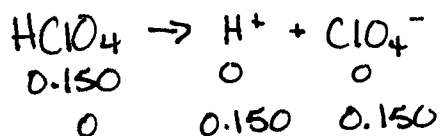
$$x = \frac{-0.013 \pm \sqrt{0.009269}}{2}$$

$$x = -0.055 \text{ or } 0.042$$

i) hydronium ion concentration 0.042 M iii) pH 1.4

ii) hydroxide ion concentration $2.4 \times 10^{-3} \text{ M}$ iv) pOH 13

2. Calculate $[\text{H}_3\text{O}^+]$, $[\text{ClO}_4^-]$ and $[\text{OH}^-]$ in an aqueous solution that is 0.150 M in $\text{HClO}_4(\text{aq})$. Is the solution acidic or basic?



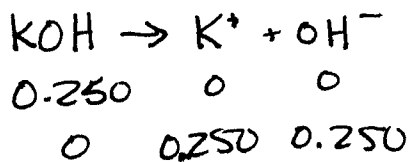
$$[\text{H}_3\text{O}^+] = 0.150 \text{ M}$$

$$[\text{ClO}_4^-] = 0.150 \text{ M}$$

$$[\text{OH}^-] = 6.67 \times 10^{-14} \text{ M}$$

ACIDIC

3. Calculate $[\text{OH}^-]$, $[\text{K}^+]$ and $[\text{H}_3\text{O}^+]$ in an aqueous solution that is 0.250 M in $\text{KOH}(\text{aq})$. Is the solution acidic or basic?



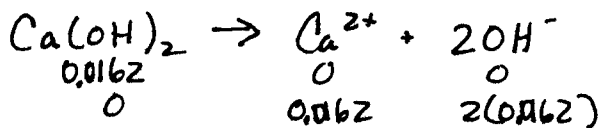
$$[\text{OH}^-] = 0.250 \text{ M}$$

$$[\text{K}^+] = 0.250 \text{ M}$$

$$[\text{H}^+] = 4.00 \times 10^{-14} \text{ M}$$

BASIC

4. Compute $[\text{Ca}^{2+}]$, $[\text{OH}^-]$ and $[\text{H}_3\text{O}^+]$ for a solution that is prepared by dissolving 0.600 g of $\text{Ca}(\text{OH})_2$ in enough water to make 0.500 dm^3 of solution.



$$[\text{OH}^-] = 0.0324 \text{ M}$$

$$[\text{Ca}^{2+}] = 0.0162 \text{ M}$$

$$[\text{H}_3\text{O}^+] = 3.09 \times 10^{-13} \text{ M}$$

$$\text{mol} = \frac{0.600 \text{ g}}{74.09268 \text{ g/mol}}$$

$$= 0.00810 \text{ mol}$$

$$C = \frac{n}{V} = \frac{0.00810 \text{ mol}}{0.500 \text{ L}} = 0.0162 \text{ M}$$

5. The pH of human muscle fluid is 6.8. Compute the value of $[H_3O^+]$ in muscle fluid at 25°C.

$$[H_3O^+] = 10^{-6.8} = 1.6 \times 10^{-7} M$$

6. The pH of household ammonia is about 12. Calculate the value of $[OH^-]$ for the ammonia solution.

$$[OH^-] = 10^{-2} = 1 \times 10^{-2} M \text{ or } 0.01 M$$

7. The pH of human blood is fairly constant at 7.4. Compute the hydronium ion and the hydroxide ion concentrations in human blood.

$$[H_3O^+] = 10^{-7.4} \\ = 4.0 \times 10^{-8} M$$

$$[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1.0 \times 10^{-14}}{4.0 \times 10^{-8}} \\ = 2.5 \times 10^{-7} M$$

8. The pH of the world's oceans is remarkably constant at 8.15. Compute the hydronium ion and hydroxide ion concentrations in the oceans.

