Clase 3 9 Octubre 2020

Título de la nota 09/10/2020

Titulaciones
- Directas ✓
- retroceso
- indirectas

$$aA + bB \rightleftharpoons cC + dD$$

b moles A = a moles B

c moles A = a moles C

d moles A = a moles de D

$[A] = C_0$ $\qquad X = \dfrac{\text{moles de B agregados}}{\text{moles de A iniciales}}$

Agregando B

$$[A] = C_0 - \frac{aX}{b} C_0 = C_0\left(1 - \frac{a}{b}X\right)$$

$$[C] = \frac{c}{b} \times C_0$$

APE

$$[D] = \frac{d}{b} \times C_0$$

Reacciones pueden { Cuantitativas (% Q) ≥ 99%
NO cuantitativas % Q < 99%

$$aA + bB \rightleftharpoons cC + dD$$

		aA	bB	cC	dD
Inicio		C_0			
Agregando			xC_0		
APE	$0 < x < \frac{b}{a}$	$C_0\left(1-\frac{a}{b}x\right)$	~ 0	$\frac{c}{b}xC_0$	$\frac{d}{b}xC_0$
PE	$x = \frac{b}{a}$	εC_0	$\frac{b}{a}\varepsilon C_0$	$\frac{c}{a}(1-\varepsilon)C_0$	$\frac{d}{a}(1-\varepsilon)C_0$
DPE	$x > \frac{b}{a}$	~ 0	$C_0\left(x-\frac{b}{a}\right)$	$\frac{c}{a}C_0$	$\frac{d}{a}C_0$

Cuadro de concentraciones

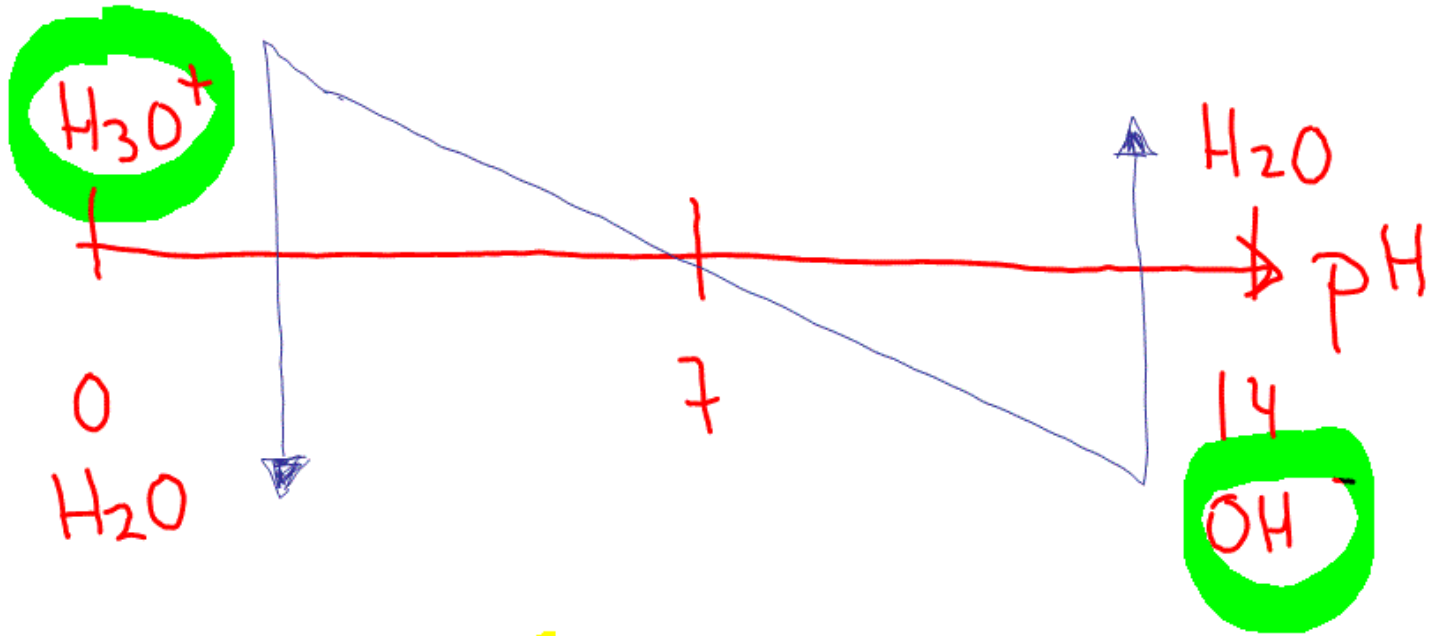
$$\% A = (1-\varepsilon)100 = \% \text{ cuantitatividad}$$

$$aA + bB \rightleftharpoons cC + dD$$

PE	ξC_0	$\frac{b}{a}\xi C_0$	$\frac{c}{a}C_0$	$\frac{d}{a}C_0$

Asumir que el volumen no afecta a la [ ], es decir el efecto de dilución es pequeño

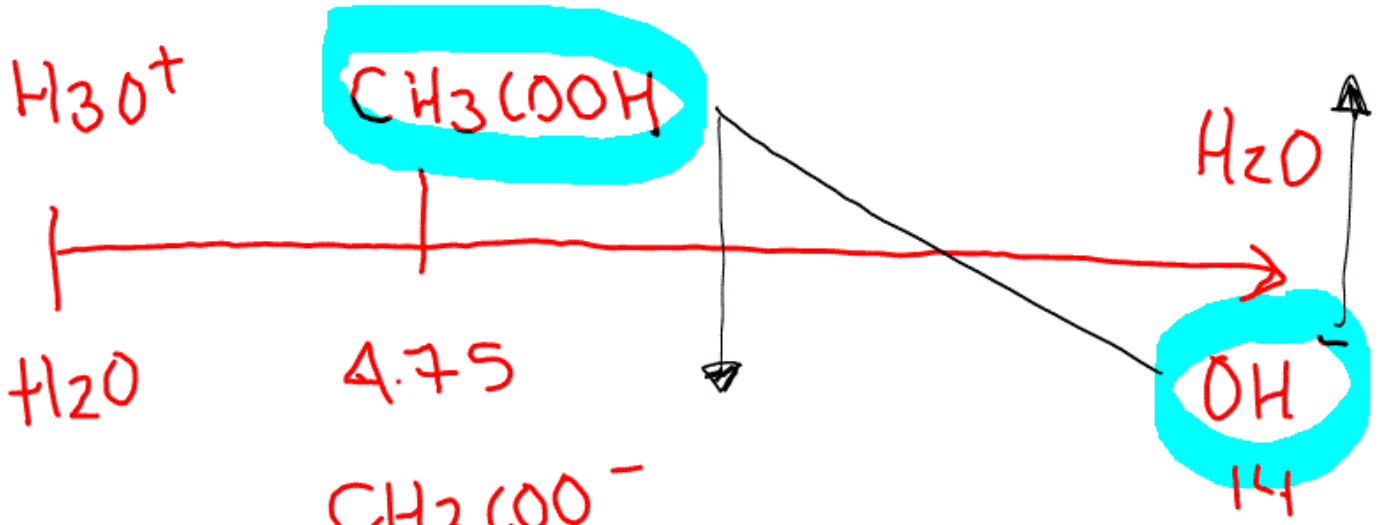
Ácido-Base (acuoso)



