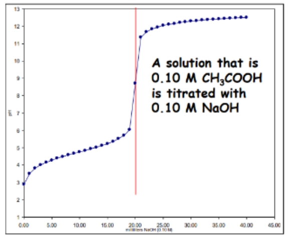
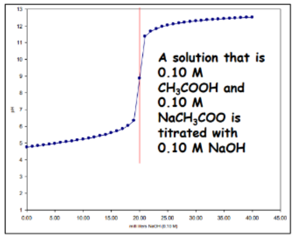
N39 – Henderson-Hasselbalch

Weak Acid	Formula of the acid	Example of a salt of the weak acid
Hydrofluoric	HF	KF – Potassium fluoride
Formic	HCOOH	KHCOO – Potassium formate
Benzoic	C_6H_5COOH	NaC_6H_5COO – Sodium benzoate
Acetic	CH_3COOH	NaH_3COO – Sodium acetate
Carbonic	H_2CO_3	$NaHCO_3$ - Sodium bicarbonate
Propanoic	$HC_3H_5O_2$	$NaC_3H_5O_2$ - Sodium propanoate
Hydrocyanic	HCN	KCN - potassium cyanide



Weak Base	Formula of the base	Example of a salt of the weak acid
Ammonia	NH_3	NH_4Cl - ammonium chloride
Methylamine	CH_3NH_2	CH_3NH_3Cl – methylammonium chloride
Ethylamine	$C_2H_5NH_2$	$C_2H_5NH_3NO_3$ - ethylammonium nitrate
Aniline	$C_6H_5NH_2$	$C_6H_5NH_3Cl$ – aniline hydrochloride
Pyridine	C_5H_5N	C_5H_5NHCl – pyridine hydrochloride



One way of doing these calculations

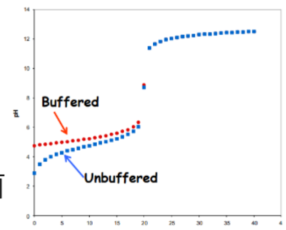
Rearrange your Law of Mass Action:

$$Ka = \frac{[H^+][A^-]}{[HA]} \rightarrow [H^+] = Ka\frac{[HA]}{[A^-]} \rightarrow = Ka\frac{[Acid]}{[conj.Base]}$$

salt

$$Kb = \frac{[BH^+][OH^-]}{[B]} \rightarrow [OH^-] = Kb\frac{[B]}{[BH^+]} \rightarrow = Kb\frac{[Base]}{[conj.Acid]}$$

salt



Henderson-Hasselbalch Equation

$$pH = pK_a + log\left(\frac{A^-}{HA}\right) = pK_a + log\left(\frac{[Base]}{[Acid]}\right)$$

$$pOH = pK_b + log\left(\frac{BH^+}{B}\right) = pK_b + log\left(\frac{[Acid]}{[Base]}\right)$$

pKa = -log(Ka)
pKb = -log(Kb)
Just like pH = -log[H⁺]

The acids or bases may be conjugates from the salt!

Other ways to think about He-Ha

Acid with a buffer:

$$pH = pK_a + log\left(\frac{[salt]}{[Acid]}\right) = pK_a + log\left(\frac{[conj.Base]}{[Acid]}\right)$$

Base with a buffer:

$$pOH = pK_b + log\left(\frac{[salt]}{[Base]}\right) = pKb + log\left(\frac{[conj.Acid]}{[Base]}\right)$$

Suggestions…

Pick a method and stick to it. They all have pros and cons.

