pH Titration Practice

1. Let’s Calculate the pH for a titration of a 0.30 M KOH with 60 mL of a 0.25 M HNO3

|  |  |
| --- | --- |
| KOH added | pH |
| 0 mL |  |
| 17 mL |  |
| 45 mL |  |
| 50 mL |  |
| 62 mL |  |
| 100 mL |  |

2. Let’s Calculate the pH for a titration of a 0.04 M HCl with 50 mL of a 0.05 M NaOH

|  |  |
| --- | --- |
| HCl added | pH |
| 0 mL |  |
| 20 mL |  |
| 40 mL |  |
| 62.5 mL |  |
| 80 mL |  |
| 90 mL |  |

Practice with weak acid equilibria when X is not negligible (quadratic formula)

Calculate the pH and the concentration of all species present in a 0.002 M HF solution, the Ka of HF = 3.5 x 10-4

1. Write the principal and subsidiary reactions and label so

 HF + H2O(l) ↔ H3O+ + F- Ka = 3.5 x 10-4

2 H2O(l) ↔ H3O+ + OH- Kw = 1 x 10-14

 To distinguish which reactions is the principal reaction, #1 water is never the principal reaction and #2 pick the reaction with the largest equil. constant, K

HF + H2O(l) ↔ H3O+ + F- Ka = 3.5 x 10-4 Principal Rxn

1. Write an equilibrium expression for the principle reaction

 Ka = [H3O+] [F-] / [HF]

1. Make an equilibrium table for the principal reaction

 HF + H2O(l) ↔ H3O+ + F-

 Initial M .002 0 0

 Δ M -x +x +x

 Eq. M .002 – x x x

1. Put values from table into Ka expression

 Ka = (x•x) / (.002-x) = x2 / (.002 – x)

1. Assume that x is negligible compared to the initial concentration of acid

 Therefore the Ka expression becomes

 Ka = x2 / .002

1. Solve for x

 3.5 x 10-4 = x2 / .002 x = 8.37 x 10-4

 Check to see if your assumption x<<.002 is correct

 .002 - 8.37 x 10-4 = .001

 The concentration of the acid did change!! So your assumption that

 x<< .002 is incorrect. You must now use the quadratic formula!!

1. Put the Ka expression into a quadratic formula state ax2 + bx +c = 0

 3.5 x 10-4 = x2 / (.002 – x)

 x2 = 7 x 10-7 – 3.5 x 10-4x

 x2 +3.5 x 10-4x – 7 x 10-7 = 0

 a = 1

 b = 3.5 x 10-4

 c= -7 x 10-7

1. Use the quadratic formula to solve for x

 X = -b (b2 – 4 ac) = -3.5 x 10-4 (3.5 x 10-4)2 – (4\*a\*-7 x 10-7)

 2a 2(1)

 X = **6.8 x 10-4** or -1.03 x 10-3

1. **6.8 x 10-4** = x, now you can fill in the table and find for the pH and the OH-

 [H3O+] = **6.8 x 10-4** pH = -log [H3O+] = 3.2

 Kw = [H3O+] [OH-] 1x10-14 / 6.8x10-4 = [OH-] = 1.47 x 10-11

 [HF] = .002 - 6.8 x 10-4 = .001

 [H3O+] = [F-] = x = 6.8 x 10-4

10. Now it’s your turn.

Calculate the pH and the concentration of all species present in a 0.0175 M HF solution,

the Ka of HF = 3.5 x 10-4

Practice with weak acids

1. Calculate the pH and the concentrations of all species present in a 0.0150 M HClO

(Ka = 3.50 x 10-8)

 Answers:

1. 0.0150 M HClO (Ka = 3.50 x 10-8)

Balanced Equation: HClO(aq) + H2O(l) ↔ H3O+(aq) + ClO-(aq)

|  |
| --- |
|  HClO(aq) + H2O(l) ↔ H3O+(aq) + ClO-(aq) |
| Initial | .0150 |  | 0 | 0 |
| Change | -x |  | +x | +x |
| Final | .0150 - x |  | x | x |

Ka = [H3O+] [ClO-] / [HClO]

3.50 x 10-8 = x2 / (.0150 – x) assume: x <<<<<<<< .0150

So,

 3.50 x 10-8 = x2 / .0150

 X2 = 5.25 x 10-10

 X = 2.29 x 10-5

 Check to make sure your assumption is correct

 .0150 -2.29 x 10-5 = .0150 using rules of significant figures and rounding

 Assumption is correct!!!

[HClO] = .0150 - 2.29 x 10-5 = .015 mol/L

[H3O+] = 2.29 x 10-5 mol/L

 pH = -log [2.29 x 10-5] = 4.64

[ClO-] = 2.29 x 10-5 mol/L

1. Calculate the pH and the concentrations of all species present in a 0.0230 M HPO4-

(Ka = 4.90 x 10-10)

1. Calculate the pH and the concentrations of all species present in a 3.20 x 10-5 M CH3CO2H

(Ka = 1.70 x 10-5)

1. 3.20 x 10-5 M CH3CO2H (Ka = 1.70 x 10-5)

Balanced Equation: CH3CO2H(aq) + H2O(l) ↔ H3O+(aq) + CH3CO2-(aq)

|  |
| --- |
|  CH3CO2H(aq) + H2O(l) ↔ H3O+(aq) + CH3CO2-(aq) |
| Initial | 3.20 x 10-5 |  | 0 | 0 |
| Change | -x |  | +x | +x |
| Final | 3.20 x 10-5 - x |  | x | x |

Ka = [H3O+] [CH3CO2-] / [CH3CO2H]

1.70 x 10-5 = x2 / (3.20 x 10-5– x) assume: x <<<<<<<< 3.20 x 10-5

So,

 1.70 x 10-5 = x2 / 3.20 x 10-5

 X2 = 5.44 x 10-10

 X = 2.33 x 10-5

 Check to make sure your assumption is correct

 3.20 x 10-5 - 2.33 x 10-5= 8.70 x 10-6 using rules of significant figures and rounding

 Assumption is **NOT** correct!!! **MUST USE QUADRATIC FORMULA**

1.70 x 10-5 = x2 / (3.20 x 10-5– x)

X2 = 5.44 x 10-10 – 1.70 x 10-5x

X2 + 1.70 x 10-5x - 5.44 x 10-10 = 0

a = 1

b = 1.70 x 10-5

c = - 5.44 x 10-10

x = (-b ± √b2 – 4ac) / 2a

x = [-1.70 x 10-5 ±√((1.70 x 10-5)2 - (4\*1\*- 5.44 x 10-10))] / (2\*1)

x = 1.63 x 10-5

[CH3CO2H] = 3.20 x 10-5 - 1.63 x 10-5 = 1.57 x 10-5

[H3O+] = 1.63 x 10-5

 pH = -log [1.63 x 10-5] = 4.79

[CH3CO2-] = 1.63 x 10-5

1. Calculate the pH and the concentrations of all species present in a 0.0020 M HOCN

(Ka = 3.50 x 10-4)