$$H_3O^+ + OH^- \rightleftharpoons 2H_2O \qquad = \frac{1}{K_w}$$

$$K_r = \frac{1}{K_w} = \frac{1}{10^{-14}} = 10^{14}$$

a 25°C



CH_3COO^-

$10^{14-4.75} = 10^{9.25}$

CH_3COOH

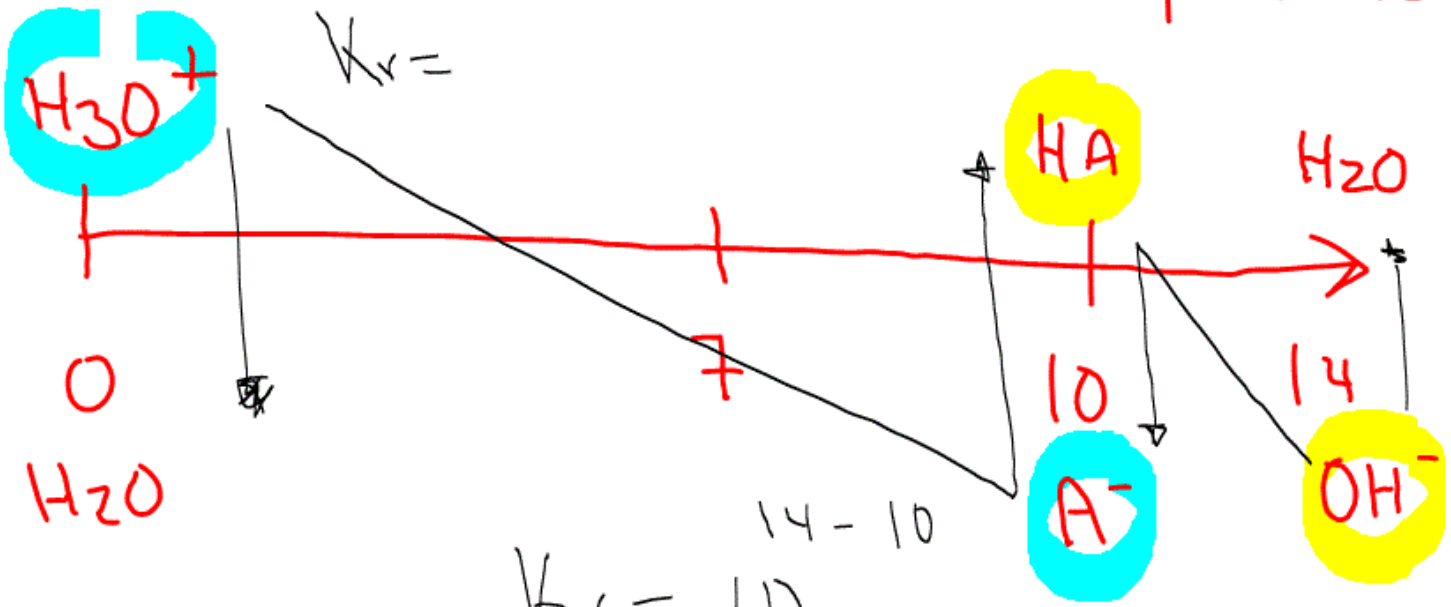
$pKa = 4.75$

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

$$Kr = \frac{[CH_3COO^-]}{[CH_3COOH][OH^-]}\frac{[H_3O^+]}{[H_3O^+]} = \frac{Ka}{Kw}$$

$$K_r = \frac{10^{-4.75}}{10^{-14}} = 10^{9.25}$$

$HA = pKa = 10$



$K_r = 10$

$K_r = 10^4$

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

$$K_r = \frac{[HA]}{[A^-][H_3O^+]} = \frac{1}{K_a}$$

$$= \frac{1}{10^{-10}} = 10^{10}$$

Ácido Fuerte - Base Fuerte

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

		H_3O^+	OH^-
Inicio		C_0	
Agregando			xC_0
APE	$0<x<1$	$C_0(1-x)$	~ 0
PE	$x=1$	εC_0	εC_0
DPE	$x>1$	~ 0	$C_0(x-1)$

1) $\frac{K_a}{C_o} \geq 10^{1}$ ácido fuerte

2) $K_r = \frac{1}{[H_3O^+][OH^-]} = \frac{1}{K_w} = 10^{14}$

3) Calcular $1 \cdot Q$

$$K_r = 10^{14} = \frac{1}{\varepsilon C_o \varepsilon C_o}$$

$$\varepsilon^2 = \frac{1}{K_r C_o^2}$$

$$\varepsilon = \sqrt{\frac{1}{K_v C_0^2}} \qquad C_0 = 10^{-2}\ M$$

$$\varepsilon = \sqrt{\frac{1}{10^{14}(10^{-2})^2}} = \sqrt{\frac{1}{10^{14}\ 10^{-4}}}$$

$$\varepsilon = \sqrt{\frac{1}{10^{10}}} = \sqrt{10^{-10}} = 10^{-10/2}$$

$$= 10^{-5}$$

$$\therefore Q = (1-\varepsilon)100 = (1-10^{-5}) = 99.999\%.$$

Si $C_0 = 10^{-3}\ M$

$$\varepsilon = \sqrt{\frac{1}{K_v C_0^2}} = \sqrt{\frac{1}{10^{14}\left(10^{-3}\right)^2}}$$

$$= \sqrt{\frac{1}{10^{14}\,10^{-6}}} = \sqrt{\frac{1}{10^{8}}} = 10^{-8/2}$$

$$= 10^{-4}$$

$\therefore\ Q = (1-\varepsilon)100 = 99.99\ \%$

Si $C_0 = 10^{-5}\ M$

$$\varepsilon = \sqrt{\frac{1}{K_r C_0^2}} = \sqrt{\frac{1}{10^{14}\left(10^{-5}\right)^2}}$$

$$= \sqrt{\frac{1}{10^{14}\,10^{-10}}} = \sqrt{\frac{1}{10^4}} = 10^{4/2}$$

$$= 10^{-2}$$

$\therefore \%Q = (1-\varepsilon)100 = 99.\%$

$K_r C_o^2$ ácido fte $\geq 10^4$

4) obtener la curva de titulación

X	pH	comportamiento
0	2	ácido fuerte
0.5	2.3	ácido fuerte
1	7	neutralización
1.5	11.7	base fuerte
2	12	base fuerte