- **Ice tables**
  Pro = familiar
  Con = takes forever, lots of steps
- **He-Ha**
  Pro = fast, on the AP eq. sheet
  Con = Have to recognize to use it, not always solving for pH
- **Rearranging Law of Mass Action**
  Pro = simple
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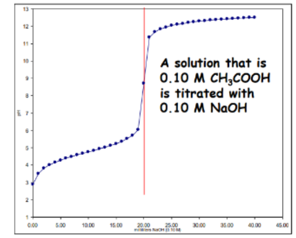

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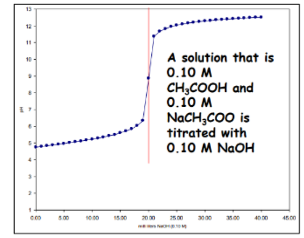

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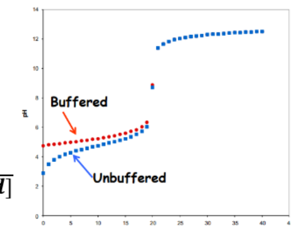

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N39 – Henderson-Hasselbalch

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$$

H_3O^+ added, equilibrium position shifts to the left

$$CH_3COOH(aq) \leftarrow CH_3COO^-(aq) + H_3O^+$$

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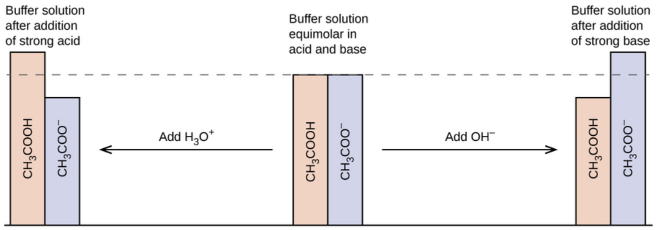

Figure 14.6.2: This diagram shows the buffer action of these reactions.

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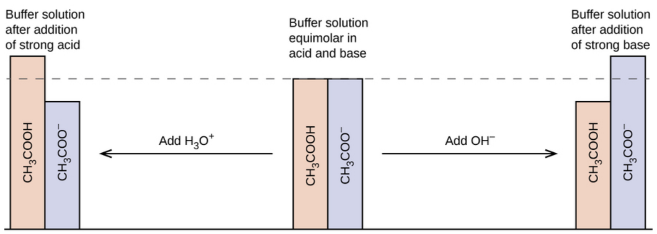

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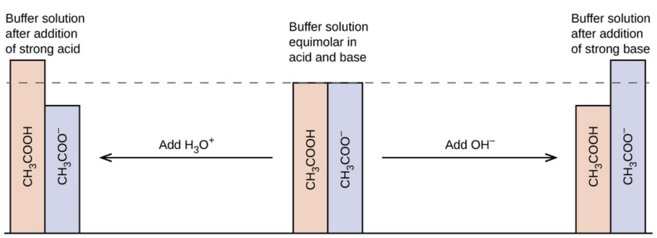

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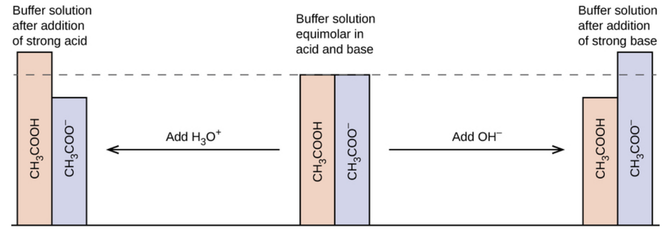

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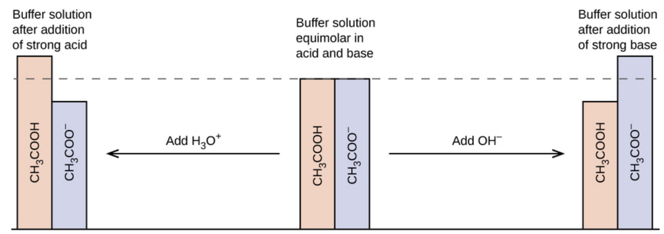

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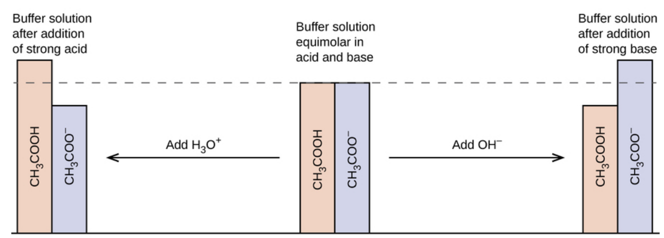

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