$$[H_3O^+] = 10^{-8.15} \\ = 7.08 \times 10^{-9} M$$

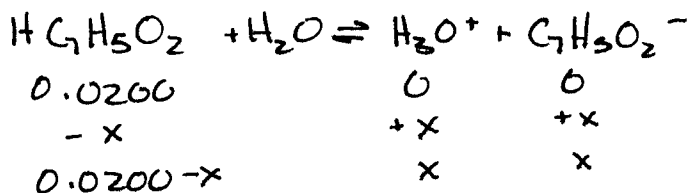
$$[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1.00 \times 10^{-14}}{7.08 \times 10^{-9}} \\ = 1.41 \times 10^{-6} M$$

9. Normal rainwater has a pH of about 5.6, whereas what is called acid rain has been observed to have pH values as low as 3.0. Compute the ratio of $[H_3O^+]$ in acid rain to that in normal rain.

$$\frac{\text{acid}}{\text{normal}} = \frac{10^{-3.0}}{10^{-5.6}} = \frac{1.0 \times 10^{-3}}{2.5 \times 10^{-6}} = 398$$

Acid rain is approximately 400 times more acidic than normal rain

10. The value of K_a in water at 25°C for benzoic acid, $HC_7H_5O_2$ is 6.46×10^{-5} . Calculate the pH of an aqueous solution with a total concentration of $HC_7H_5O_2$ of 0.0200 M.



$$6.46 \times 10^{-5} = \frac{x^2}{0.0200}$$

$$1.292 \times 10^{-6} = x^2$$

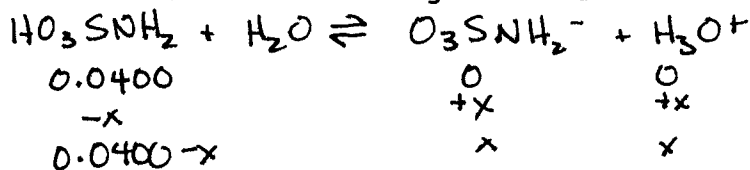
$$x = 1.14 \times 10^{-3}$$

$$K_a = \frac{[H_3O^+][C_7H_5O_2^-]}{[HC_7H_5O_2]}$$

$$6.46 \times 10^{-5} = \frac{(x)(x)}{(0.0200-x)}$$

$$pH = -\log(1.14 \times 10^{-3}) \\ = 2.94$$

11. Sulfamic acid, HO_3SNH_2 , is used as a stabilizer for chlorine in swimming pools. Calculate the pH of a 0.0400 M sulfamic acid solution given that $K_a = 0.100$.



$$K_a = \frac{[\text{O}_3\text{SNH}_2^-][\text{H}_3\text{O}^+]}{[\text{HO}_3\text{SNH}_2]}$$

$$0.100 = \frac{(x)(x)}{(0.0400-x)}$$

$$(0.100)(0.0400-x) = x^2$$

$$\left\{ \begin{array}{l} 0.00400 - 0.100x = x^2 \\ 0 = x^2 + 0.100x - 0.00400 \end{array} \right.$$

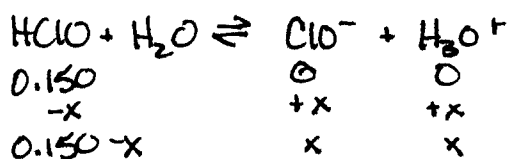
$$\begin{aligned} \text{pH} &= -\log(0.0306) \\ &= 1.51 \end{aligned}$$

$$x = \frac{-0.1 \pm \sqrt{(0.1)^2 - 4(1)(-0.004)}}{2(1)}$$

$$x = \frac{-0.100 \pm \sqrt{0.0260}}{2}$$

$$x = -0.131 \text{ or } 0.0306$$

12. Calculate the pH of an aqueous solution of 0.150 M HClO .



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{ClO}^-]}{[\text{HClO}]}$$

$$2.9 \times 10^{-8} = \frac{(x)(x)}{0.150-x}$$

$$2.9 \times 10^{-8} = \frac{x^2}{0.150}$$

$$4.35 \times 10^{-9} = x^2$$

$$x = 6.6 \times 10^{-5}$$

$$\begin{aligned} \text{pH} &= -\log(6.6 \times 10^{-5}) \\ &= 4.2 \end{aligned}$$