$X = \frac{b}{a}$

pH $x = 0$ ácido fuerte $C_0 = 10^{-2}$ M

$pH = -\log C_0$

$= -\log 10^{-2} = 2$

pH $x = 0.5$ ácido fte

$pH = -\log C_0(1-x)$

$= -\log 10^{-2}(1-0.5)$

$= -\log 10^{-2}(0.5) = -\log 5 \times 10^{-3}$

$= 3 - 0.7 = 2.3$

pH x = 1 neutralización

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

si p ε $[H_3O^+] = [OH^-]$

$$\left[K_w = 10^{-14} = [H_3O^+]^2\right] - \log$$

$$2pH = pK_w$$

$$pH = \frac{14}{2} = 7$$

pH $x = 1.5$ base fuerte

$pH = 14 + \log C_b \qquad C_b = C_o$

$= 14 + \log C_o(x-1)$

$= 14 + \log 10^{-2}(1.5-1)$

$= 14 + \log 10^{-2}(0.5) = 14 + \log 5 \times 10^{-3}$

$= 14 + (-3 + 0.7)$

$= 14 - 2.3 = 11.7$

pH x = 2 base fuerte

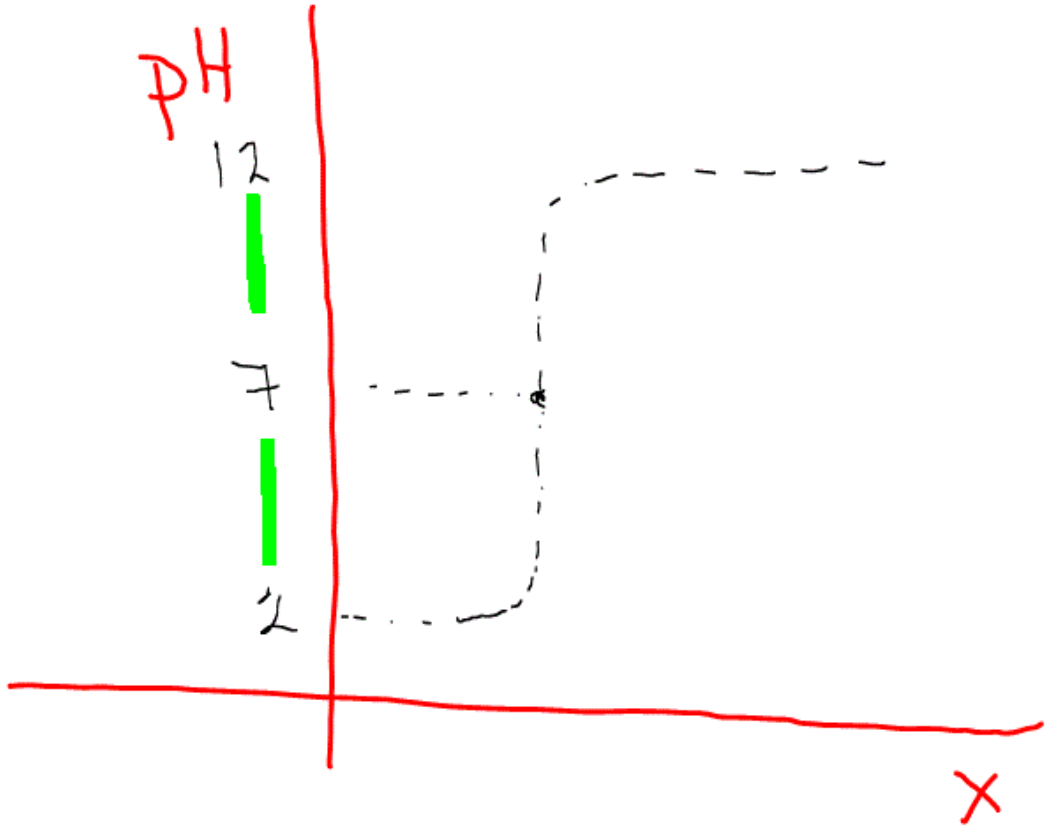
$$pH = 14 + \log C_b$$

$$pH = 14 + \log C_o(x-1)$$

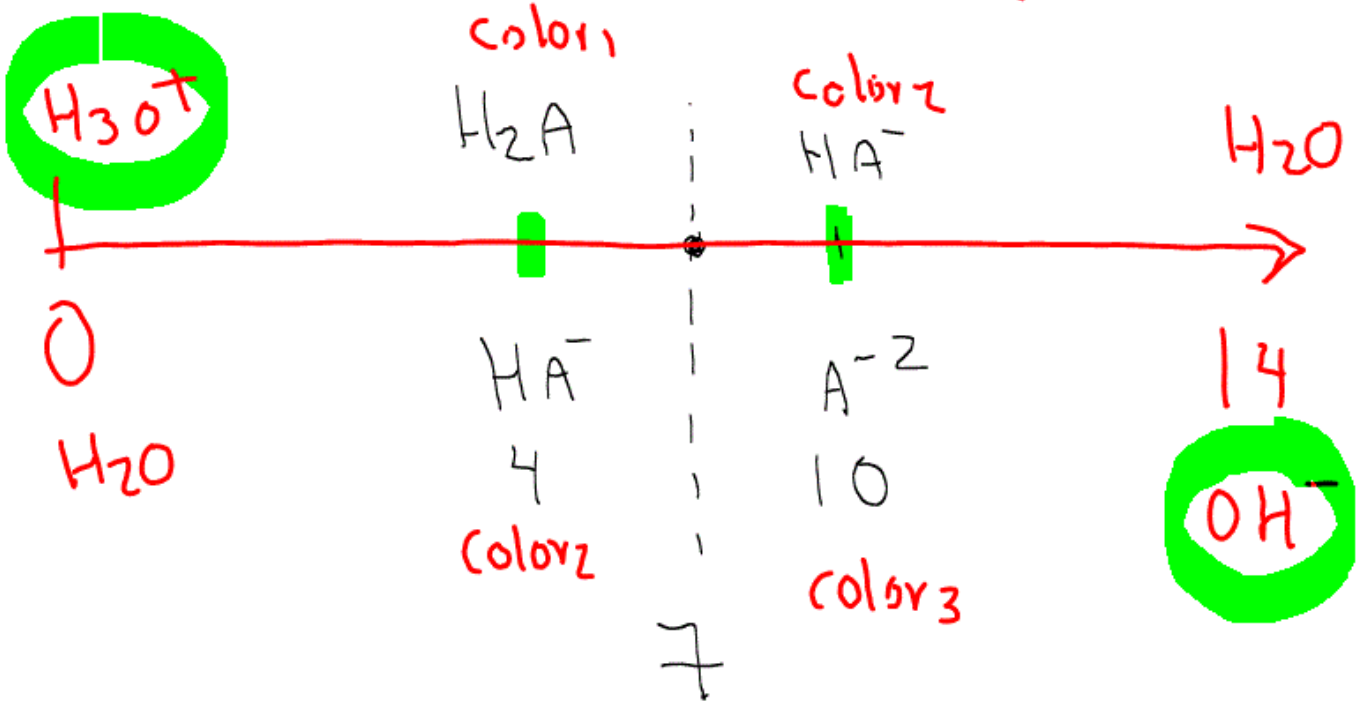
$$= 14 + \log 10^{-2}(2-1)$$

$$= 14 + \log 10^{-2} = 14 - 2 = 12$$

5) Curva



