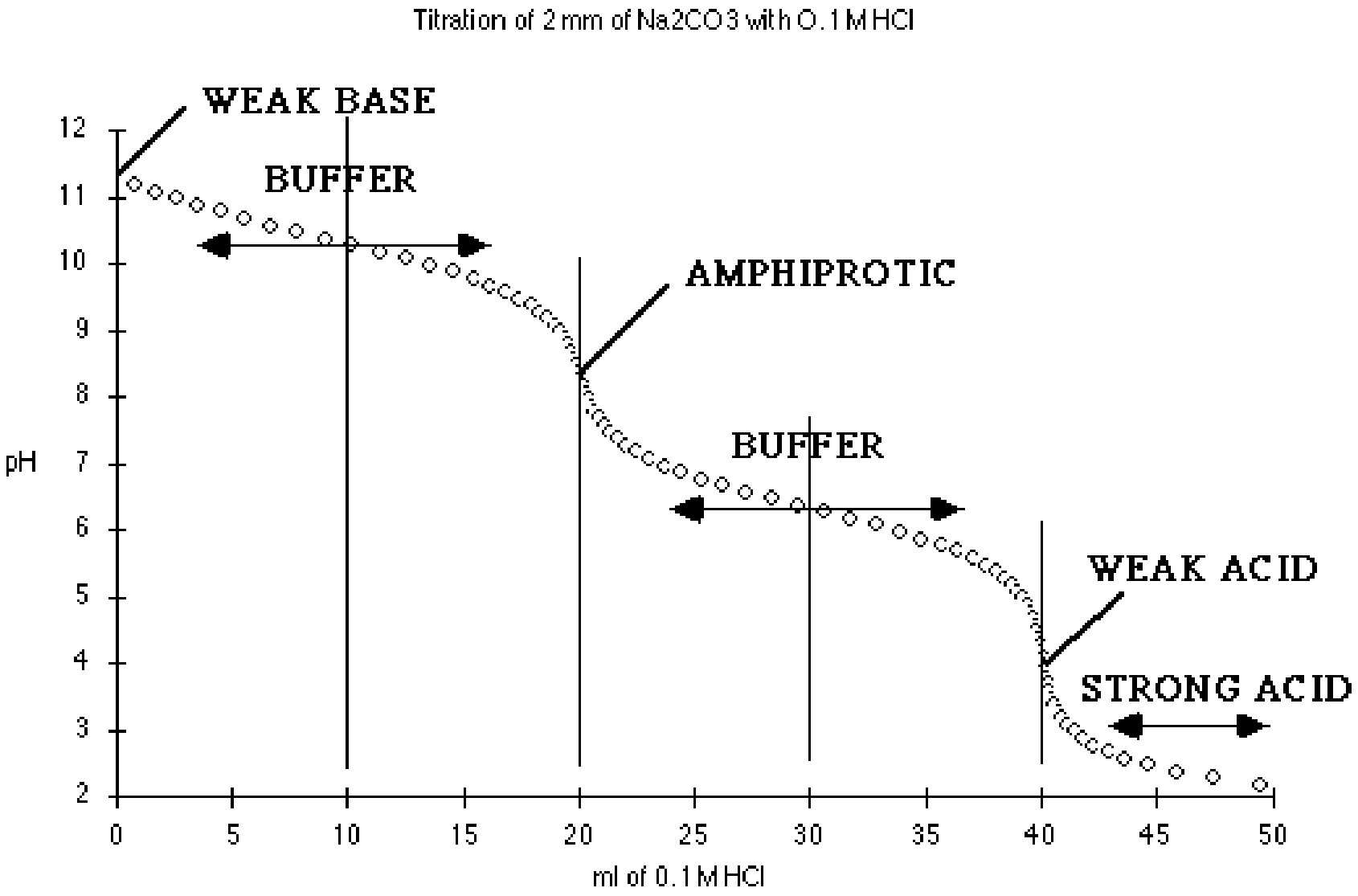
Titration of Polyprotic Base with Strong Acid



Fractional Composition Equations

Why determine fractional compositions?

- Fractional composition clearly show the dominant and minor species in solution.
- Fractional compositions provide a way to know what reactions are occurring, and what reactions are relatively unimportant.
- Fractional compositions make really cool plots.

