Relation of pH, pK & buffer concentration

"Henderson - Hasselbalch Equation"

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$[H^+] = K_a \frac{[HA]}{[A^-]}$$

$$-\log [H^+] = -\log K_a - \log \frac{HA}{[A^-]}$$

$$\rightarrow pH = pKa + \log \frac{[A^-]}{[HA]}$$

pH = pKa at mid point = $[A^-] = [HA]$

$$pH = pKa + \log \frac{[\text{conjugate base}]}{[\text{conjugate acid}]}$$

e.g. $pH = pKa - 1$ base/acid $= 1/10$

$pH = pKa + 1$ base/acid $= 10/1$

Titration Curves

1. Monoprotic acids

weak acid strong base

$$CH_3COOH + NaOH \rightleftharpoons CH_3COO^-Na^+ + H_2O$$

Acid Base Conjugate base

Unnumbered figure pg 51b Concepts in Biochemistry, 3/e

strong acids have weak conjugate bases
weak acid have strong conjugate bases

acid strength ↑

Acid	
CH_3COOH	
C_6H_5OH	phenol
H_2O	
C_2H_5OH	ethanol

Conjugate base	
CH_3COO^-	
$C_6H_5O^-$	phenoxide
OH^-	hydroxide
$C_2H_5O^-$	ethoxide