6) elección de indicador (H_2A) débil



Error de elección de indicador

$1\% = \frac{1}{100} = 10^{-2}$

pH APE

$pH = -\log C_o$

$= -\log 10^{-2}\, 10^{-2}$

$= -\log 10^{-4}$

$= 4$

pH DPE

$pH = 14 + \log C_b$

$pH = 14 + \log 10^{-2}\, 10^{-2}$

$pH = 14 + \log 10^{-4}$

$pH = 14 - 4 = 10$

$\frac{4+10}{2} = 7$ pH

el del punto de equivalencia

Error de elección de indicador

$0.1\% = \frac{1}{1000} = 10^{-3}$

pH APE

$pH = -\log C_o$

$= -\log 10^{-2}\,10^{-3}$

$= -\log 10^{-5}$

$= 5$

pH DPE

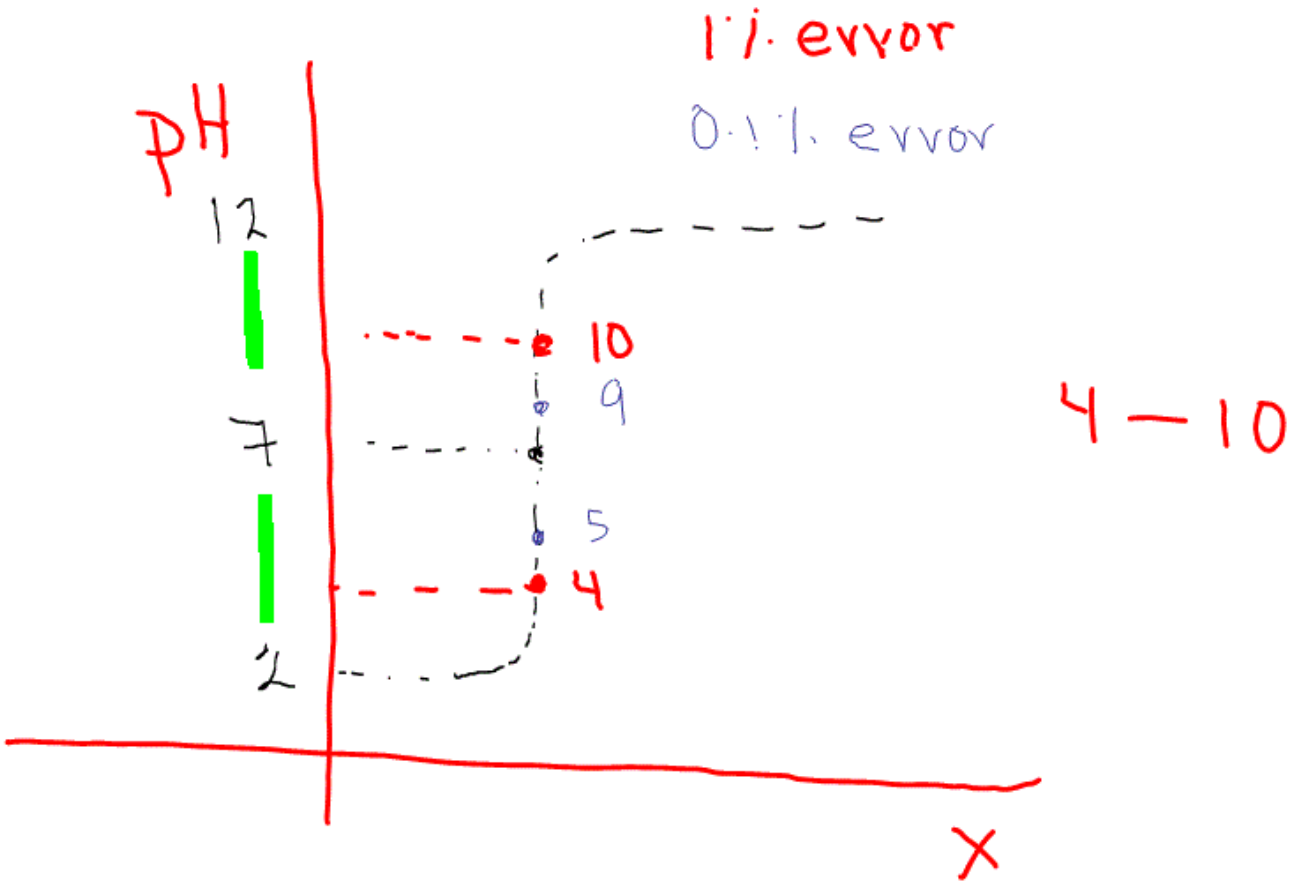
$pH = 14 + \log C_b$

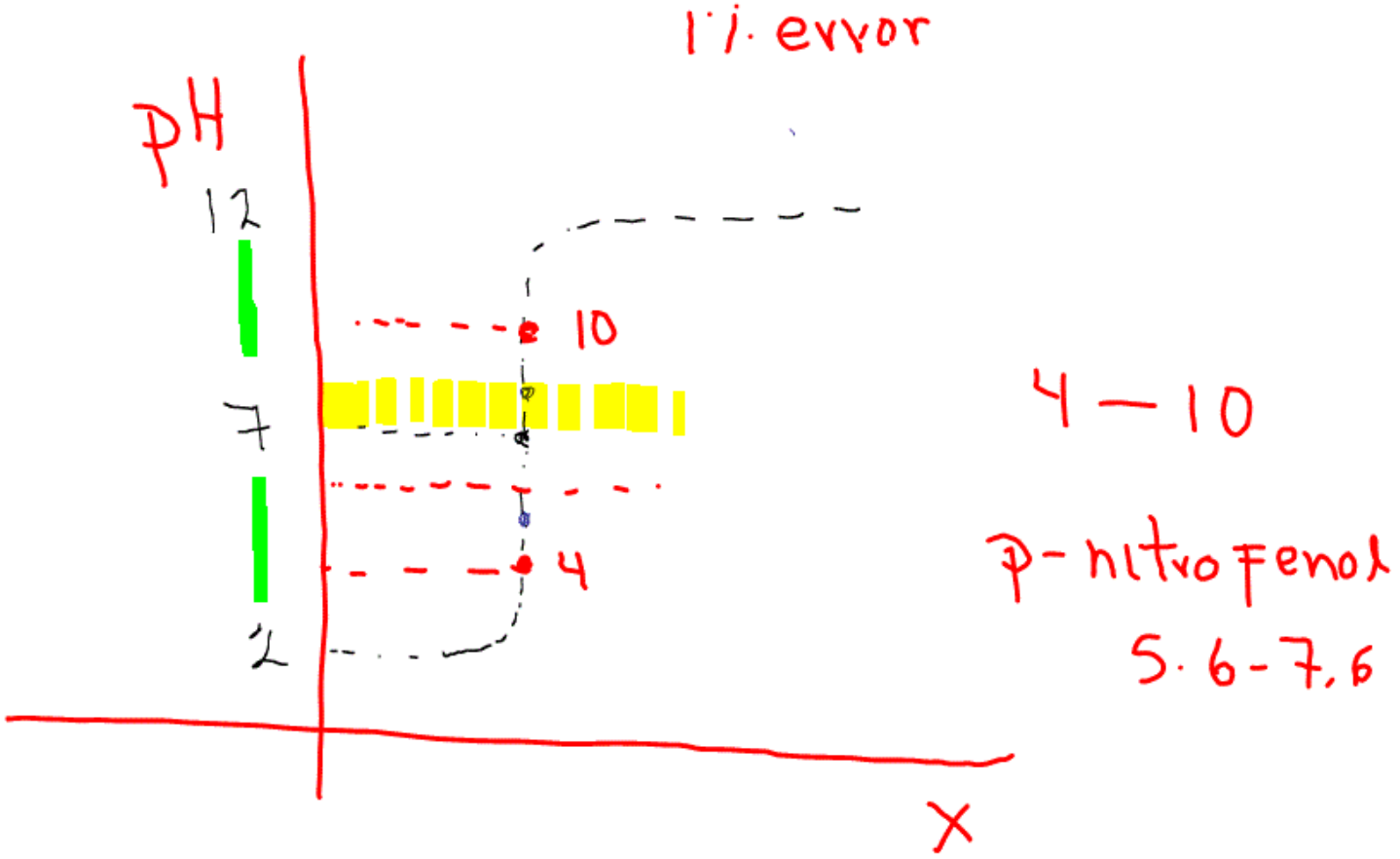
$pH = 14 + \log 10^{-2}\,10^{-3}$

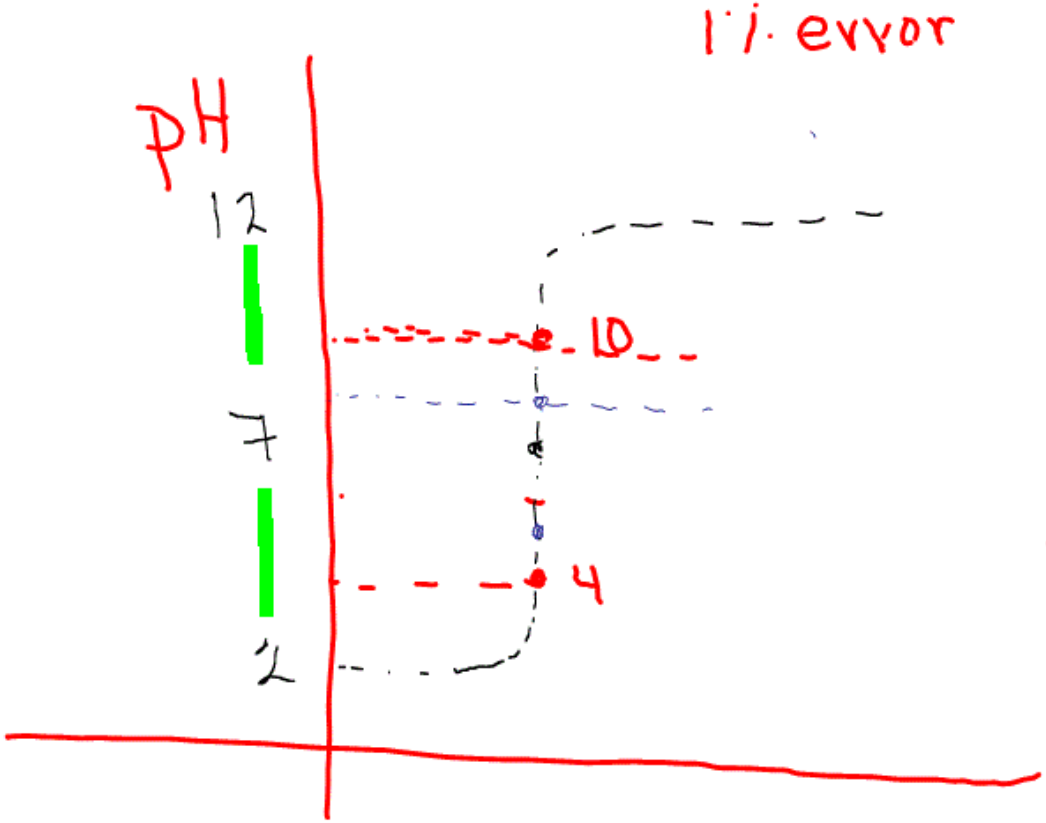
$pH = 14 + \log 10^{-5}$

$pH = 14 - 5 = 9$

$$\frac{5+9}{2} = 7$$


1'i. error
0.1'1. error
pH
12
7
2
10
9
5
4
X
4 — 10

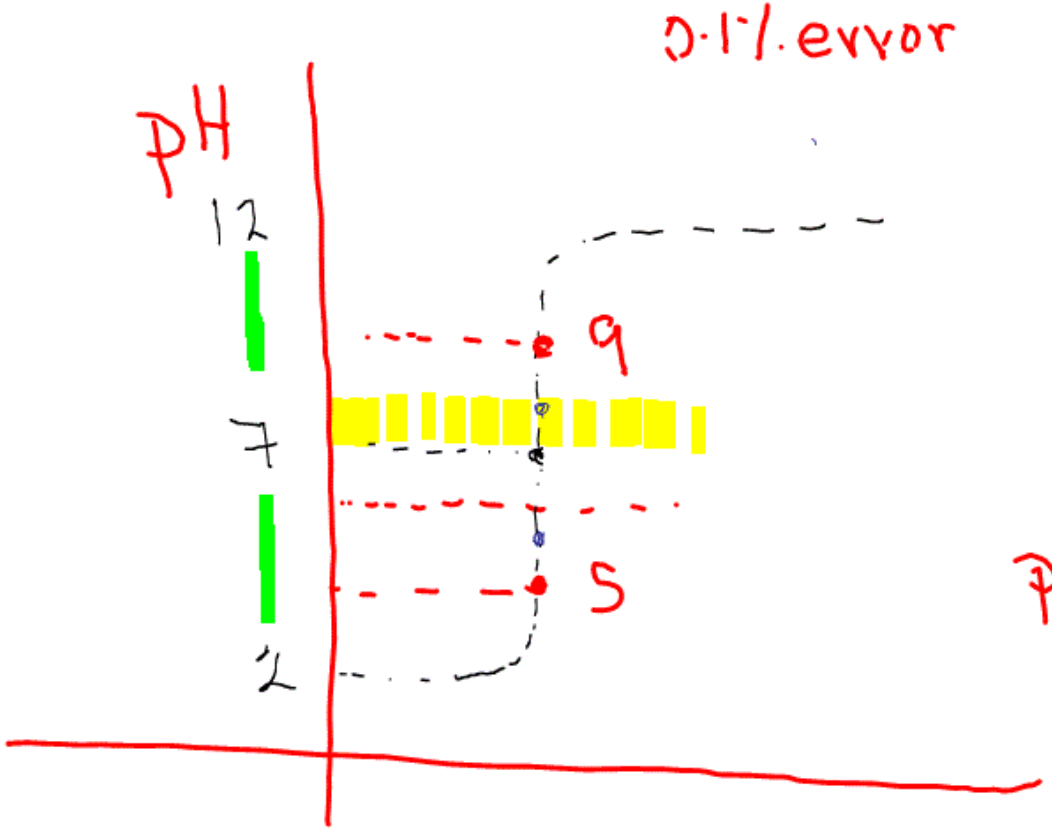

1.i. error
pH
12
10
7
4
2
X
4 — 10
