Reazioni acido base

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ACIDO ⇨ HA ⇨ SPECIE CAPACE DI DONARE IONI H^+

BASE ⇨B ⇨ SPECIE CAPACE DI ACCETTARE IONI H^+

BASE — ACIDO CONIUGATO

$HA + B \leftrightarrows A^- + BH^+$

ACIDO — BASE CONIUGATA

$HNO_2 + H_2O \leftrightarrows NO_2^- + H_3O^+$

acido1 base2 base1 acido2

$NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$

base1 acido2 acido1 base2

$NaOH \rightarrow Na^+ + OH^-$

H_3O^+ = IONE IDROSSONIO (OSSONIO)

OH^- = IONE OSSIDRILE

H_2O = anfolita

$H_2O + H_2O \leftrightarrows H_3O^+ + OH^-$ ⟸ Reazione di autoprotolisi

base1 acido2 acido1 base2

$2\ H_2O \leftrightarrows H_3O^+ + OH^-$

$K = \frac{[H_3O^+][OH^-]}{[H_2O]^2}$ $[H_2O]$=55,55 M = costante

$K_W = [H_3O^+][OH^-] = 10^{-14}$ ⟸ Costante di autoprotolisi
Prodotto ionico

Acqua neutra $[H_3O^+] = [OH^-] = x$ ⇨ $K_W = x^2 = 10^{-14}$

$\rightarrow x = [H_3O^+] = [OH^-] = \sqrt{K_W} = \sqrt{10^{-14}} = 10^{-7}$ M

$K_W = [H_3O^+][OH^-] = 10^{-14}$

pH+pOH=14

$pH = -\log [H_3O^+]$ $pOH = -\log [OH^-]$

Acqua neutra $[H_3O^+] = [OH^-] = 10^{-7}$ M ⇨ $pH = -\log [H_3O^+] = -\log 10^{-7} = 7$ $pOH = -\log [OH^-] = 7$

Soluzione acida $[H_3O^+] > [OH^-]$ $[H_3O^+] > 10^{-7}$ M ⇨ $pH = -\log [H_3O^+] < 7$

$HA + H_2O \leftrightarrows A^- + H_3O^+$ $[OH^-] < 10^{-7}$ M ⇨ $pOH = -\log [OH^-] > 7$

Soluzione basica $[OH^-] > [H_3O^+]$ $[H_3O^+] < 10^{-7}$ M ⇨ $pH = -\log [H_3O^+] > 7$

$B + H_2O \leftrightarrows OH^- + BH^+$ $[OH^-] > 10^{-7}$ M ⇨ $pOH = -\log [OH^-] < 7$

$pH = -\log [H_3O^+]$ ⇒ $[H_3O^+] = 10^{-pH}$

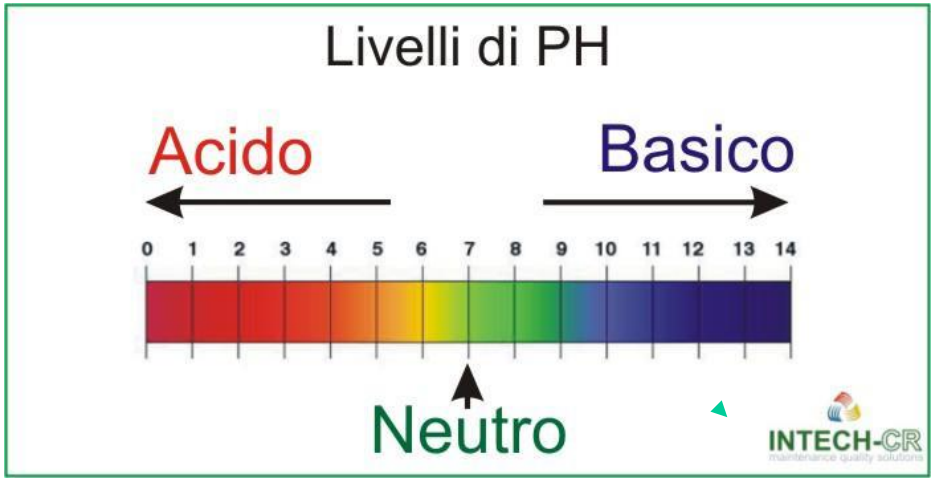
$pOH = -\log [OH^-]$ ⇒ $[OH^-] = 10^{-pOH}$

$K_W = [H_3O^+][OH^-] = 10^{-14}$ ⇒ $pH + pOH = 14$

$0 \leq pH \leq 14$

$1\ M \geq [H_3O^+] \geq 10^{-14}\ M$

Acqua neutra:
$[H_3O^+] = [OH^-] = 10^{-7}\ M$
$pH = pOH = 7$



Soluzione acida $[H_3O^+] > [OH^-]$

$[H_3O^+] > 10^{-7}\ M$ ⇨ $pH < 7$

$[OH^-] < 10^{-7}\ M$ ⇨ $pOH > 7$

Soluzione basica $[OH^-] > [H_3O^+]$

$[H_3O^+] < 10^{-7}\ M$ ⇨ $pH > 7$

$[OH^-] > 10^{-7}\ M$ ⇨ $pOH < 7$

$14 \geq pOH \geq 0$

$10^{-14} \leq [OH^-] \leq 1\ M$

Acidi e basi

ACIDI FORTI

$HA + H_2O \rightarrow A^- + H_3O^+$

Es. $HCl + H_2O \rightarrow Cl^- + H_3O^+$

ACIDI DEBOLI

$HA + H_2O \leftrightarrows A^- + H_3O^+$ ← $K_a = \frac{[A^-][H_3O^+]}{[HA]}$

$HF + H_2O \leftrightarrows F^- + H_3O^+$ ← $K_a = \frac{[F^-][H_3O^+]}{[HF]} = 6{,}6 \times 10^{-4}$

BASI FORTI

$NaOH \rightarrow Na^+ + OH^-$ ← MONOPROTICA

$Ba(OH)_2 \rightarrow Ba^{2+} + 2\ OH^-$ ← DIPROTICA

BASI DEBOLI

$B + H_2O \leftrightarrows BH^+ + OH^-$ ← $K_b = \frac{[BH^+][OH^-]}{[B]}$

$NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$ ← $K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = 1{,}8 \times 10^{-5}$

CALCOLO DEL pH

Acido forte: HCl c= 0,1 M pH = ?

$HCl + H_2O \rightarrow Cl^- + H_3O^+$

c $\rightarrow$ c c

$[H_3O^+] = c = 0{,}1\ M = 10^{-1}\ M$ $pH = - \log [H_3O^+] = 1$

Base forte: NaOH c= 0,1 M pH = ?

$NaOH \rightarrow Na^+ + OH^-$

c $\rightarrow$ c c

$[OH^-] = c = 0{,}1\ M = 10^{-1}\ M$

$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{10^{-14}}{10^{-1}} = 10^{-13}\ M$ $pH = - \log [H_3O^+] = 13$

$pOH = -\log [OH^-] = 1$ $pH = 14 - pOH = 13$

ACIDO DEBOLE

HCN c= 0,1 M K_a= 6,2 x 10^{-10}

$$\underset{c-x}{HCN} + H_2O \leftrightarrows \underset{x}{H_3O^+} + \underset{x}{CN^-}$$

$$K_a = \frac{[CN^-][H_3O^+]}{[HCN]} = \frac{x^2}{c-x} \simeq \frac{x^2}{c}$$

$x << c \rightarrow c-x \simeq c$

$K_a < 10^{-3}$ $c > 10^{-3}$ M

$$[H_3O^+] = x = \sqrt{K_a \times c} = \sqrt{6{,}2 \times 10^{-10} \times 0{,}1} = 7{,}8 \times 10^{-6} \text{ M}$$

$$pH = -\log [H_3O^+] = -\log(7{,}8 \times 10^{-6}) = 5{,}1$$

BASE DEBOLE NH_3 $c=0{,}1$ M $K_b = 1{,}8 \times 10^{-5}$

$$NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$$

c-x x x

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{x^2}{c-x} \simeq \frac{x^2}{c}$$