13. Suppose two aspirin tablets (1 tablet = 324 mg) are dissolved in enough water to make 500.0 cm^3 of solution. Compute the pH of the resulting solution if $K_a = 2.75 \times 10^{-5}$ and the molar mass for aspirin (acetylsalicylic acid) is 180.15 g/mol.

$$2 \text{ tablets} = 2(324) = 648 \text{ mg} = 0.648 \text{ g}$$

$$\text{mol} = \frac{0.648 \text{ g}}{180.15 \text{ g/mol}} = 0.00360 \text{ mol aspirin}$$

$$C = \frac{0.00360 \text{ mol}}{0.5000 \text{ dm}^3} = 0.00719 \text{ M}$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

$$2.75 \times 10^{-5} = \frac{(x)(x)}{0.00719-x}$$

$$(2.75 \times 10^{-5})(0.00719-x) = x^2$$

$$1.98 \times 10^{-7} - 2.75 \times 10^{-5}x = x^2$$

$$0 = x^2 + 2.75 \times 10^{-5}x - 1.98 \times 10^{-7}$$

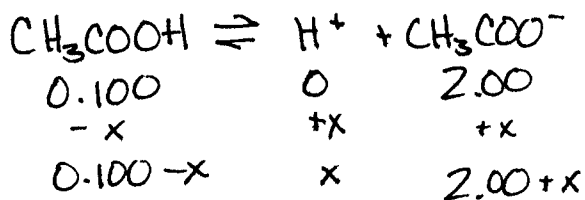
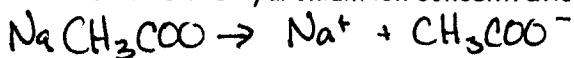
$$x = \frac{-2.75 \times 10^{-5} \pm \sqrt{(2.75 \times 10^{-5})^2 - (4)(1)(-1.98 \times 10^{-7})}}{2(1)}$$

$$x = \frac{-2.75 \times 10^{-5} \pm 8.90 \times 10^{-4}}{2}$$

$$x = -4.59 \times 10^{-4} \text{ or } 4.31 \times 10^{-4}$$

$$\begin{aligned} \text{pH} &= -\log(4.31 \times 10^{-4}) \\ &= 3.37 \end{aligned}$$

14. What is the hydronium ion concentration in a solution of 0.100 M CH_3COOH and 2.00 M NaCH_3COO ?



$$K_a = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

$$1.8 \times 10^{-5} = \frac{(x)(2.00+x)}{(0.100-x)}$$

$$(0.100-x)(1.8 \times 10^{-5}) = (x)(2.00+x)$$

$$1.8 \times 10^{-6} - 1.8 \times 10^{-5}x = 2.00x + x^2$$

$$0 = x^2 + 2.000018x - 1.8 \times 10^{-6}$$

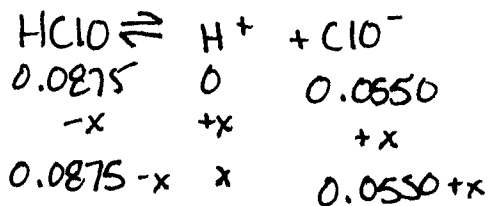
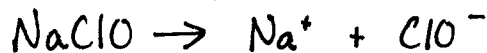
$$x = \frac{-2.000018 \pm \sqrt{(2.000018)^2 - 4(1)(-1.8 \times 10^{-6})}}{2(1)}$$

