Acid and Base Titrations - Equation Guide

Strong Acid + Strong Base: *(SA + SB)*

Initial Region: **pH = - log (n_{sa} / V_{sa})** *or* **pH = - log (C_{sa})**

Pre-Equivalence Region: $\mathbf{pH = -\log\left(\frac{n_{sa} - n_{sb}}{V_{sa} + V_{sb}}\right)}$ *or* $\mathbf{pH = -\log\left(\frac{n_{sa} - n_{sb}}{V_{total}}\right)}$

Equivalence: **pH = 7**

Post-Equivalence Region: $\mathbf{pH = 14 + \log\left(\frac{n_{sb} - n_{sa}}{V_{sa} + V_{sb}}\right)}$ *or* $\mathbf{pH = 14 + \log\left(\frac{n_{sb} - n_{sa}}{V_{total}}\right)}$

Strong Base + Strong Acid: *(SB + SA)*

Initial Region: **pH = 14 + log (n_{sb} / V_{sb})** *or* **pH = 14 + log (C_{sb})**

Pre-Equivalence Region: $\mathbf{pH = 14 + \log\left(\frac{n_{sb} - n_{sa}}{V_{sa} + V_{sb}}\right)}$ *or* $\mathbf{pH = 14 + \log\left(\frac{n_{sb} - n_{sa}}{V_{total}}\right)}$

Equivalence: **pH = 7**

Post-Equivalence Region: $\mathbf{pH = -\log\left(\frac{n_{sa} - n_{sb}}{V_{sa} + V_{sb}}\right)}$ *or* $\mathbf{pH = -\log\left(\frac{n_{sa} - n_{sb}}{V_{total}}\right)}$

Weak Acid + Strong Base: *(WA + SB)*

Initial Region: $\mathbf{pH = -\log\sqrt{K_a \cdot \frac{n_{wa}}{V_{wa}}}}$ *or* $\mathbf{pH = -\log\sqrt{K_a \cdot C_{wa}}}$

Pre-Equivalence Region: $\mathbf{pH = pK_a + \log\left(\frac{n_{sb}}{n_{wa} - n_{sb}}\right)}$

Half-Equivalence Region: **pH = pK_a**

Equivalence: $\mathbf{pH = 14 + \log\sqrt{\frac{K_w}{K_a} \cdot \frac{n_{wa}}{(V_{wa} + V_{sb})}}}$ *or* $\mathbf{pH = 14 + \log\sqrt{K_b \cdot C_{wb}}}$

Post-Equivalence Region: $\mathbf{pH = 14 + \log\left(\frac{n_{sb} - n_{wa}}{V_{sb} + V_{wa}}\right)}$ *or* $\mathbf{pH = 14 + \log\left(\frac{n_{sb} - n_{wa}}{V_{total}}\right)}$

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<u>Weak Base + Strong Acid</u>: *(WB + SA)*

Initial Region: $\mathbf{pH = 14 + \log}\sqrt{K_b \cdot \frac{n_{wb}}{V_{wb}}}$ *or* $\mathbf{pH = 14 + \log}\sqrt{K_b \cdot C_{wb}}$

Pre-Equivalence Region: $\mathbf{pH = p}K_a \mathbf{+ \log}\left(\frac{n_{wb} - n_{sa}}{n_{sa}}\right)$

Half-Equivalence Region: $\mathbf{pH = pK_a}$

Equivalence: $\mathbf{pH = -\log}\sqrt{\frac{K_w}{K_b} \cdot \frac{n_{wb}}{(V_{wb} + V_{sa})}}$ *or* $\mathbf{pH = -\log}\sqrt{K_a \cdot C_{wa}}$

Post-Equivalence Region: $\mathbf{pH = -\log}\left(\frac{n_{sa} - n_{wb}}{V_{sa} + V_{wb}}\right)$ *or* $\mathbf{pH = -\log}\left(\frac{n_{sa} - n_{wb}}{V_{total}}\right)$

Guide to Symbols

n = moles
V = volume (L)
C = concentration (M or mol/L)
sa = strong acid
sb = strong base
wa = weak acid
wb = weak base

$\mathbf{K_a}$ = acid dissociation constant for a weak acid
$\mathbf{pK_a = -\log K_a}$
$\mathbf{K_a = 10^{-pKa}}$

$\mathbf{K_b}$ = base dissociation constant for a weak base
$\mathbf{pK_b = -\log K_b}$
$\mathbf{K_b = 10^{-pKb}}$

$\mathbf{K_w = 10^{-14}}$ = autoionization constant for water at 25 ˚C
Also, $\mathbf{K_w = [H_3O^+]*[OH^-] = K_a*K_b = 10^{-14}}$

$\mathbf{pH = -\log [H_3O^+]}$
$\mathbf{pOH = -\log [OH^-]}$
$\mathbf{14 = pH + pOH = pK_a + pK_b}$