p-nitrofenol
5.6-7.6

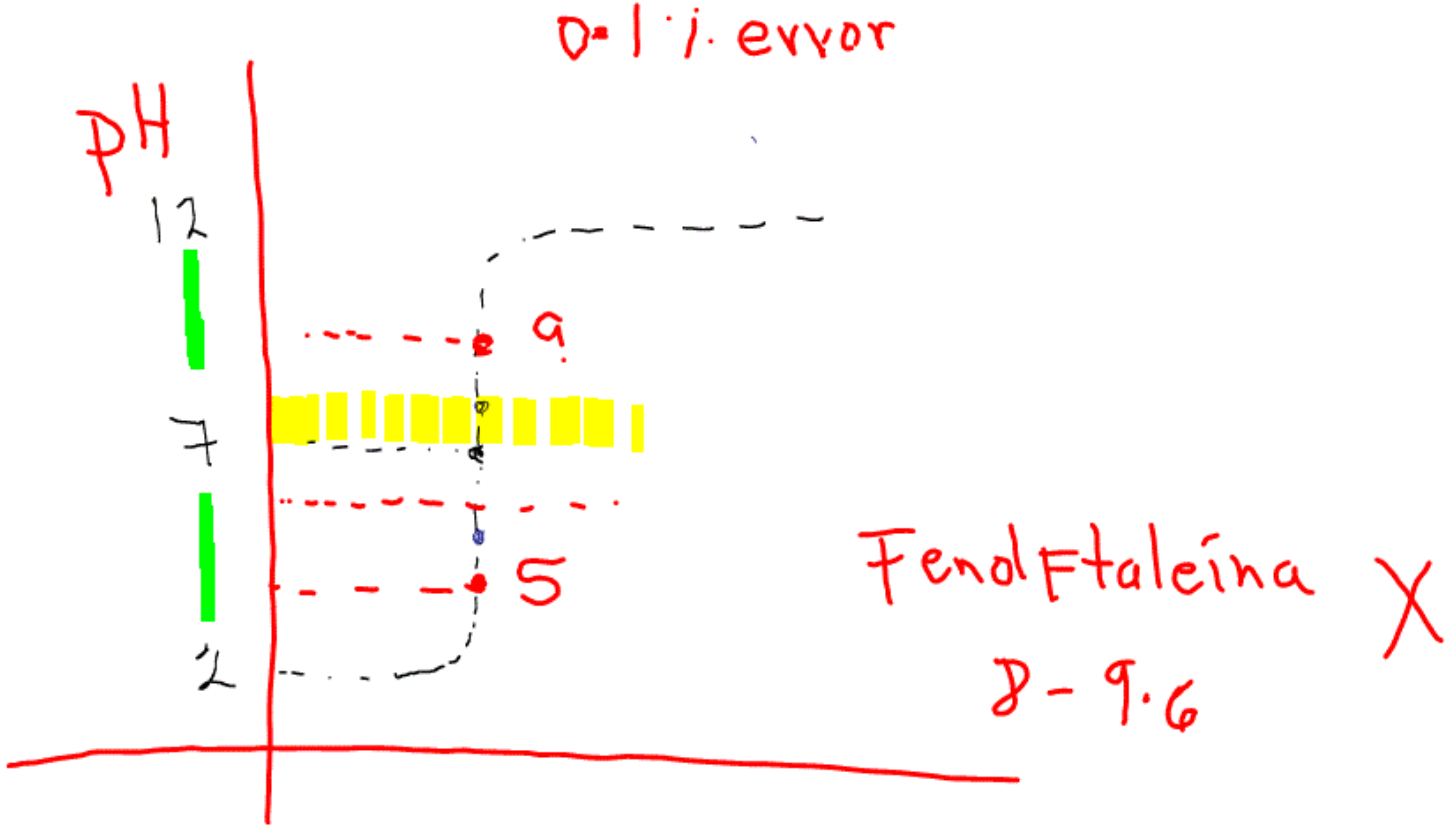


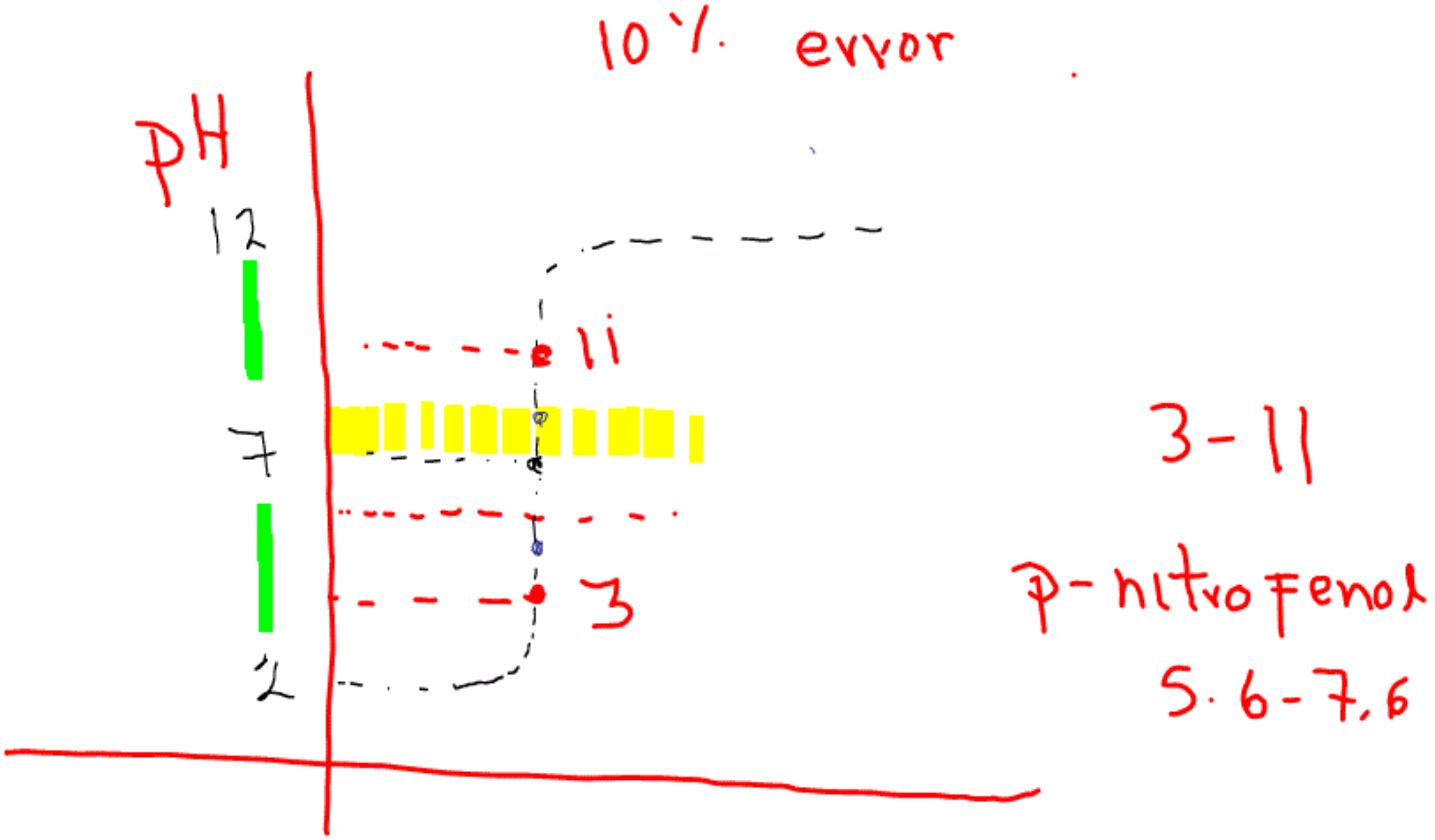
4 — 10

Fenolftaleína

8 - 9.6


5.1% error
pH
12
7
2
9
5
4 — 10
p-nitrofenol
5.6-7.6


0.1 i. error
pH
12
7
2
9
5
Fenolftaleína X
8 - 9.6


10 % error
pH
12
7
2
11
3
3-11
p-nitrofenol
5.6-7.6

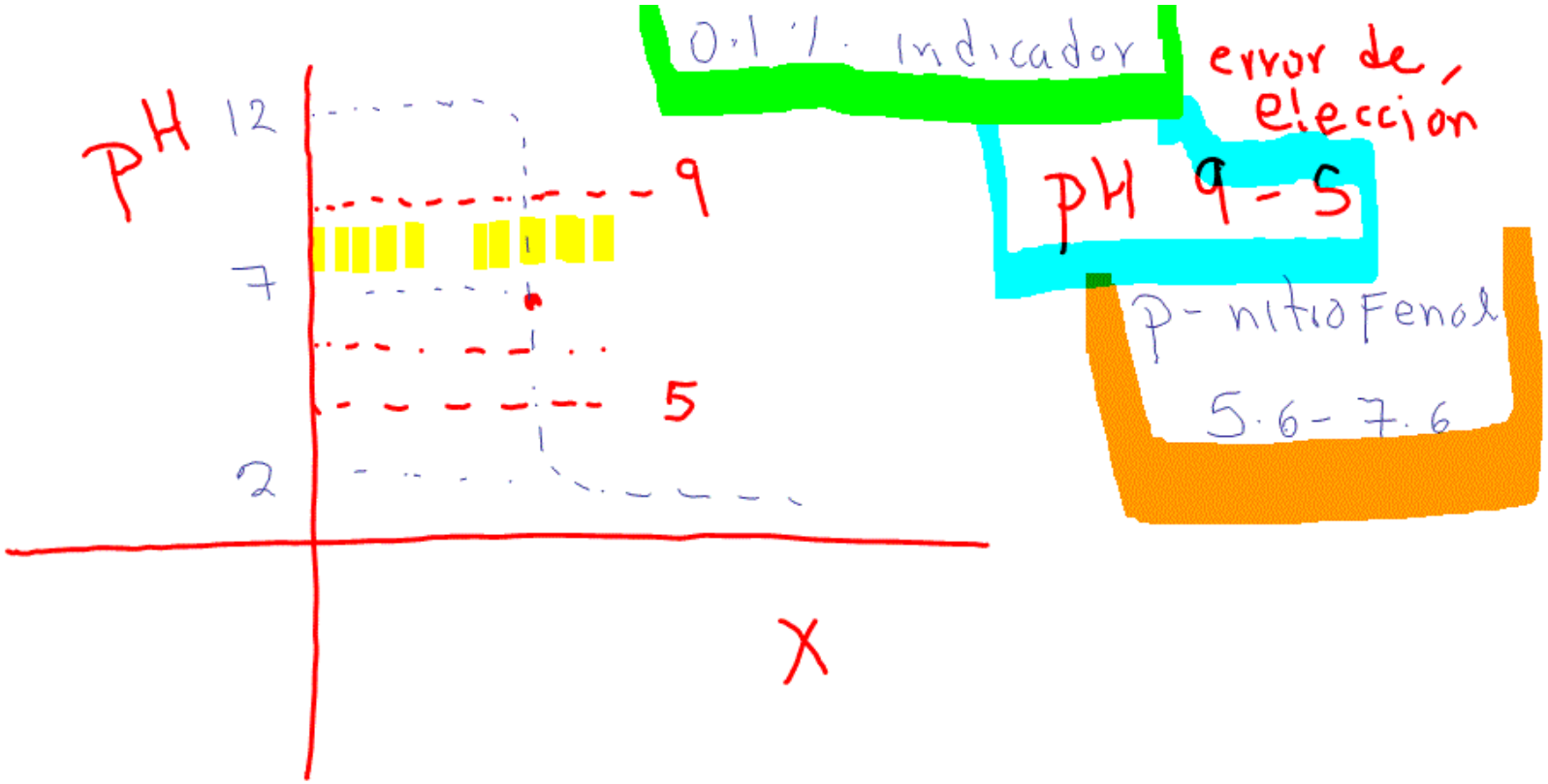
Base Fuerte - ácido Fuerte

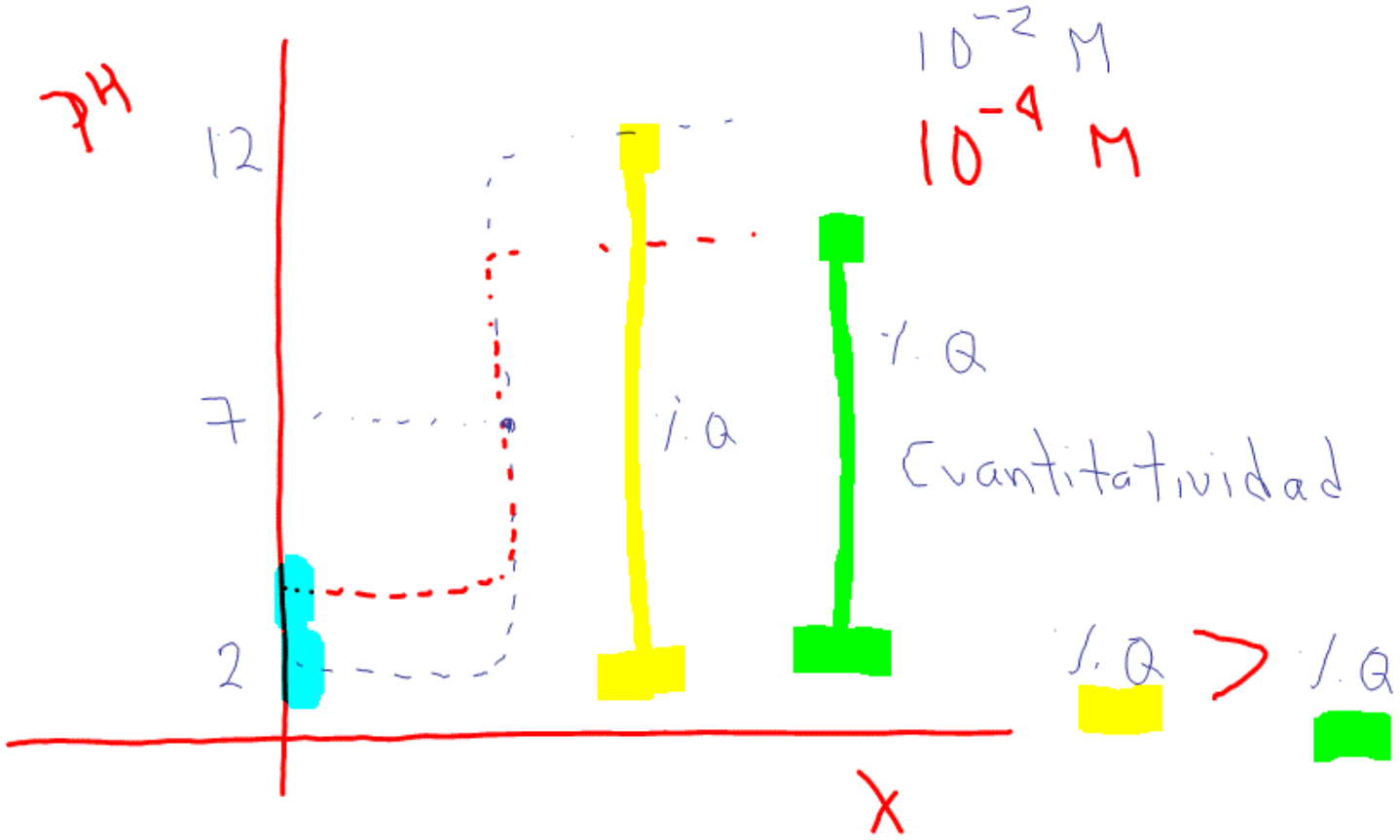
$$OH^- + H_3O^+ \rightleftharpoons 2H_2O$$