$$x = \frac{-2.000018 \pm \sqrt{4.0000792}}{2}$$

$$x = -2.00 \text{ or } 9.00 \times 10^{-7}$$

$$[\text{H}_3\text{O}^+] = 9.0 \times 10^{-7} \text{ M}$$

15. What is the hydronium ion concentration in a solution of 0.0875 M HClO and 0.0550 M NaClO ?



$$K_a = \frac{[\text{H}^+][\text{ClO}^-]}{[\text{HClO}]}$$

$$2.9 \times 10^{-8} = \frac{(x)(0.0550+x)}{(0.0875-x)}$$

$$(2.9 \times 10^{-8})(0.0875-x) = (x)(0.0550+x)$$

$$2.5375 \times 10^{-9} - 2.9 \times 10^{-8}x = 0.0550x + x^2$$

$$0 = x^2 + 0.0550x - 2.5375 \times 10^{-9}$$

$$x = \frac{-0.0550 \pm \sqrt{(0.0550)^2 - 4(1)(-2.5375 \times 10^{-9})}}{2(1)}$$

$$x = \frac{-0.0550 \pm \sqrt{0.003025}}{2}$$

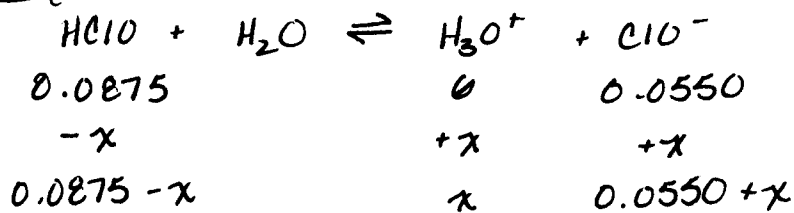
$$x = \frac{-0.0550 \pm 0.0550}{2}$$

$$x = -0.055 \text{ or } 4.6 \times 10^{-8}$$

$$[\text{H}_3\text{O}^+] = 4.6 \times 10^{-8} \frac{\text{mol}}{\text{L}}$$

15

What is the hydronium ion concentration in a solution of 0.0875 M HClO and 0.0550 M NaClO?



$$2.9 \times 10^{-8} = \frac{(x)(0.0550 - x)}{(0.0875 - x)}$$

$$[\text{H}_3\text{O}^+] = 4.6 \times 10^{-8} \text{ mol/L}$$

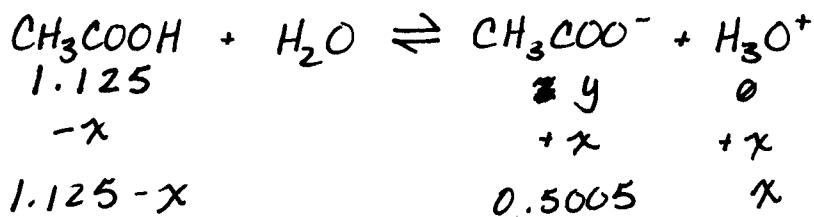
$$\begin{aligned}
 (2.9 \cdot 10^{-8})(0.0875 - x) &= (x)(0.0550 + x) \\
 2.5375 \cdot 10^{-9} - 2.9 \cdot 10^{-8}x &= 0.0550x + x^2 \\
 0 &= x^2 + 0.0550x - 2.5375 \cdot 10^{-9}
 \end{aligned}$$

$$x = \frac{-0.0550 \pm \sqrt{(0.0550)^2 - 4(1)(-2.5375 \cdot 10^{-9})}}{2(1)}$$

$$x = \frac{-0.0550 \pm 0.0550}{2} \quad x = -0.055 \text{ or } \underline{\underline{4.6 \times 10^{-8}}}$$

16

Calculate the $[\text{H}_3\text{O}^+]$ in a solution that is 1.125 M CH_3COOH if enough NaCH_3COO is added to make the solution 0.5005 M with respect to the CH_3COO^- ?