$x << c \rightarrow c\text{-}x \simeq c$

$K_b < 10^{-3}$ $c > 10^{-3}$ M

$$[OH^-] = x = \sqrt{K_b \times c} = \sqrt{1{,}8 \times 10^{-5} \times 0{,}1} = 1{,}34 \times 10^{-3} \text{ M}$$

$$pOH = -\log [OH^-] = -\log (1{,}34 \times 10^{-3}) = 2{,}87$$

$$pH = 14 - pOH = 11{,}13$$

$$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{10^{-14}}{1{,}34 \times 10^{-3}} = 7{,}5 \times 10^{-12} \text{ M}$$

$$pH = -\log [H_3O^+] = -\log (7{,}5 \times 10^{-12}) = 11{,}13$$

ACIDI POLIPROTICI

$$H_2S + H_2O \leftrightarrows HS^- + H_3O^+ \qquad K_{a1} = \frac{[HS^-][H_3O^+]}{[H_2S]} = 10^{-7}$$

$$K_{a1} >> K_{a2}$$

$$HS^- + H_2O \leftrightarrows S^{2-} + H_3O^+ \qquad K_{a2} = \frac{[S^{2-}][H_3O^+]}{[HS^-]} = 1{,}3 \times 10^{-14}$$

$$H_3PO_4 + H_2O \leftrightarrows H_2PO_4^- + H_3O^+ \qquad K_{a1} = \frac{[H_2PO_4^-][H_3O^+]}{[H_3PO_4]}$$

$$H_2PO_4^- + H_2O \leftrightarrows HPO_4^{2-} + H_3O^+ \qquad K_{a2} = \frac{[HPO_4^{2-}][H_3O^+]}{[H_2PO_4^-]}$$

$$HPO_4^{2-} + H_2O \leftrightarrows PO_4^{3-} + H_3O^+ \qquad K_{a3} = \frac{[PO_4^{3-}][H_3O^+]}{[HPO_4^{2-}]}$$

$$K_{a1} > K_{a2} > K_{a3}$$

✸ $HNO_2 + H_2O \leftrightarrows NO_2^- + H_3O^+$ $\quad K_a = \dfrac{[NO_2^-][H_3O^+]}{[HNO_2]}$

acido1 base2 base1 acido2

$NaNO_2 \rightarrow Na^+ + NO_2^-$

✵ $NO_2^- + H_2O \leftrightarrows HNO_2 + OH^-$ $\quad K_b = \dfrac{[HNO_2][OH^-]}{[NO_2^-]}$

base1 acido2 acido1 base2

Lo ione NO_2^- è la base coniugata dell'acido HNO_2

$$K_a \times K_b = \frac{[NO_2^-][H_3O^+]}{[HNO_2]} \times \frac{[HNO_2][OH^-]}{[NO_2^-]} = [H_3O^+][OH^-] = K_W$$

$K_a x K_b = K_W$ $\quad K_b = \dfrac{K_W}{K_a}$ $\quad K_a = \dfrac{K_W}{K_b}$

IDROLISI SALINA

$NaNO_2 \rightarrow$ deriva da → $NaOH$ = base forte

$NaNO_2 \rightarrow$ deriva da → HNO_2 = acido debole

$NaNO_2 \rightarrow Na^+ + NO_2^-$

$NO_2^- + H_2O \leftrightarrows HNO_2 + OH^-$

$K_i = K_b = \frac{[HNO_2][OH^-]}{[NO_2^-]} = \frac{K_W}{K_a}$

pH basico

~~$Na^+ + H_2O \leftrightarrows NaOH + H^+$~~

$NH_4Cl \rightarrow$ deriva da → NH_3 = base debole

$NH_4Cl \rightarrow$ deriva da → HCl = acido forte

$NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$

$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$

$NH_4Cl \rightarrow NH_4^+ + Cl^-$

$NH_4^+ + H_2O \leftrightarrows NH_3 + H_3O^+$

$K_i = K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = \frac{K_W}{K_b}$

pH acido

base	acido	reazione	sale	catione	anione	idrolisi	K_i=	pH
forte	forte							
NaOH	+ HCl	$\rightarrow NaCl + H_2O$	NaCl	$\rightarrow Na^+$	$+ Cl^-$	/	/	neutra
forte	debole				basico			
NaOH	+ HNO_2	$\rightarrow NaNO_2 + H_2O$	$NaNO_2$	$\rightarrow Na^+$	+ NO_2^-	$NO_2^- + H_2O \rightleftarrows HNO_2 + OH^-$	$K_i=K_b=\frac{K_w}{K_a}$	basica
debole	forte			acido				
NH_3	+ HCl	$\rightarrow NH_4Cl$	NH_4Cl	$\rightarrow NH_4^+$	$+ Cl^-$	$NH_4^+ + H_2O \rightleftarrows NH_3 + H_3O^+$	$K_i=K_a=\frac{K_w}{K_b}$	acida
debole	debole			acido	basico			
NH_3	+ HNO_2	$\rightarrow NH_4NO_2$	NH_4NO_2	$\rightarrow NH_4^+$	+ NO_2^-	$NO_2^- + H_2O \rightleftarrows HNO_2 + OH^-$ $NH_4^+ + H_2O \rightleftarrows NH_3 + H_3O^+$	$K_i=K_b=\frac{K_w}{K_a}$ $K_i=K_a=\frac{K_w}{K_b}$	?

SOLUZIONE TAMPONE → Si oppone a variazioni di pH

ACIDO DEBOLE (HA) + un suo SALE con BASE FORTE (NaA) $NaOH+HA \rightarrow NaA+H_2O$

Es. HF + NaF, HNO_2 + $NaNO_2$

$HA + H_2O \leftrightarrows A^- + H_3O^+$ dissociazione acido: parziale

$NaA \rightarrow Na^+ + A^-$ dissociazione sale: totale

c_A = conc. dell'acido

c_S = conc. del sale

c_S

$HA + H_2O \leftrightarrows A^- + H_3O^+$

c_A c_S

$[HA] = c_A$

$[A^-]=c_S$

$$K_a = \frac{[A^-][H_3O^+]}{[HA]} \Rightarrow [H_3O^+] = K_a \times \frac{[HA]}{[A^-]} = K_a \times \frac{c_A}{c_S}$$

$$pH = -\log[H_3O^+] = -\log\left(K_a \frac{c_A}{c_S}\right) = -\log K_a - \log\frac{c_A}{c_S} = pK_a + \log\frac{c_S}{c_A}$$

$$pH = pK_a + \log\frac{c_S}{c_A}$$

$c_S = c_A$ $pH = pK_a$

SOLUZIONE TAMPONE

$$pH = pK_a + \log \frac{c_S}{c_A}$$

Aggiungiamo c_H moli/l di un acido forte HCl ($c_H << c_S, c_A$)

$HCl + H_2O \rightarrow Cl + H_3O^+$

$A^- + H_3O^+ \rightarrow HA + H_2O$

	c_S	c_H	c_A
	$c_S - c_H$		$c_A + c_H$

$$K_a = \frac{[A^-][H_3O^+]}{[HA]} = \frac{(c_S - c_H)[H_3O^+]}{(c_A + c_H)} \simeq pK_a + \log \frac{c_S}{c_A}$$

$$[H_3O^+] = K_a \times \frac{(c_A + c_H)}{(c_S - c_H)}$$

$$pH = pK_a + \log \frac{c_S - c_H}{c_A + c_H} \simeq pK_a + \log \frac{c_S}{c_A}$$

Aggiungiamo c_{OH} moli/l di una base forte NaOH ($c_{OH} << c_S, c_A$)

$NaOH \rightarrow Na^+ + OH^-$

$HA + OH^- \rightarrow A^- + H_2O$

	c_A	c_{OH}	c_S
	$c_A - c_{OH}$		$c_S + c_{OH}$

$$K_a = \frac{[A^-][H_3O^+]}{[HA]} = \frac{(c_S + c_{OH})[H_3O^+]}{(c_A - c_{OH})}$$

$$[H_3O^+] = K_a \frac{(c_A - c_{OH})}{(c_S + c_{OH})}$$

$$pH = pK_a + \log \frac{c_S + c_{OH}}{c_A - c_{OH}}$$

BASE DEBOLE B (c_B) $B+HCl \rightarrow BHCl$

+ suo SALE con ACIDO FORTE BHCl (c_S) Es. $NH_3 + NH_4Cl$

$$BHCl \rightarrow BH^+ + Cl^-$$
$$c_S$$

$$[B] = c_B$$
$$[BH^+] = c_S$$

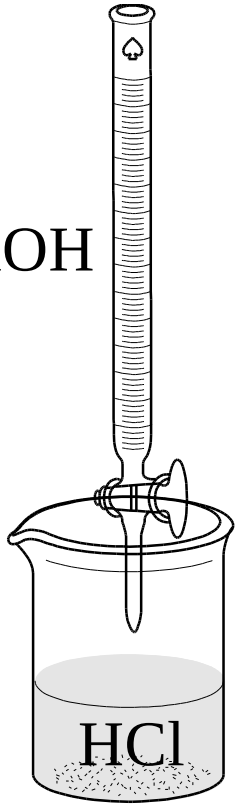
$$B + H_2O \leftrightarrows BH^+ + OH^-$$
$$c_B \qquad\qquad c_S$$

