pC-pH Diagram

pH

5

10

log concentration, pc

[Ac]⁻

[H⁺]

H₂O

C₅₄H₂₆O₆

[HAc]
(#1) Develop pC - pH diagram for 10^{-4} M HAc

**Equilibrium equations**

\[ \text{HAc} \rightleftharpoons \text{H}^+ + \text{Ac}^- \]

\[ K_a = 10^{-4.7} = \frac{[\text{H}^+][\text{Ac}^-]}{[\text{HAc}]} \]

\[ K_w = [\text{H}^+][\text{OH}^-] = 10^{-14} \]

**Mass Balance**

\[ [\text{HAc}] + [\text{Ac}^-] = C_{T,\text{Ac}^-} = 10^{-4} \text{ M} \]

**Charge balance** (also the proton condition)

\[ [\text{H}^+] = [\text{OH}^-] + [\text{Ac}^-] \]

**Plot all species vs. pH**

- For Kw Expression \( \Rightarrow \) In log form
  \[ \log K_w = \log ([\text{H}^+] + [\text{OH}^-]) \]
  \[ pOH = 14 - pH \rightarrow \text{slope} = -1 \]
  \[ y = b + mx \]
  plot point on graph
  \[ w/ -1 \text{ slope} \]
  \[ (0, 14) \]
  line labeled [OH^-] on graph

- By definition
  \[ -\log ([\text{H}^+]) = pH \]
  \[ pC = pH \rightarrow \text{line labeled [H}^+] \text{ on graph} \]

**Now draw lines for [Ac^-] and [HAc]**

Need to relate concentrations vs. pH and constants

- For Ac^- Combine \( K_a \) and m.b. equations to eliminate [HAc]
  \[ K_a = \frac{[\text{H}^+][\text{Ac}^-]}{C_T - [\text{Ac}^-]} \]
solve for \([A^-]\):

\[
[A^-] = \frac{K_a \ C_T}{([H^+]) + K_a}
\]

Now - check around system point:

If \(K_a \gg [H^+]\) \(\Rightarrow \) \(pH > pK_a\)

\([A^-] = C_T = 10^{-y}\)

\(pC_{A^-} = 4\) when \(pH > 4.7\)

If \([H^+] \gg K_a\) \(\Rightarrow \) \(pK_a > pH\)

Again combine \(K_a + m.B\) equations:

\[
\frac{K_a \ C_{T,A^-}}{[H^+]} = [A^-]
\]

\(-\log K_a - \log C_{T,A^-} = (-\log [H^+]) = -\log [A^-]\)

\(p[A^-] = pC_{T,A^-} + pK_a - pH\)

\(y = \frac{pK_a}{b}\)

slope = -1

when \(pH = pK_a = 4.7\)

\(p[A^-] = pC_{T,A^-} = 4\)

\((4.7, 4)\) slope -1

line marked \([A^-]\) in figure

- Use similar procedure for \([HA^-]\) line - refer to lecture note handout

- remember to check around system point
(#2) Find equilibrium species conc?

\[ \text{HAc } \rightleftharpoons \text{H}^+ + \text{Ac}^- \]

\[ \text{Ac}^- + \text{H}_2\text{O} \rightleftharpoons \text{HAc} + \text{OH}^- \]

Proton condition \[ \frac{[\text{H}^+]}{[\text{OH}^-]} = \frac{[\text{Ac}^-]}{[\text{HAc}]} \]

see point on graph representing solution

\[ [\text{H}^+] = 10^{-4.4} \quad \text{pH} = 4.4 \]

\[ [\text{HAc}] = 10^{-4} \]

\[ [\text{Ac}^-] = 10^{-4.4} \]

\[ [\text{OH}^-] = 10^{-9.5} \]

(#3) Find conc of species if \(10^{-4} \text{ M}\) NaAc added

\[ \text{NaAc } \rightleftharpoons \text{Na}^+ + \text{Ac}^- \]

\[ \text{Ac}^- + \text{H}_2\text{O} \rightleftharpoons \text{HAc} + \text{OH}^- \]

\[ \text{HAc } \rightleftharpoons \text{H}^+ + \text{Ac}^- \]

Proton condition \[ \frac{[\text{H}^+][\text{HAc}]}{[\text{OH}^-]} = \frac{[\text{Ac}^-]}{[\text{HAc}]} \]

\[ \text{pH} \approx 7.2 \quad [\text{H}^+] = 10^{-7.2} \]

\[ [\text{HAc}] \approx 10^{-6.8} \]

\[ [\text{Ac}^-] \approx 10^{-4} \]

\[ [\text{OH}^-] \approx 10^{-6.8} \]