$$1.8 \times 10^{-5} = \frac{(0.5005)(x)}{1.125 - x}$$

$$[\text{H}_3\text{O}^+] = 4.0 \times 10^{-5} \text{ M}$$

$$(1.8 \cdot 10^{-5})(1.125 - x) = 0.5005x$$

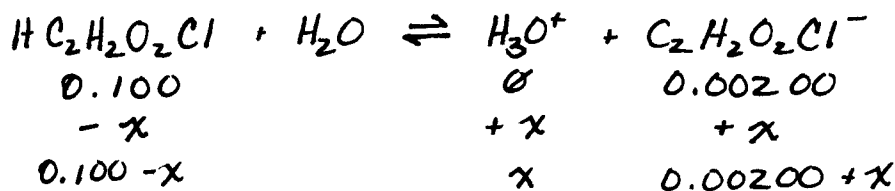
$$2.025 \cdot 10^{-5} - 1.8 \cdot 10^{-5}x = 0.5005x$$

$$2.025 \cdot 10^{-5} = 0.500482x$$

$$x = 4.046 \times 10^{-5}$$

17

30. A solution was made up to be 0.100 M in chloroacetic acid ($\text{HC}_2\text{H}_2\text{O}_2\text{Cl}$) and also 0.00200 M in sodium chloroacetate ($\text{NaC}_2\text{H}_2\text{O}_2\text{Cl}$). The K_a for chloroacetic acid is 1.36×10^{-3} . Determine the pH of the solution.



$$1.36 \cdot 10^{-3} = \frac{(x)(0.00200 + x)}{(0.100 - x)}$$

$$\begin{aligned}
 \text{pH} &= -\log(0.0101) \\
 &= \boxed{2.00}
 \end{aligned}$$

$$(0.00136)(0.100 - x) = 0.00200x + x^2$$

$$0.000136 - 0.00136x = 0.00200x + x^2$$

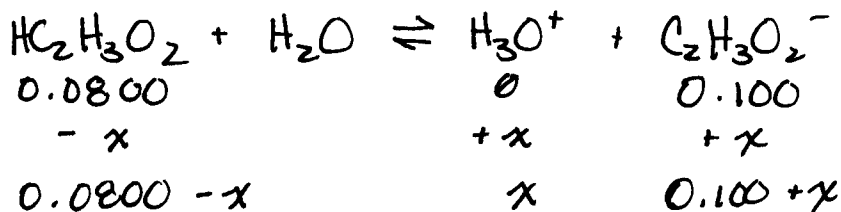
$$0 = x^2 + 0.00336x - 0.000136$$

$$x = \frac{-0.00336 \pm \sqrt{(0.00336)^2 - (4)(1)(-0.000136)}}{(2)(1)}$$

$$x = \frac{-0.00336 \pm 0.02356}{2} \quad x = -0.0135 \text{ or } 0.0101$$

18

18. Find the pH of a liter of solution, in which is dissolved 0.0800 mol of $\text{HC}_2\text{H}_3\text{O}_2$ and 0.100 mol of $\text{NaC}_2\text{H}_3\text{O}_2$.



$$1.8 \cdot 10^{-5} = \frac{(x)(0.100 + x)}{(0.0800 - x)}$$

$$x = \frac{-0.100018 \pm \sqrt{(0.100018)^2 - 4(1)(1.44 \cdot 10^{-6})}}{2(1)}$$

$$(0.0800 - x)(1.8 \cdot 10^{-5}) = 0.100x + x^2$$

$$1.44 \cdot 10^{-6} - 1.8 \cdot 10^{-5}x = 0.100x + x^2$$

$$0 = x^2 + 0.100018x - 1.44 \cdot 10^{-6}$$

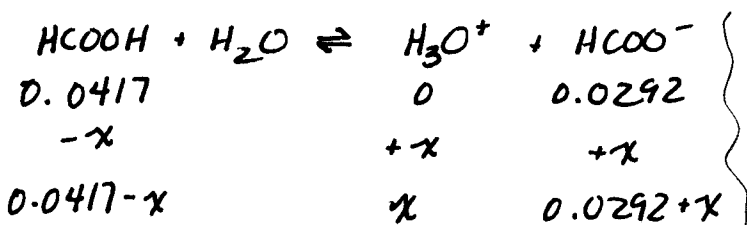
$$x = \frac{-0.100018 \pm 0.100047}{2}$$