$$K_b = \frac{[BH^+][OH^-]}{[B]} \quad \Rightarrow \quad [OH^-] = K_b \frac{[B]}{[BH^+]} = K_b \frac{c_B}{c_S}$$

$$pOH = - \log [OH^-] = pK_b + \log \frac{c_S}{c_B}$$

TITOLAZIONI ACIDO-BASE

ACIDO FORTE - BASE FORTE

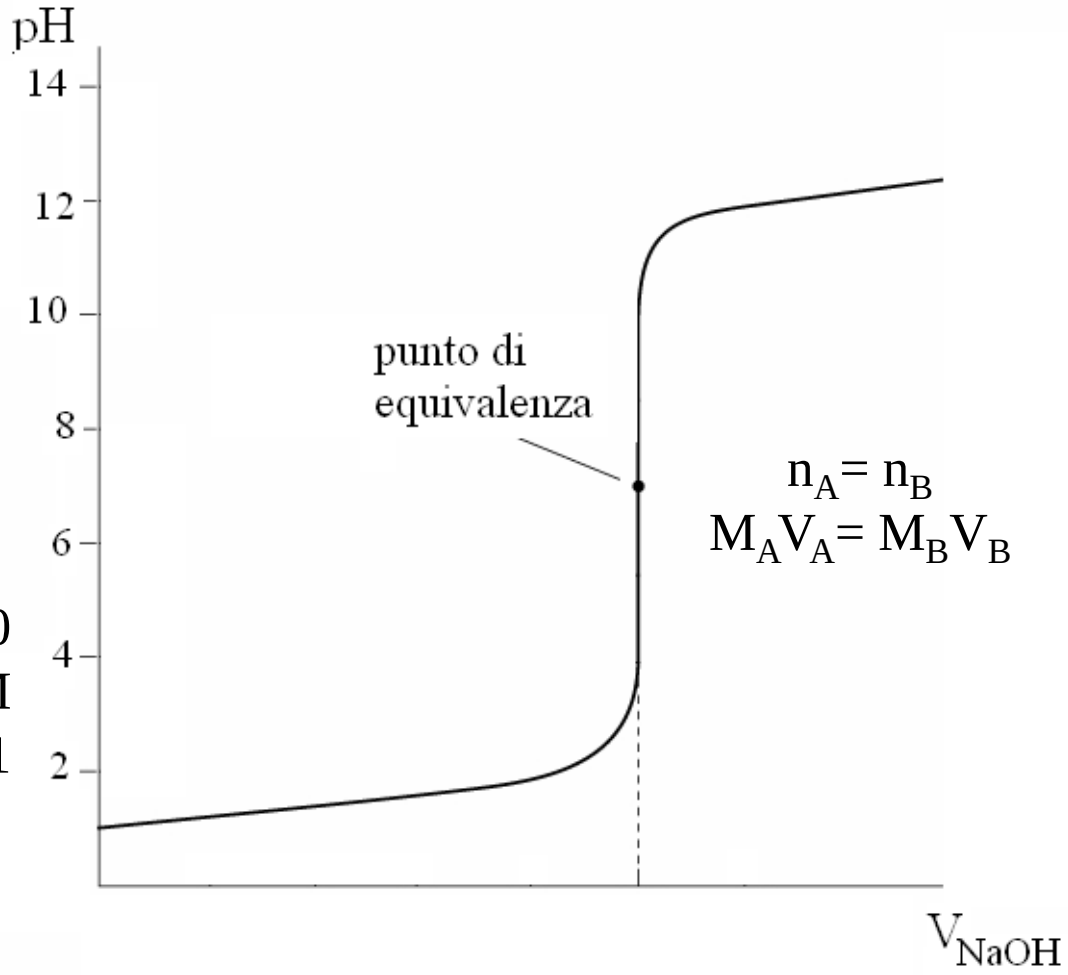


HCl 0,1 M

$V_B = 0$

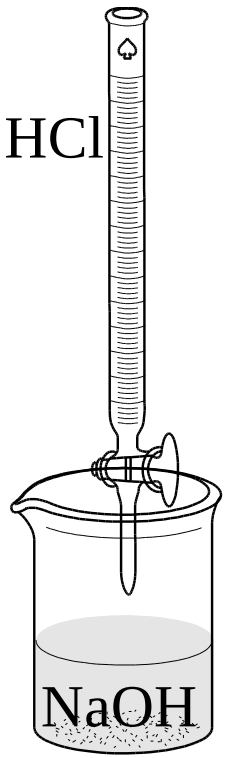
$[H_3O^+] = 0{,}1$ M

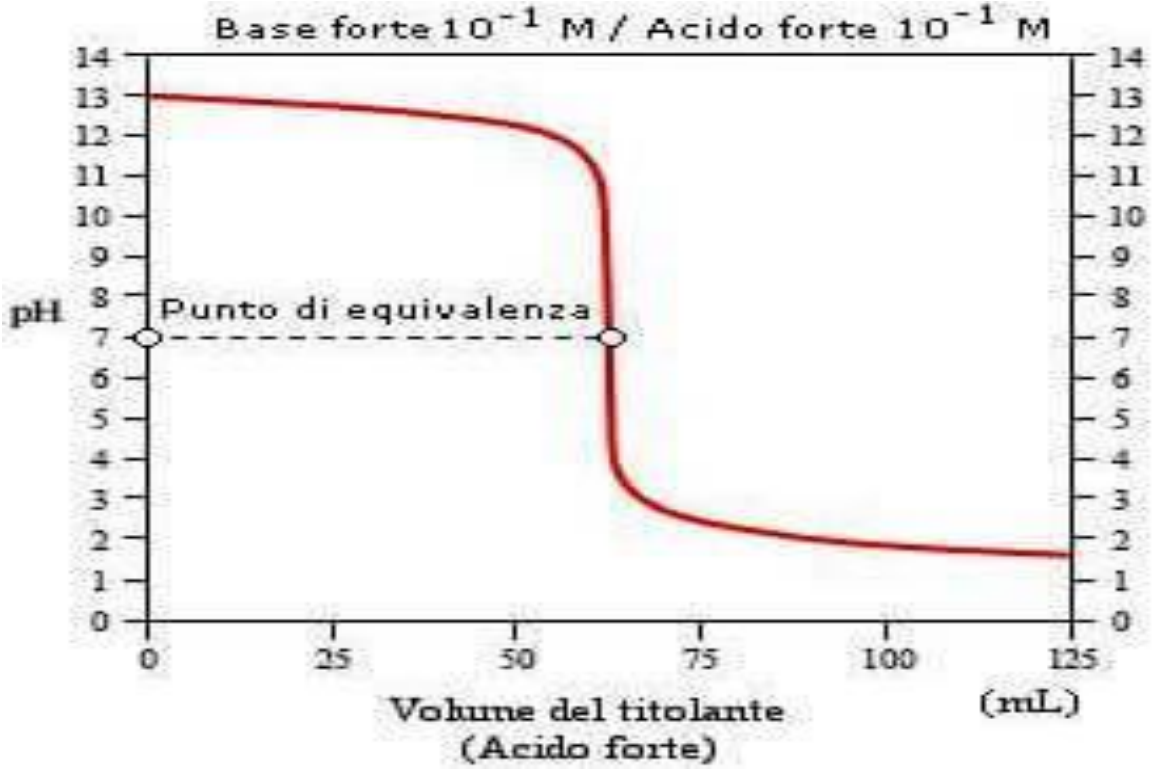
$pH = -\log [H_3O^+] = 1$



$HCl + NaOH \rightarrow NaCl + H_2O$

BASE FORTE - ACIDO FORTE



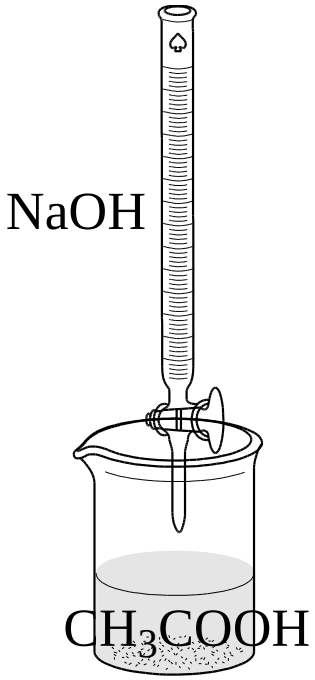


$NaOH \rightarrow Na^+ + OH^-$

$V_A = 0$ $[OH^-]=0{,}1$ M $pOH=-\log [OH^-]=1$ $pH=14-pOH=13$

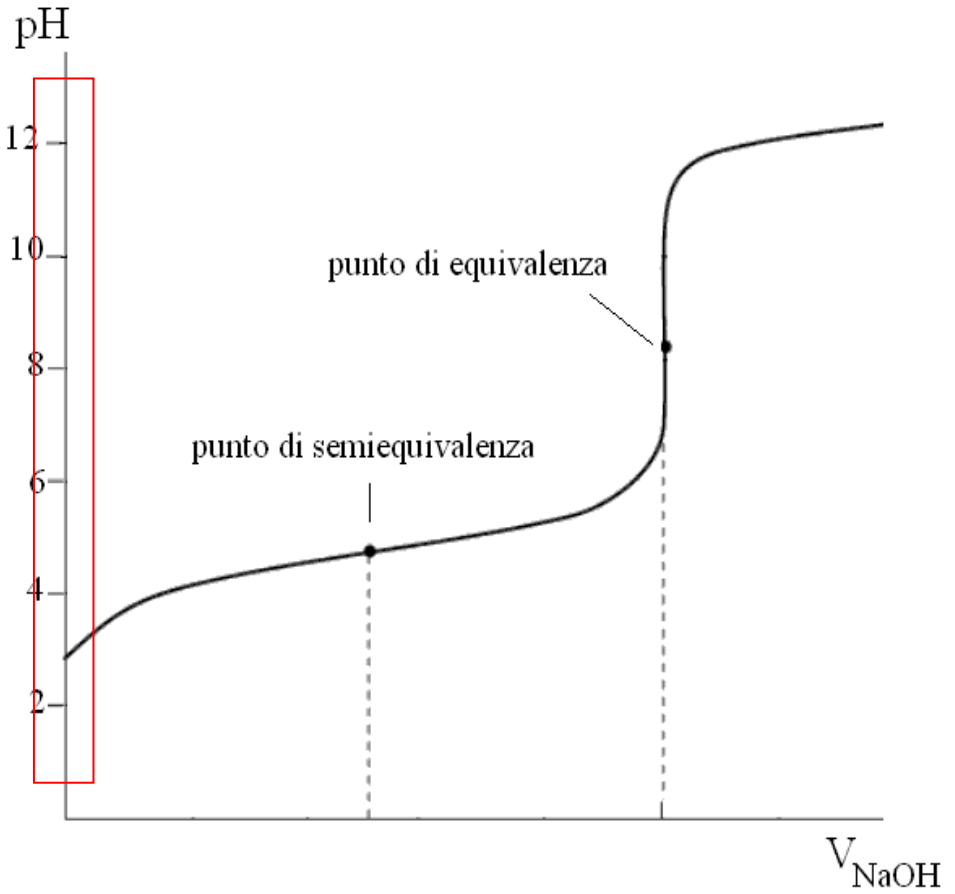