↓ Base strength

Titration Curve

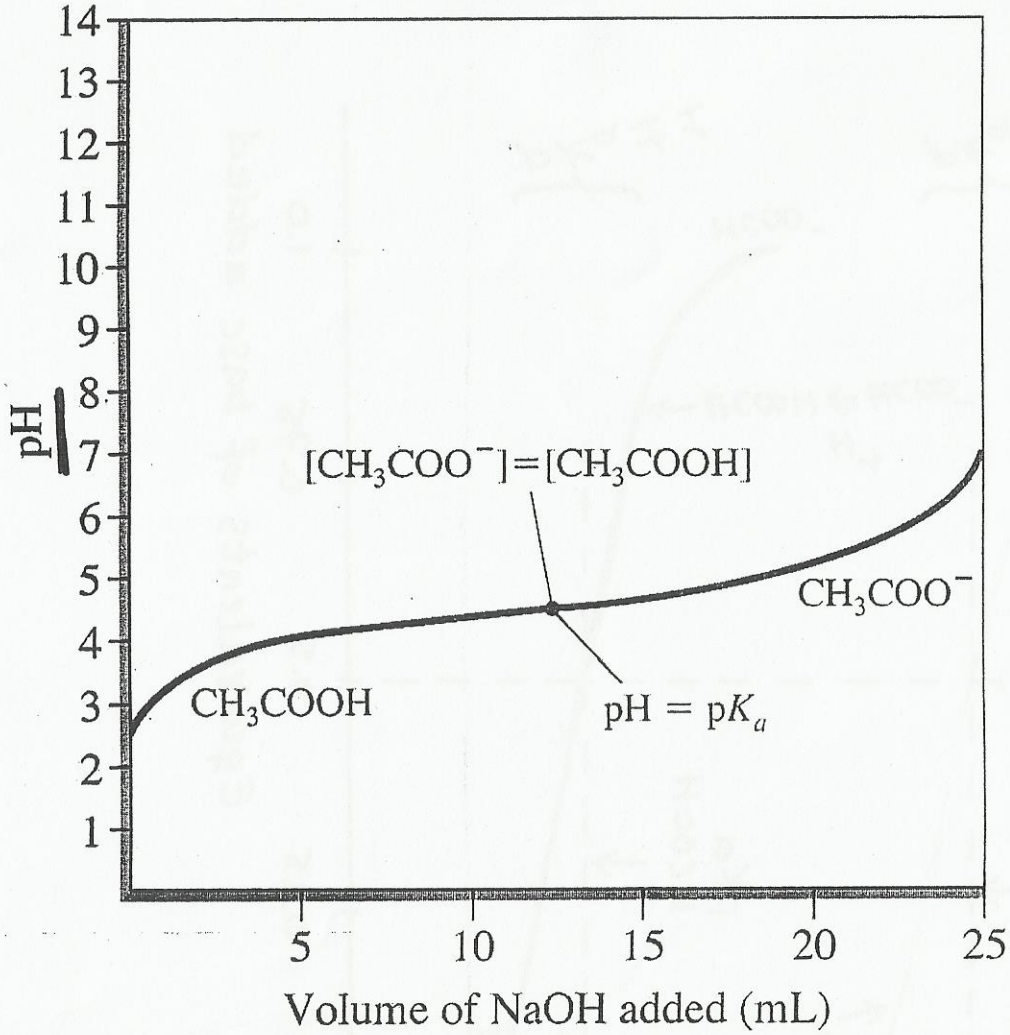