$$x = -0.10 \text{ or } 1.4 \cdot 10^{-5}$$

$$\begin{aligned}
 \text{pH} &= -\log(1.4 \cdot 10^{-5}) \\
 &= \boxed{4.8}
 \end{aligned}$$

19

25.0 mL of a 0.100 M HCOOH is added to 35.0 mL of 0.0500 M HCOONa. Determine the pH.



$$C_2 = \frac{C_1 V_1}{V_2} \quad [\text{HCOOH}] = \frac{(0.100)(25.0)}{60.0}$$

$$= 0.0417 \text{ M}$$

$$[\text{HCOONa}] = \frac{(0.0500)(35.0)}{60.0}$$

$$= 0.0292 \text{ M}$$

$$1.8 \cdot 10^{-4} = \frac{(x)(0.0292+x)}{(0.0417-x)}$$

$$(0.0417-x)(1.8 \cdot 10^{-4}) = (x)(0.0292+x)$$

$$7.5 \times 10^{-6} - 1.8 \times 10^{-4} x = 0.0292 x + x^2$$

$$0 = x^2 + 0.0293 x - 7.5 \cdot 10^{-6}$$

$$x = \frac{-0.0293 \pm \sqrt{(0.0293)^2 - (4)(1)(-7.5 \cdot 10^{-6})}}{2(1)}$$

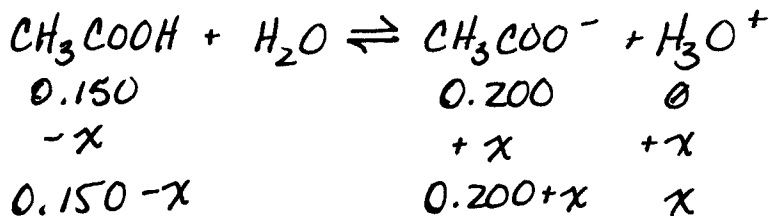
$$x = \frac{-0.0293 \pm 0.0299}{2}$$

$$x = -0.0296 \text{ or } 2.53 \times 10^{-4}$$

$$\text{pH} = -\log(2.5 \times 10^{-4}) = \boxed{3.6}$$

26

100.0 mL of 0.300 M CH₃COOH is mixed with 100.0 mL of 0.400 M CH₃COONa. Determine the pH.



$$[\text{CH}_3\text{COOH}] = \frac{(0.300)(100.0)}{(200.0)}$$

$$= 0.150 \text{ M}$$

$$[\text{CH}_3\text{COONa}] = \frac{(0.400)(100.0)}{(200.0)}$$

$$= 0.200 \text{ M}$$

$$1.8 \cdot 10^{-5} = \frac{(0.200+x)(x)}{(0.150-x)}$$

$$(0.150-x)(1.8 \cdot 10^{-5}) = (0.200 x + x^2)$$

$$2.7 \times 10^{-6} - 1.8 \cdot 10^{-5} x = 0.200 x + x^2$$

$$0 = x^2 + 0.200018 x - 2.7 \times 10^{-6}$$

$$x = \frac{-0.200018 \pm \sqrt{(0.200018)^2 - 4(1)(2.7 \cdot 10^{-6})}}{2(1)}$$

$$x = \frac{-0.200018 \pm 0.200045}{2}$$

$$x = -0.20$$

$$\text{or } 1.3 \times 10^{-5}$$

$$\text{pH} = -\log(1.3 \times 10^{-5}) = \boxed{4.9}$$