$HCl + NaOH \rightarrow NaCl + H_2O$ $N_A V_A = N_B V_B$

ACIDO DEBOLE - BASE FORTE



$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

CH_3COOH
0,10 M = c
$K_a = 1{,}8 \times 10^{-5}$
NaOH 0,1 M



$CH_3COOH + H_2O \leftrightarrows CH_3COO^- + H_3O^+$

c-x ~ c x x

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = \frac{x^2}{c}$$

$$[H_3O^+] = x = \sqrt{K_a \times c} = \sqrt{1{,}8 \times 10^{-5} \times 0{,}1} = 1{,}34 \times 10^{-3} M$$

$pH = -\log[H_3O^+] = 2{,}9$

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

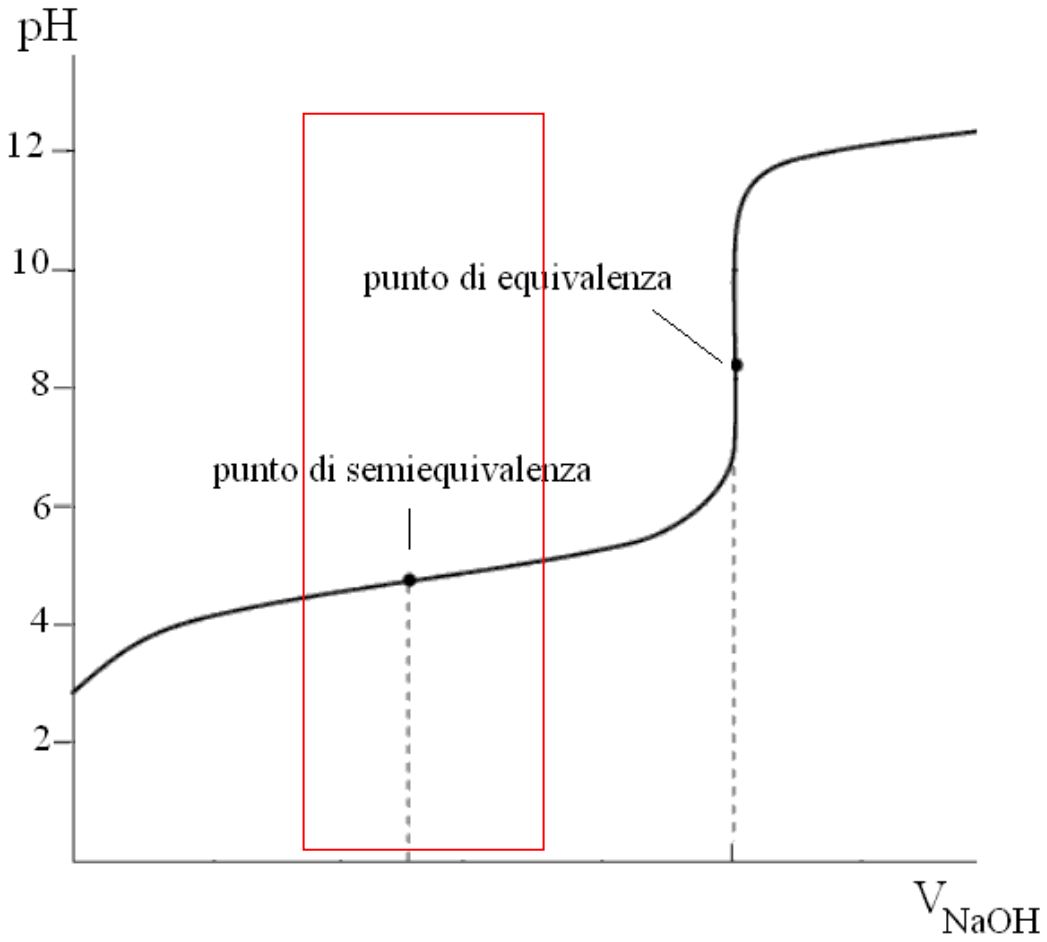
$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$