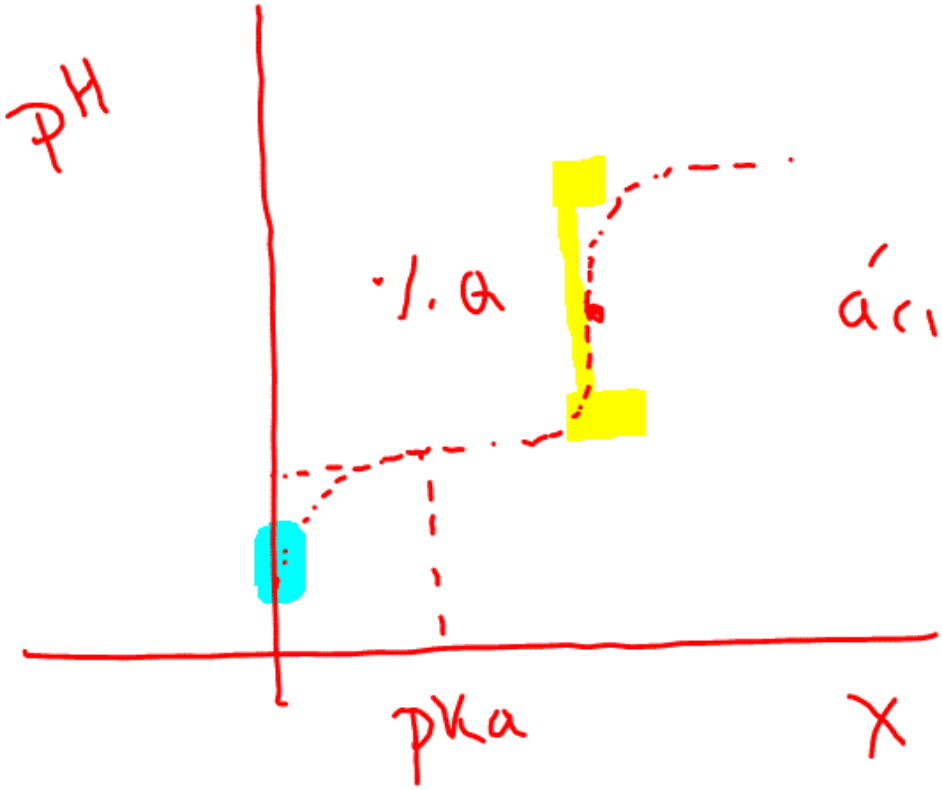
Inicio	C_0	
Agregando		$x\,C_0$
APE	$C_0(1-x)$	~ 0
PE	εC_0	εC_0
DPE	~ 0	$C_0(x-1)$

$$x = \frac{b}{a}$$

x	pH	comportamiento
0	12	base Fuerte
0.5	11.7	base Fuerte
1	7	neutralización
1.5	2.3	ácido Fuerte
2	2	ácido Fuerte


pH
12
9
7
5
2
X
0.1 % indicador
error de elección
pH 9 - 5
p-nitroFenol
5.6 - 7.6


pH
12
7
2
10^{-2} M
10^{-9} M
% Q
% Q
Cuantitatividad
% Q > % Q
X



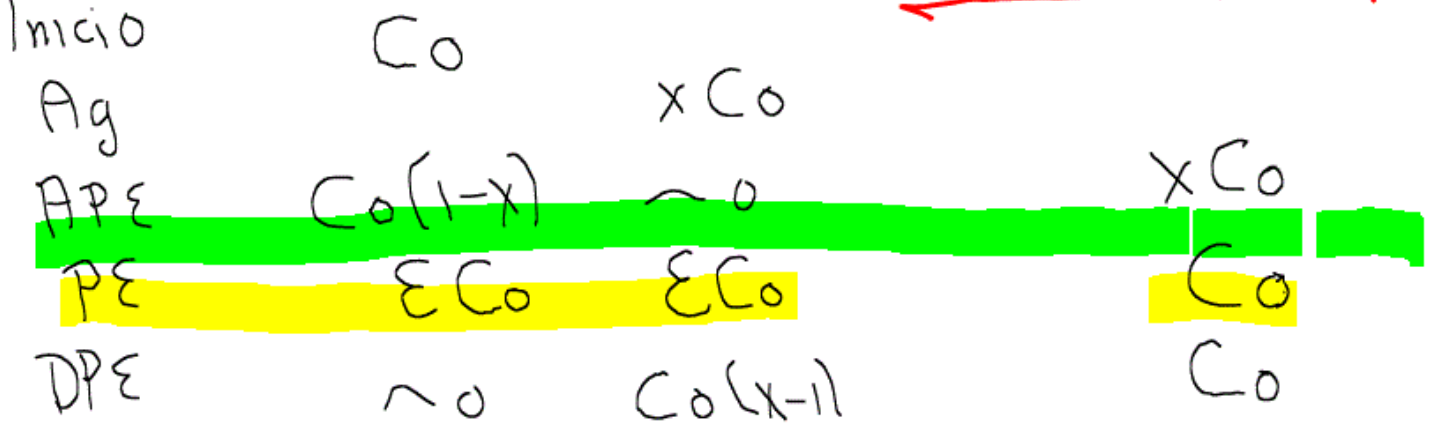
ácido débil

o Fuerza media

ácido débil - base fuerte

pKa = 4.75 ácido acético $10^{-?}$ M con base fuerte

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



1) Calcular Kr

$$K_r = \frac{[A^-]}{[HA][OH^-]} \cdot \frac{[H_3O^+]}{[H_3O^+]}$$

$$= \frac{K_a}{K_w} = \frac{10^{-4.75}}{10^{-14}} = 10^{9.25}$$

2) % Q $\quad K_r = 10^{9.25} = \frac{[A^-]}{[HA][OH^-]}$

$$10^{9.25} = \frac{C_0}{\varepsilon C_0 \; \varepsilon C_0}$$

$$\varepsilon^2 = \frac{1}{K_r C_0} = \frac{1}{10^{9.25} 10^{-2}}$$

$$\varepsilon = \sqrt{\frac{1}{K_r C_0}} = \sqrt{\frac{1}{10^{9.25}\, 10^{-2}}}$$

$$= \sqrt{\frac{1}{10^{+7.25}}} = 10^{-7.25/2}$$

$$\varepsilon = 10^{-3.625}$$

$$\%\, Q = (1-\varepsilon)\, 100$$

$$= 99.97\%.$$

$x = \frac{b}{a}$

x	pH	comportamiento
0	3.37	ácido débil
0.5	4.75	amortiguador débil
1	8.375	base débil
1.5	11.7	base fuerte
2	12	base fuerte

Comportamiento $x=0$

ácido débil

$$\frac{K_a}{C_o} = \frac{10^{-4.75}}{10^{-2}} = 10^{-2.75}$$

$x=1$

$$\frac{K_b}{C_o} = \frac{10^{-9.25}}{10^{-2}} = 10^{-7.25}$$

base débil

$x = 0$

$pH = \frac{1}{2} pKa - \frac{1}{2} \log Ca$

$= \frac{1}{2}(4.75) - \frac{1}{2} \log 10^{-2}$

$= \frac{1}{2}(4.75) + 1$

$= 2.375 + 1 = 3.375$

$x = 0.5$ amortiguador

$pH = pKa + \log \frac{Cb}{Ca}$

$= 4.75 + \log \frac{x\,Co}{Co(1-x)}$

$= 4.75 + \log \frac{0.5\,Co}{Co(1-0.5)} = 4.75$

$x = 1$ base débil

$$pH = \frac{1}{2} pKw + 1/2\, pKa + 1/2 \log Cb$$

$$= \frac{1}{2}(14) + 1/2\,(4.75) + 1/2 \log 10^{-2}$$

$$= 7 + 2.375 - 1 = 8.375$$

$x = 1.5$ base fuerte

$$pH = 14 + \log Cb$$

$$= 14 + \log Co(x-1)$$

$$= 14 + \log 10^{-2}(1.5-1)$$

$$= 14 + \log 5 \times 10^{-3} = 14 - 2.3$$

$$= 11.7$$

$$x = 2$$

$$pH = 14 + \log C_b$$

$$= 14 + \log C_o (x-1)$$

$$= 14 + \log 10^{-2} (2-1)$$

$$= 14 + \log 10^{-2} = 14 - 2$$

$$= 12$$