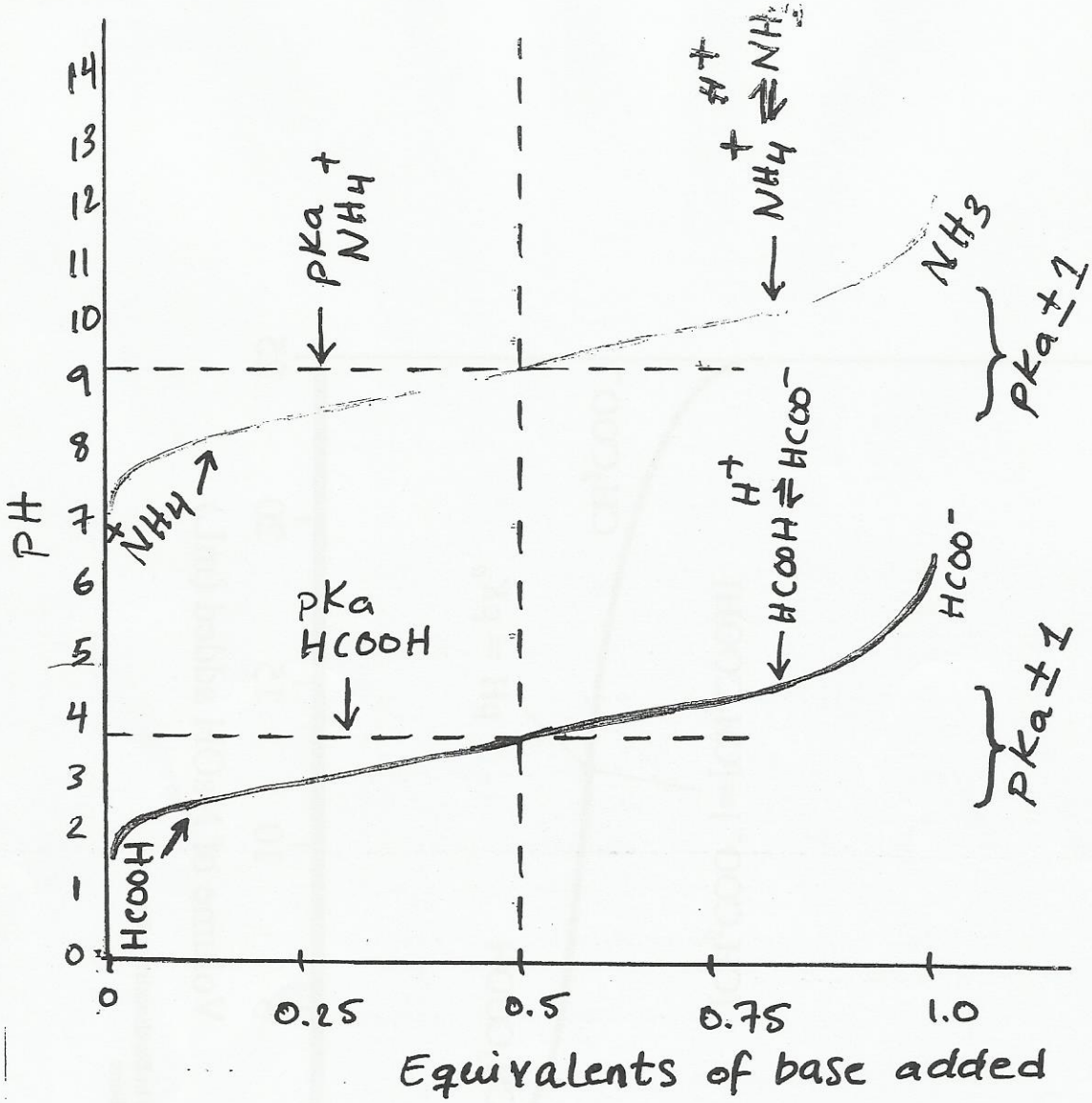
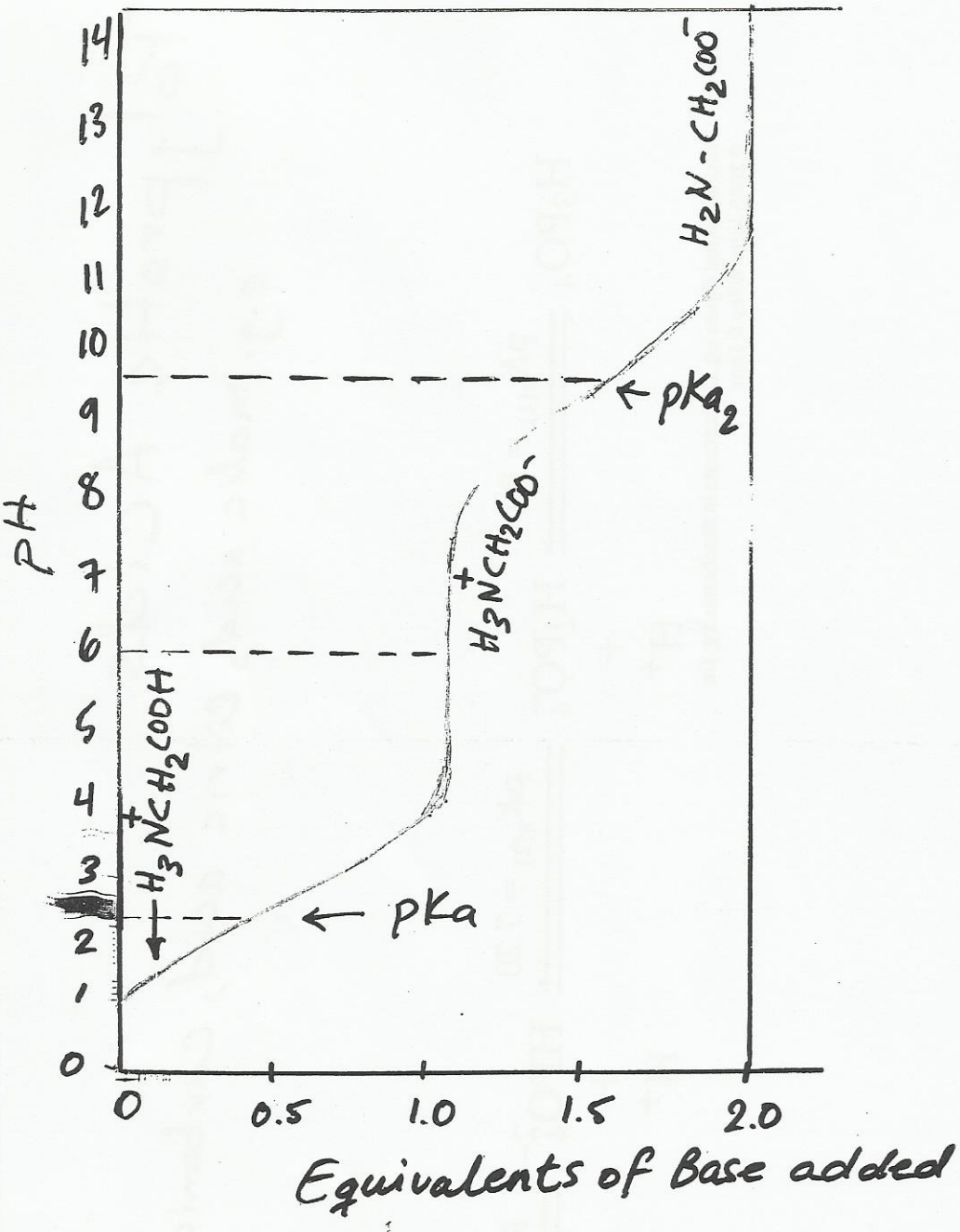