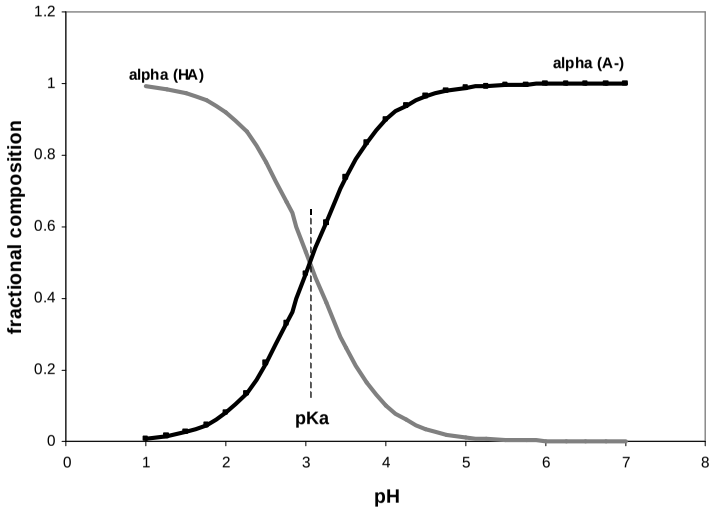
Monoprotic Systems

For an acid - $\alpha_{HA} = [HA] / F$

$\alpha_{A^-} = [A^-] / F$

For a base - $\alpha_{b} = [B] / F$

$\alpha_{BH^+} = [BH^+] / F$



F = Formal concentration

Diprotic Systems

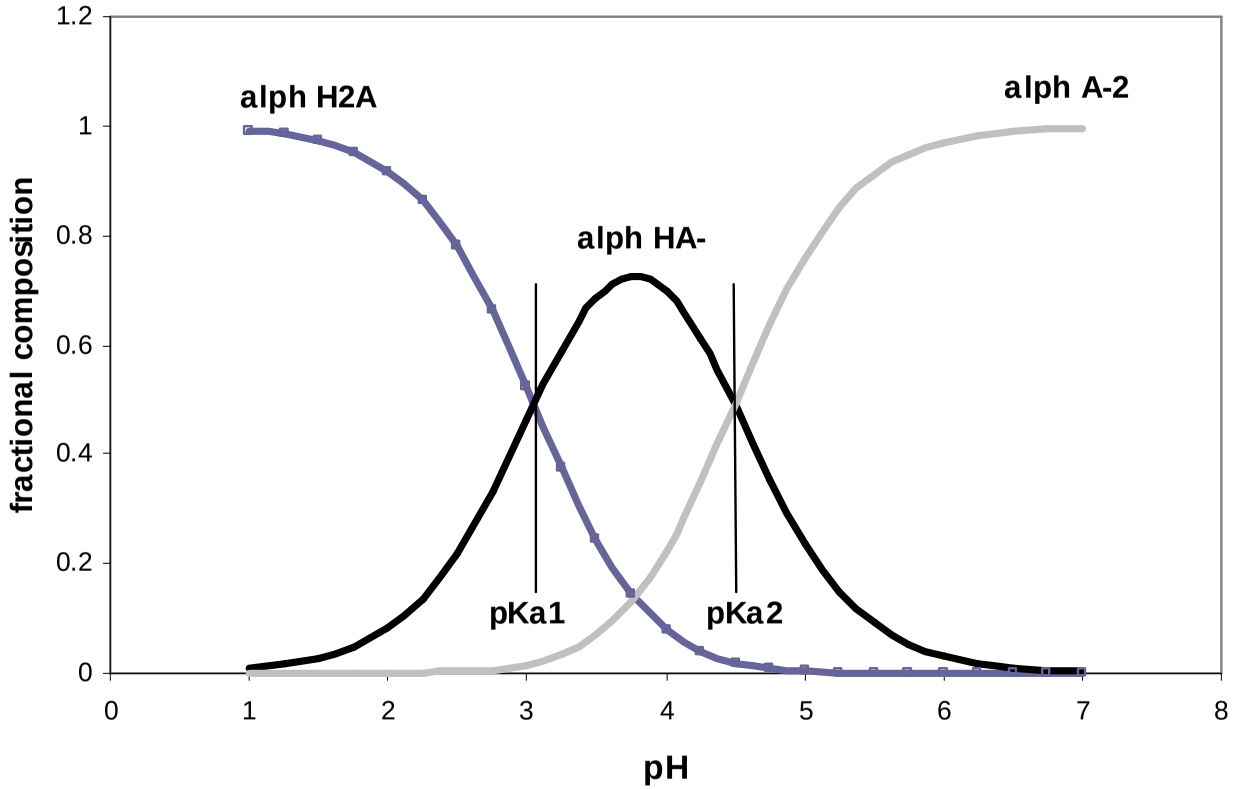
For an acid -

$$\alpha_{H2A} = [H_2A] / F$$

$$\alpha_{HA-} = [HA^-] / F$$

$$\alpha_{A2-} = [A^{-2}] / F$$

F = Formal concentration



Calculating Fractional Compositions from $[H^+]$ and K_a's

For an acid – H_2A:

$$\alpha_{H2A} = [H_2A] / F$$
$$\alpha_{HA^-} = [HA^-] / F$$
$$\alpha_{A2^-} = [A^{-2}] / F$$