Si forma una soluzione tampone

$$pH = pKa + \log\frac{c_S}{c_A}$$

50% di titolante aggiunto

$c_A = c_S$ $pH = pK_a$



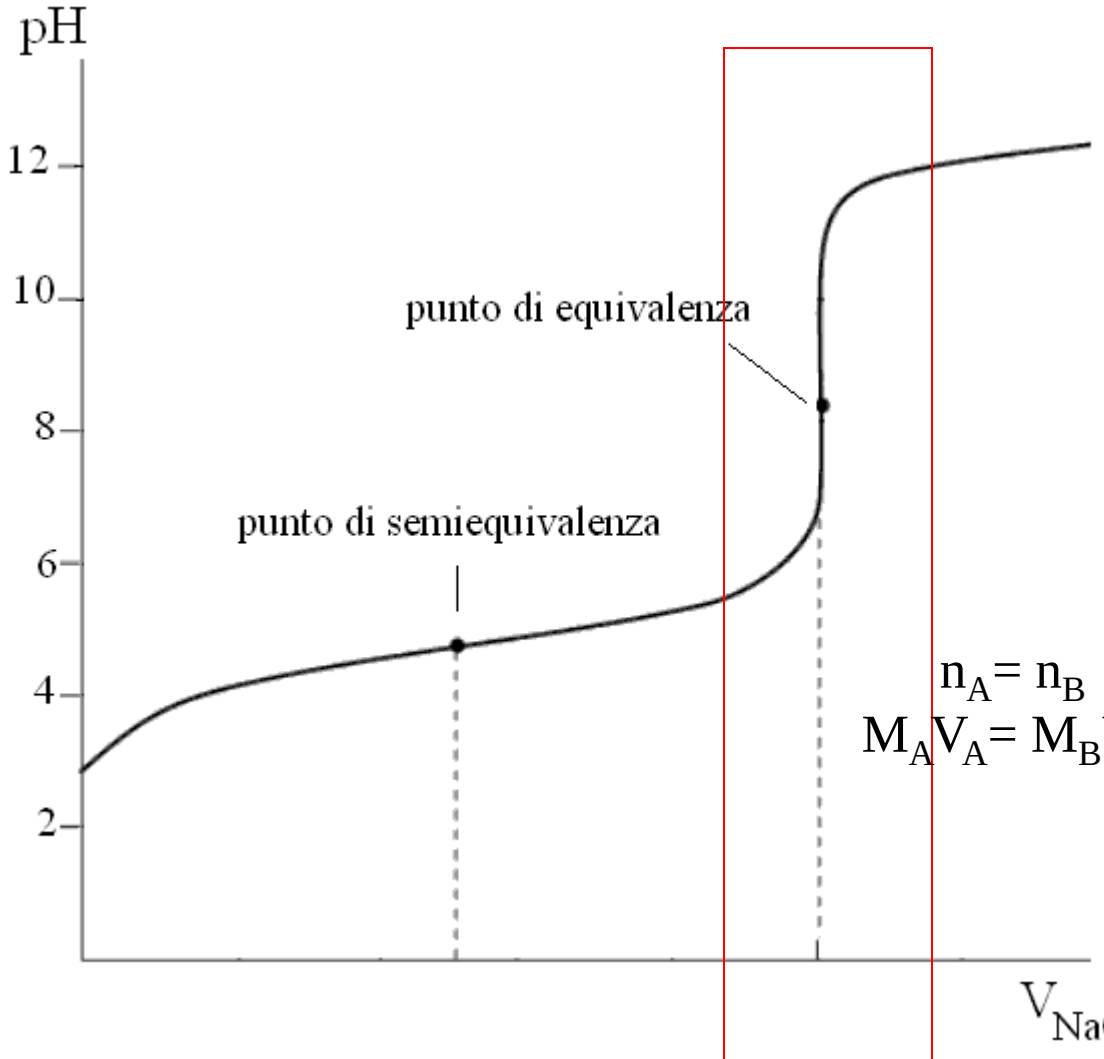
$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$
$$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$$

Punto di equivalenza

$$CH_3COO^- + H_2O \leftrightarrows CH_3COOH + OH^-$$

$$K_i = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]}$$

$$K_i = \frac{K_w}{K_a} = \frac{10^{-14}}{1{,}8 \times 10^{-5}} = 5{,}5 \times 10^{-11}$$



$$n_A = n_B$$
$$M_A V_A = M_B V_B$$

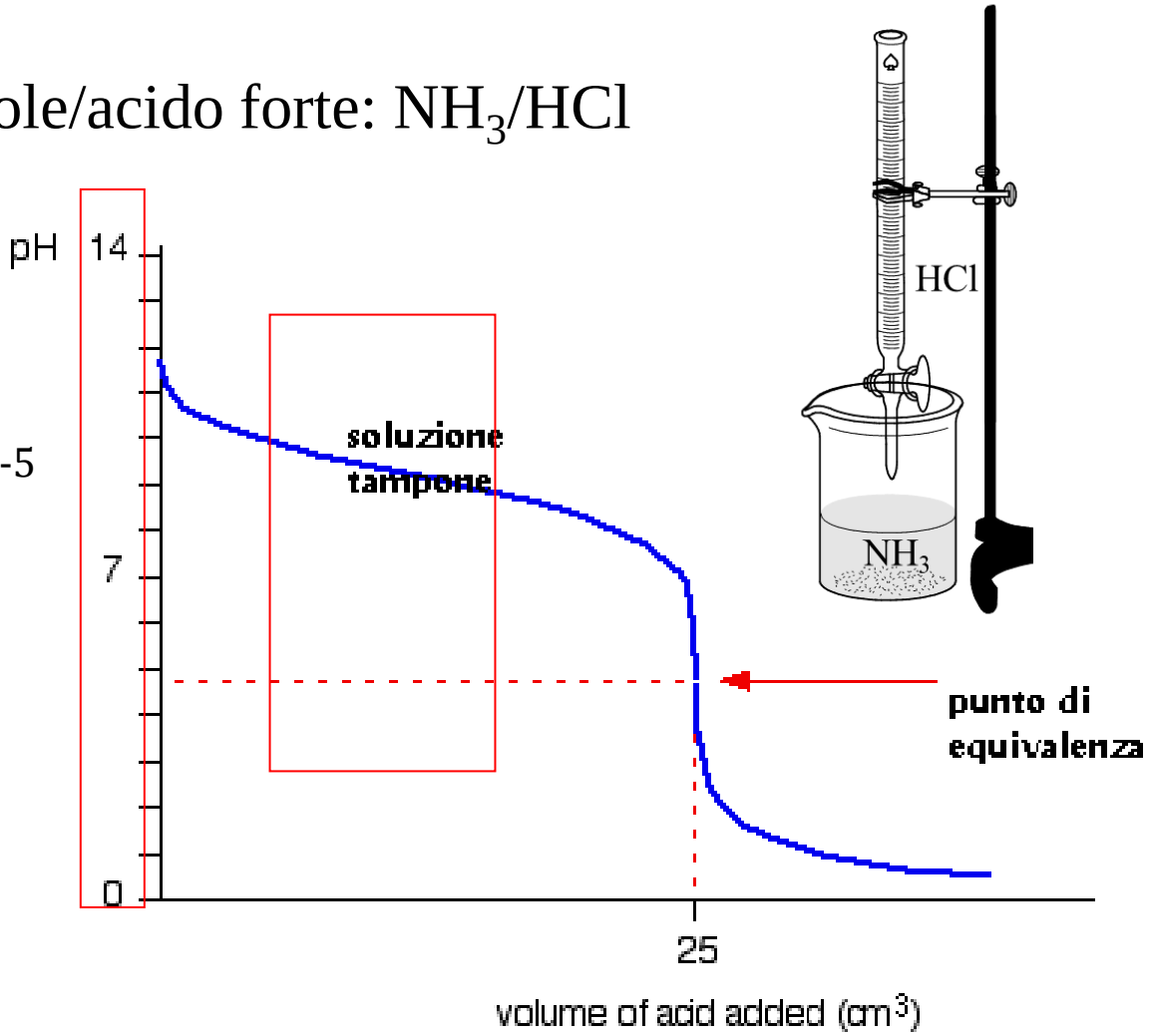
Base debole/acido forte: NH_3/HCl

Situazione iniziale

$$NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = 1{,}8 \times 10^{-5}$$

$$[OH^-] = \sqrt{K_b \times c}$$



Reazione:

$$NH_3 + HCl \rightarrow NH_4Cl$$

$$NH_3 + H_3O^+ \rightarrow NH_4^+$$

Soluzione tampone

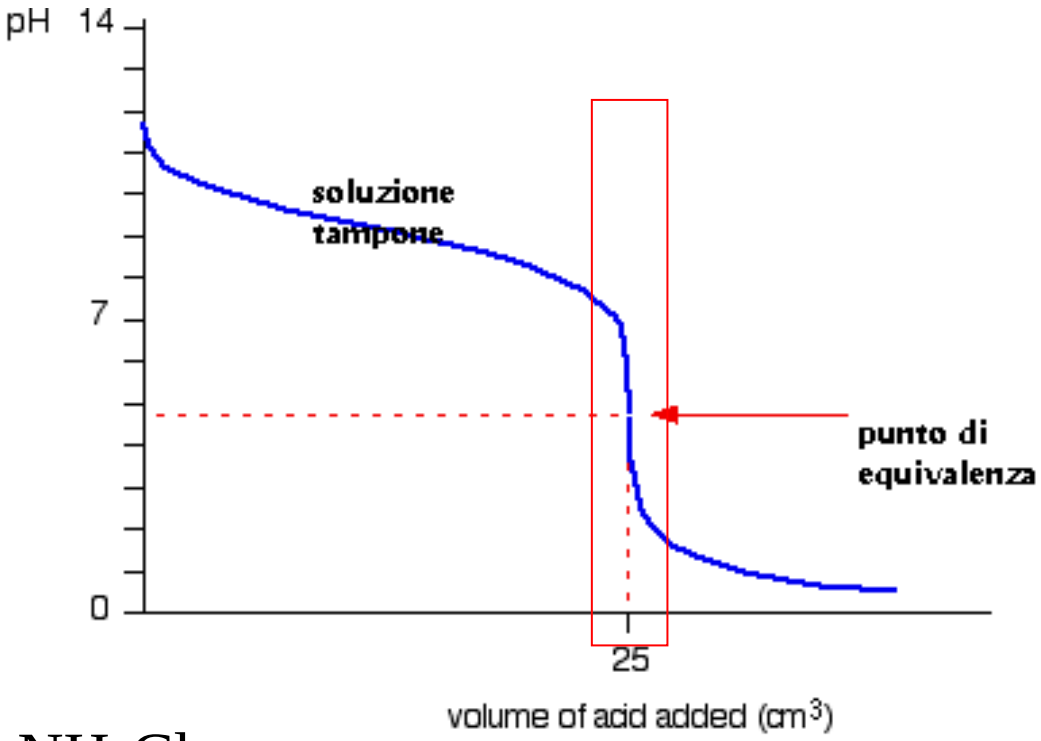
$$pOH = -\log [OH^-] = pK_b + \log \frac{c_S}{c_B}$$

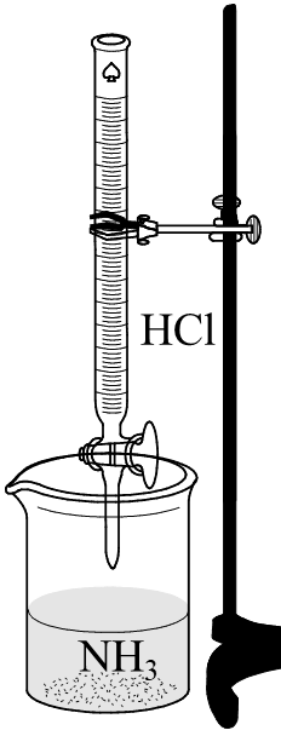
$$pOH = 14 - pH$$

semiequivalenza $c_S = c_B$

$pOH = pK_b = 4{,}75$

$pH = 14 - pOH = 9{,}25$





$NH_3 + HCl \rightarrow NH_4Cl$

All'equivalenza: $NH_4^+ + H_2O \leftrightarrows NH_3 + H_3O^+$

$$K_i = K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = \frac{K_W}{K_b}$$

pH acido

TITOLAZIONI ACIDI POLIPROTICI

$H_3PO_4 + H_2O \leftrightarrows H_2PO_4^- + H_3O^+$ $\quad K_{a1} = \frac{[H_2PO_4^-][H_3O^+]}{[H_3PO_4]} = 6{,}3\times10^{-3}$ $\quad pK_{a1}=2{,}2$

$H_2PO_4^- + H_2O \leftrightarrows HPO_4^{2-} + H_3O^+$ $\quad K_{a2} = \frac{[HPO_4^{2-}][H_3O^+]}{[H_2PO_4^-]} = 6{,}3\times10^{-8}$ $\quad pK_{a2}=7{,}2$

$HPO_4^{2-} + H_2O \leftrightarrows PO_4^{3-} + H_3O^+$ $\quad K_{a3} = \frac{[PO_4^{3-}][H_3O^+]}{[HPO_4^{2-}]} = 2{,}0\times10^{-13}$ $\quad pK_{a3}=12{,}7$

$H_3PO_4 + 3\ NaOH \rightarrow Na_3PO_4 + 3\ H_2O$ in forma molecolare

$H_3PO_4 + 3\ OH^- \rightarrow PO_4^{3-} + 3\ H_2O$ in forma ionica

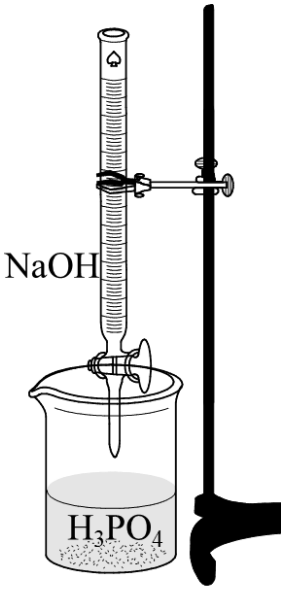
$H_3PO_4 + OH^- \rightarrow H_2PO_4^- + H_2O$

$H_2PO_4^- + OH^- \rightarrow HPO_4^{2-} + H_2O$

$HPO_4^{2-} + OH^- \rightarrow PO_4^{3-} + H_2O$

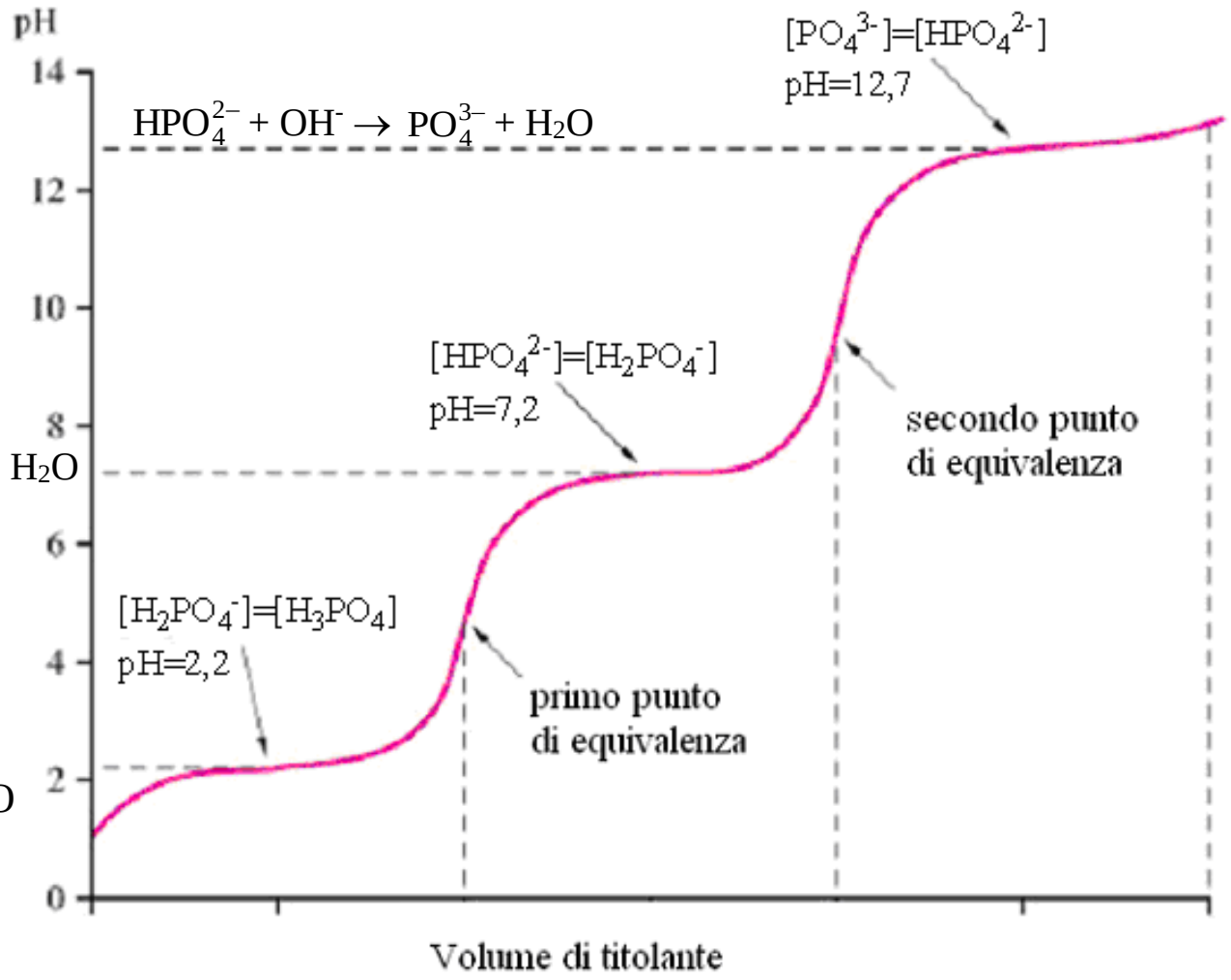
$Ka_1/Ka_2 \geq 10^4 \quad Ka_2/Ka_3 \geq 10^4 \qquad \Delta pK_a \geq 4$