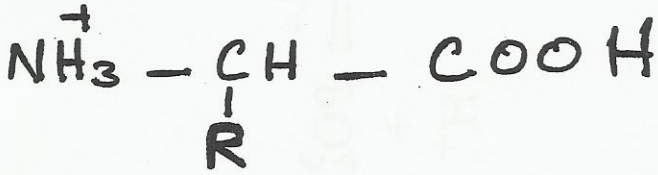
Figure 2-10 Concepts in Biochemistry, 3/e


pH
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
0.25
0.5
0.75
1.0
Equivalents of base added
pKa NH_4^+
$NH_4^+ + H^+ \rightleftharpoons NH_3$
NH_3
pKa ± 1
NH_4^+
pKa HCOOH
$HCOOH \rightleftharpoons H^+ + HCOO^-$
$HCOO^-$
pKa ± 1
HCOOH

Titration Curves of Glycine



Amino acids General Formula

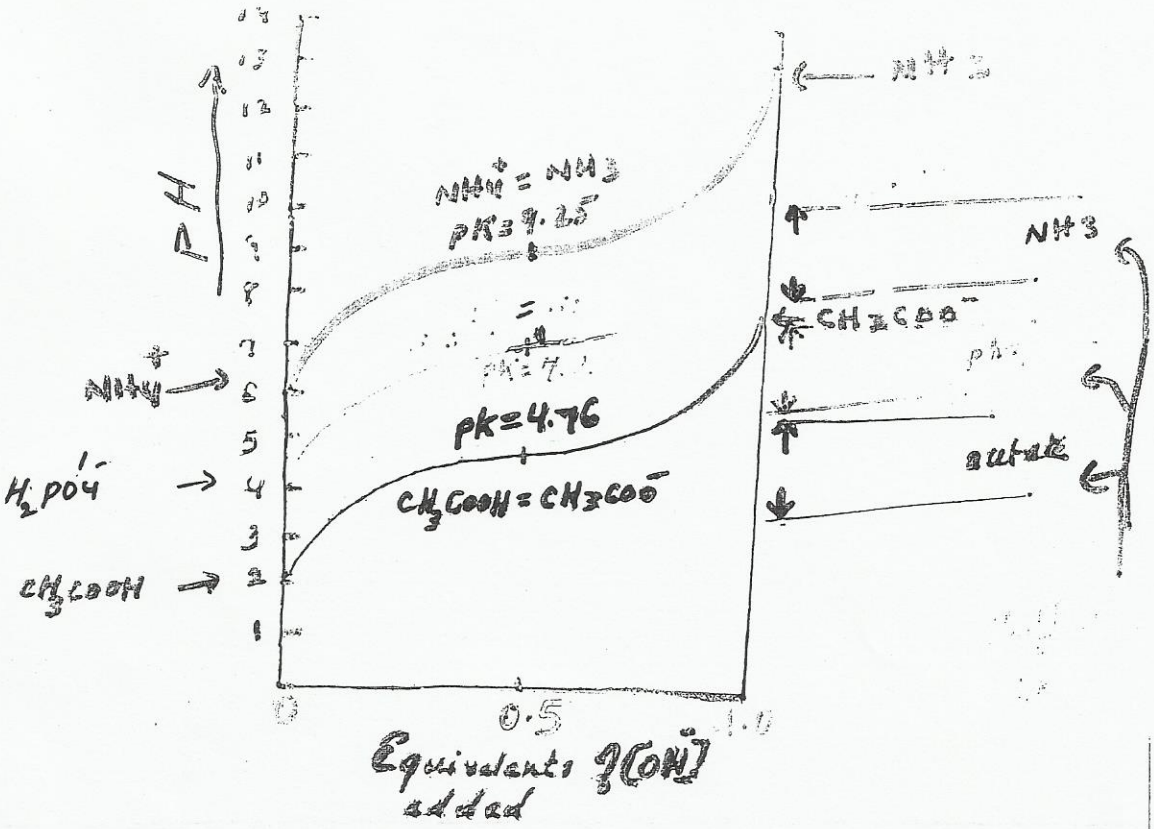


Polyprotic Acids

e.g. malic acid, citric acid, carbonic acid, phosphoric acid

$$H_3PO_4 \underset{}{\overset{pK_{a(1)} = 2.14}{\rightleftharpoons}} H_2PO_4^- + H^+ \overset{pK_{a(2)} = 7.20}{\rightleftharpoons} HPO_4^{2-} + H^+ \overset{pK_{a(3)} = 12.4}{\rightleftharpoons} PO_4^{3-} + H^+$$

Unnumbered figure pg 52 Concepts in Biochemistry, 3/e



Henderson-Hasselbalch Equation

Buffer Capacity

Effective buffering range

at a pH range = pKa ± 1