F = Formal concentration

$$\alpha_{H2A} = [H^+]^2 / D$$

$$\alpha_{HA^-} = [H^+] K_{a1} / D \qquad \text{where } D = [H^+]^2 + [H^+] K_{a1} + K_{a1}K_{a2}$$

$$\alpha_{A^{-2}} = K_{a1}K_{a2} / D$$

Biochemical terms

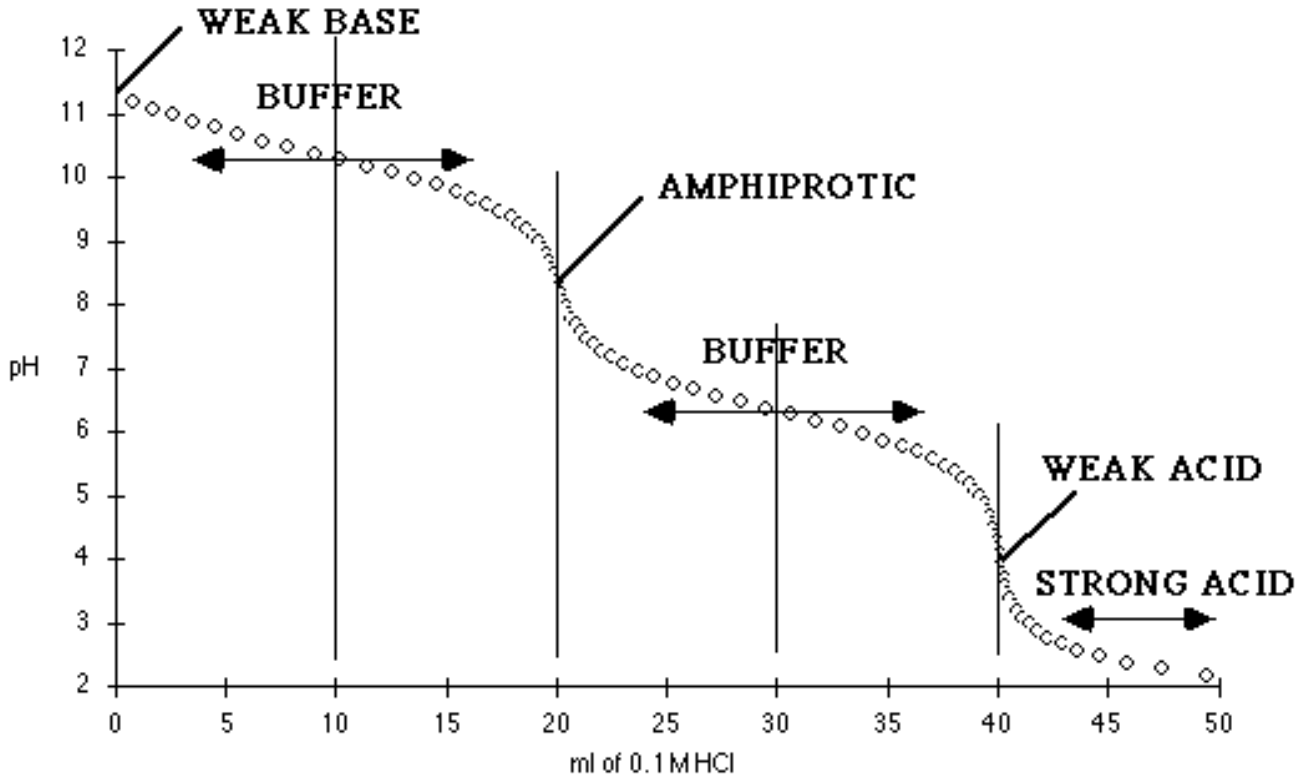
Isoionic pH : pH of a solution where the pure, neutral polyprotic acid has been dissolved.

Isoelectric pH : pH of a solution when the average charge on the polyprotic acid is 0.

The isoelectric pH is useful for separating various polyprotic acids from one another. If you put these acids in a electric field and a pH gradient, they will focus themselves in a region of the pH corresponding to their isoelectric pH (they do not move toward the positive or negative pole).

Diprotic Buffers – treated similar to a monoprotic buffer. You must know what the desired pH and the appropriate pKa are.

pH = pKa + log [base]/[acid]



Buffer problem

How many grams of $NaHCO_3$ (FM 84.007) must be added to 4.00 g of K_2CO_3 (FM 138.206) to give a pH of 10.80 in 500 mL of water?

What will be the pH if 100 mL of 0.1 M HCl are added to above solution?

Draw the structure and the fractional composition of the principal species of 1,3-dihydroxybenzene at the following pH values:

(pK_{a1} = 9.30 pK_{a2} = 11.06)

pH 9

pH 11