Titolazione H_3PO_4/NaOH



$H_2PO_4^- + OH^- \rightarrow HPO_4^{2-} + H_2O$

$H_3PO_4 + OH^- \rightarrow H_2PO_4^- + H_2O$



$H_2C_2O_4 + H_2O \leftrightarrows HC_2O_4^- + H_3O^+$

$$K_{a1} = \frac{[HC_2O_4^-][H_3O^+]}{[H_2C_2O_4]} = 5{,}9\times10^{-2}$$

$HC_2O_4^- + H_2O \leftrightarrows C_2O_4^{2-} + H_3O^+$

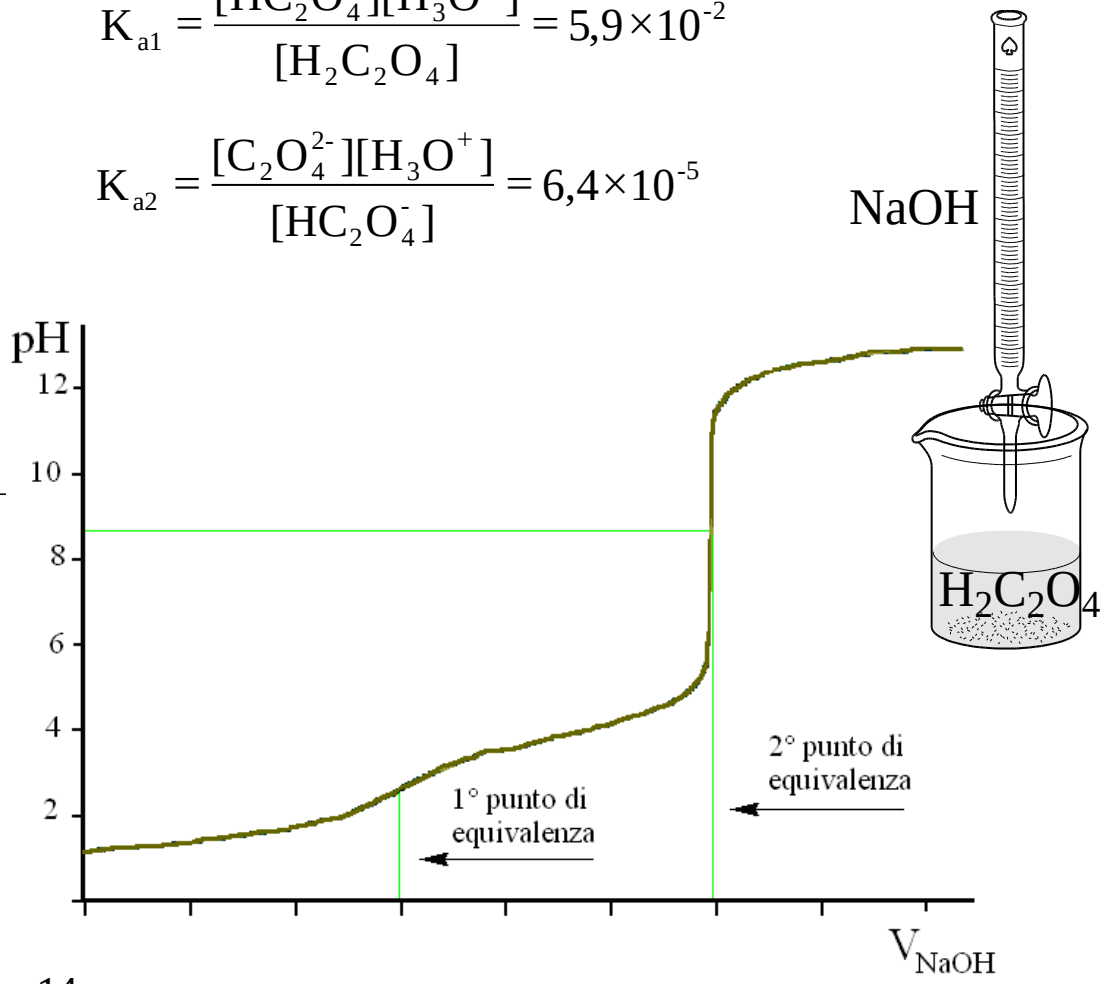
$$K_{a2} = \frac{[C_2O_4^{2-}][H_3O^+]}{[HC_2O_4^-]} = 6{,}4\times10^{-5}$$

1) $H_2C_2O_4 + OH^- \rightarrow HC_2O_4^- + H_2O$

2) $HC_2O_4^- + OH^- \rightarrow C_2O_4^{2-} + H_2O$

$H_2C_2O_4 + 2\ OH^- \rightarrow C_2O_4^{2-} + 2\ H_2O$

$H_2C_2O_4 + 2\ NaOH \rightarrow Na_2C_2O_4 + 2\ H_2O$



$C_2O_4^{2-} + H_2O \leftrightarrows HC_2O_4^- + OH^-$

$$K_i = \frac{[HC_2O_4^-][OH^-]}{[C_2O_4^{2-}]} = \frac{K_W}{K_{a\,2}} = \frac{10^{-14}}{5{,}2\times10^{-5}} = 1{,}9\times10^{-10}$$

Punto finale di una titolazione:

a) Metodi strumentali
b) Indicatori

Indicatori acido-base

$$HInd + H_2O \leftrightarrows Ind^- + H_3O^+$$

coloreA colore B

$$K_{Ind} = \frac{[Ind^-][H_3O^+]}{[HInd]}$$

$$[H_3O^+] = K_{Ind} \frac{[HInd]}{[Ind^-]} \Longrightarrow pH = pK_{Ind} + \log \frac{[Ind^-]}{[HInd]}$$

$[H_3O^+] > K_{ind}$ ⇨ $pH < pK_{Ind}$ ⇨ $[HInd] > [Ind^-]$ ⇨ Colore A

$[H_3O^+] < K_{ind}$ ⇨ $pH > pK_{Ind}$ ⇨ $[Ind^-] > [HInd]$ ⇨ Colore B

$[H_3O^+] = K_{ind}$ ⇨ $pH = pK_{Ind}$ ⇨ $[HInd] = [Ind^-]$ ⇨ Viraggio

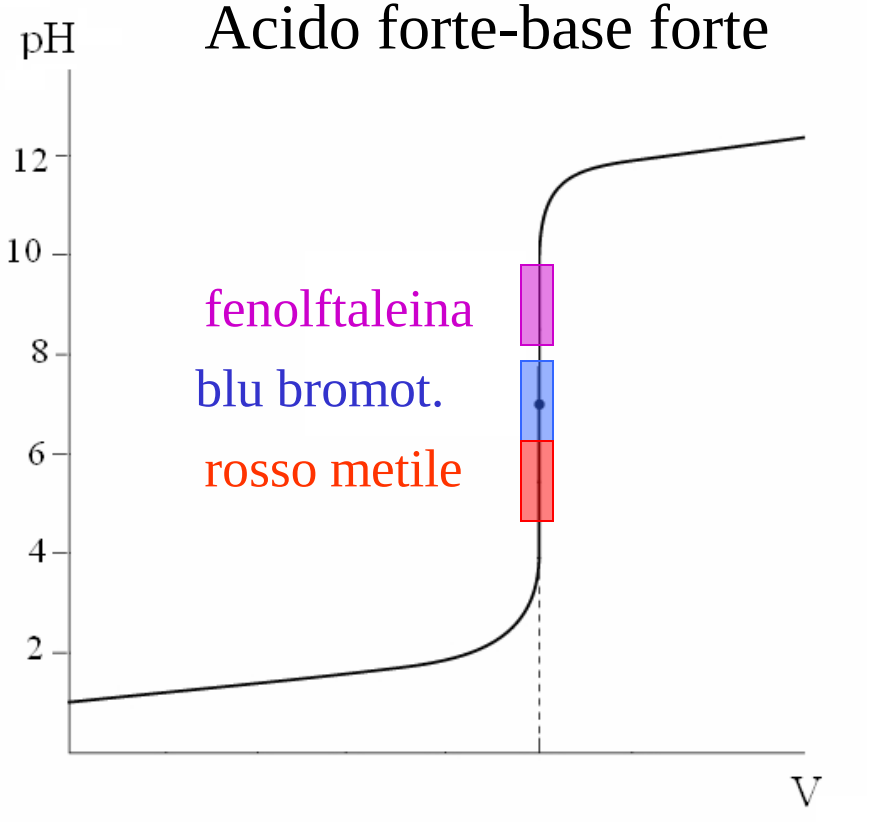
$[HInd] = 10[Ind^-]$ $pH = pK_{Ind} - 1$ colore A

$[Ind^-] = 10[HInd]$ $pH = pK_{Ind} + 1$ colore B

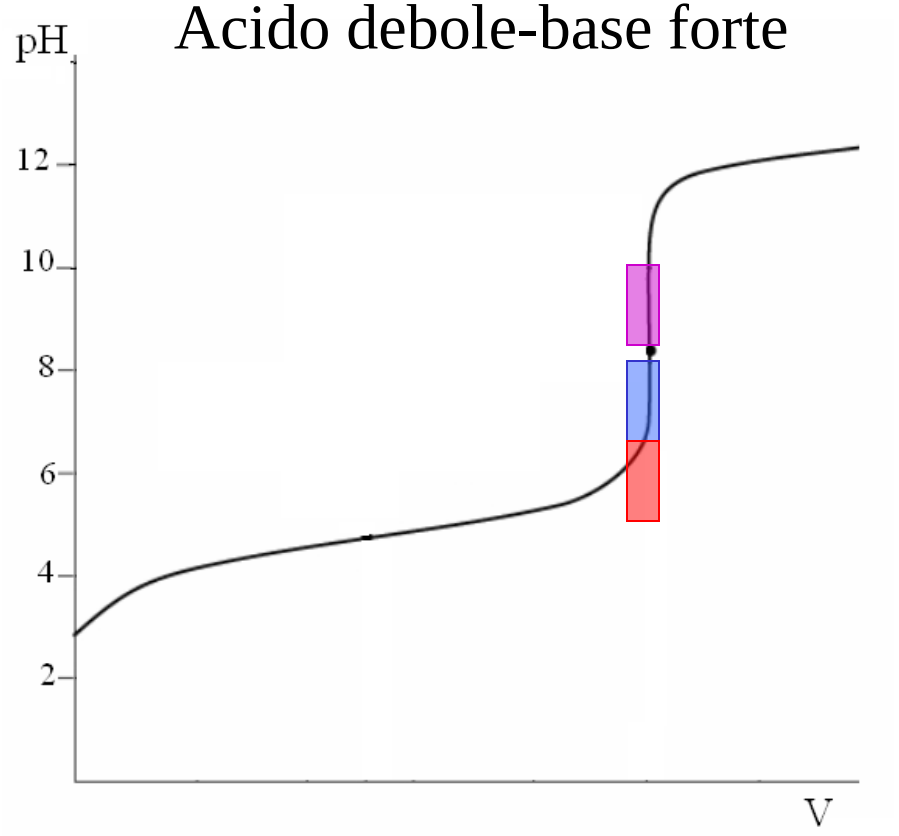
$pH = pK_{Ind} \pm 1$ intervallo di viraggio

Indicatore	pK_{Ind}	Intervallo	col. A	col. B
metilarancio	3,7	3,1 – 4,4	rosso	giallo
rosso metile	5,1	4,4 – 6,2	rosso	giallo
blu bromotimolo	7,0	6,2 – 7,6	giallo	blu
rosso fenolo	7,9	6,4 – 8,0	giallo	rosso
fenolftaleina	9,4	8,0 – 10,0	incolore	viola

Acido forte-base forte



Acido debole-base forte

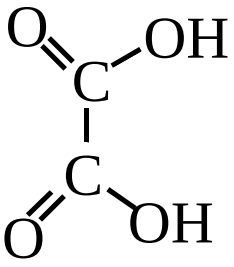


Esperienza 1 – Titolazione $H_2C_2O_4$/NaOH

$H_2C_2O_4 \cdot 2H_2O$ sostanza madre

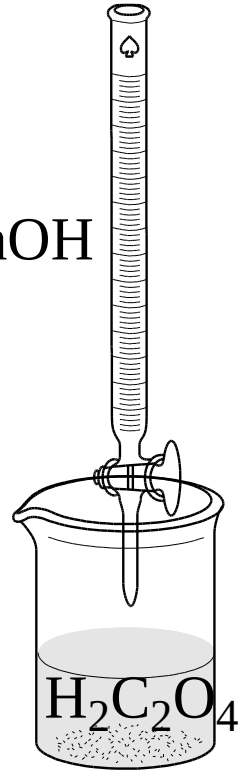
NaOH assorbe H_2O, CO_2

$NaOH + CO_2 \rightarrow NaHCO_3$



$Ka_1 = 5{,}9 \cdot 10^{-2}$

$Ka_2 = 6{,}4 \cdot 10^{-5}$



$H_2C_2O_4 + H_2O \leftrightarrows HC_2O_4^- + H_3O^+$

$$Ka_1 = \frac{[HC_2O_4^-][H_3O^+]}{[H_2C_2O_4]}$$

$HC_2O_4^- + H_2O \leftrightarrows C_2O_4^{2-} + H_3O^+$

$$Ka_2 = \frac{[C_2O_4^{2-}][H_3O^+]}{[HC_2O_4^-]}$$

$NaOH \rightarrow$ $Peq = PM$ $g_{NaOH} = N_B V_B Peq_{NaOH}$

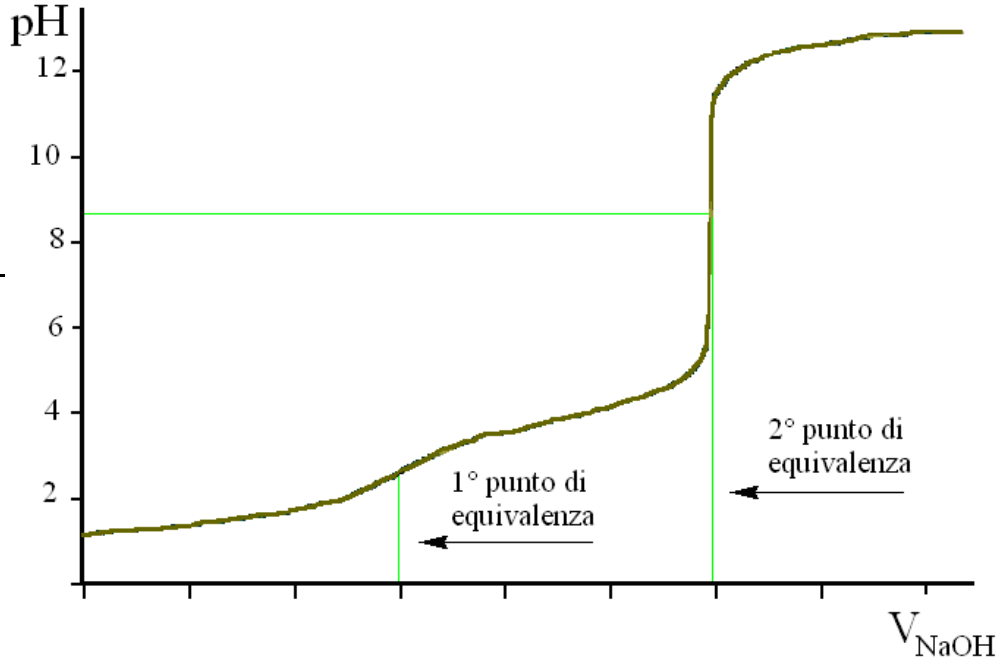
$H_2C_2O_4 \rightarrow$ $Peq = PM/2$ $g_{H_2C_2O_4} = N_a V_B Peq_{H_2C_2O_4}$

1) $H_2C_2O_4 + OH^- \rightarrow HC_2O_4^- + H_2O$

2) $HC_2O_4^- + OH^- \rightarrow C_2O_4^{2-} + H_2O$

$H_2C_2O_4 + 2OH^- \rightarrow C_2O_4^{2-} + 2H_2O$

$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$



$C_2O_4^{2-} + H_2O \leftrightarrows HC_2O_4^- + OH^-$

$$K_i = \frac{K_w}{K_{a2}} = \frac{10^{-14}}{5{,}2\times10^{-5}} = 1{,}9\times10^{-11}$$

$$K_i = \frac{[HC_2O_4^-][OH^-]}{[C_2O_4^{2-}]} = \frac{x^2}{c_S}$$

$$[OH^-] = \sqrt{K_i \cdot c_S}$$

all'equivalenza pH≅9

⇨indicatore fenolftaleina

pKa= 9,4 Viraggio 8,2-10