

# Clase 10 5 Noviembre 2021

Título de la nota

05/11/2021

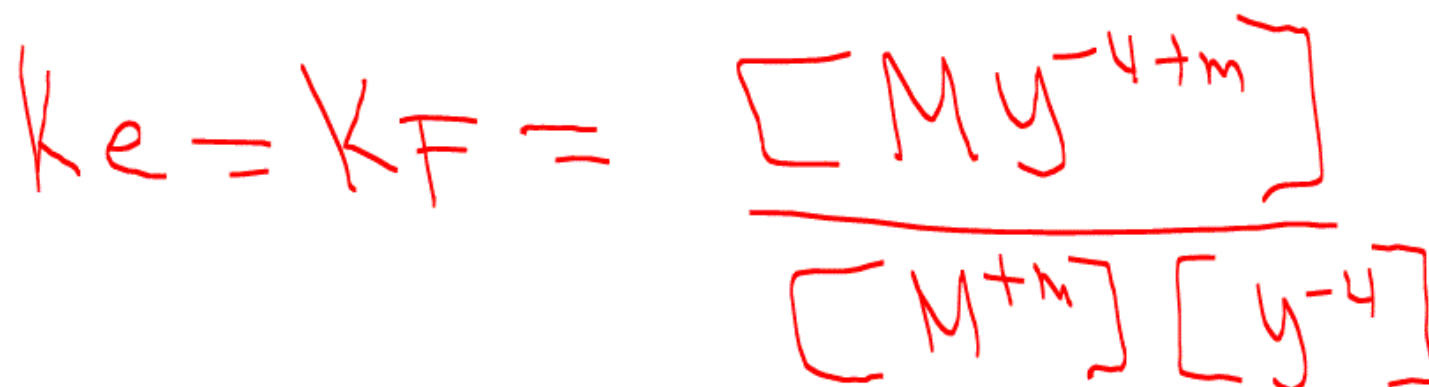
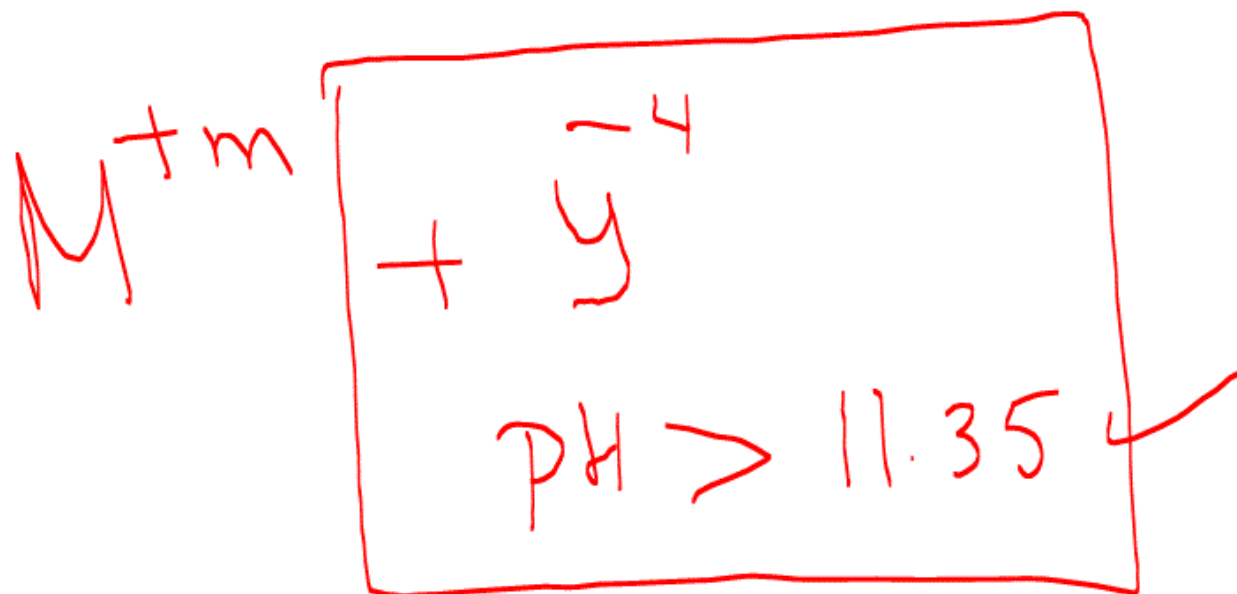
$$\alpha_L(H_{30t})$$

$$\alpha_L(H_{30t}) = \frac{[L]_T}{[L]_L} = \frac{[L']}{[L]}$$

$$[L]_T = [L']$$

$$\alpha_{M(OH)} = \frac{[M]_T}{[M]_L} = \frac{[M']}{[M]}$$

$$\alpha_{Ind(H_3O^+)} = \frac{[Ind]_T}{[Ind]_L} = \frac{[Ind']}{[Ind]}$$



$$y^{-4} = A \epsilon D T A^{-4}$$

$$\alpha_{y(H_3O^+)} = \frac{[y^{-4}] + [H y^{-3}] + [H_2 y^{-2}] + [H_3 y] + [H_4 y] + [H_5 y^+] + [H_6 y^{+2}]}{[y^{-4}]}$$

$$\alpha_{y(H_3O^+)} = 1 + \frac{[H y^{-3}]}{[y^{-4}]} + \frac{[H_2 y^{-2}]}{[y^{-4}]}$$

$$K_{a6} = \frac{[Y^{-4}][H_3O^+]}{[HY^{-3}]}$$



$$\frac{[HY^{-3}]}{[Y^{-4}]} = \frac{[H_3O^+]}{K_{a6}}$$

$$\frac{1}{K_{a6}} = \beta p_1$$

$$\frac{[H_2Y^{-3}]}{[Y^{-4}]} = \frac{[H_3O^+]}{K_{a6}}$$
$$= \beta p_1 [H_3O^+]$$

$$\alpha_y(\text{H}_3\text{O}^+) = 1 + \beta_1 [\text{H}_3\text{O}^+]$$

$$\frac{[\text{H}_2\text{Y}^{-2}]}{[\text{Y}^{-4}]}$$

$$K_{a4} = \frac{[\text{Y}^{-4}][\text{H}_3\text{O}^+]}{[\text{HY}^{-3}]}$$

$$[\text{HY}^{-3}] = \frac{[\text{Y}^{-4}][\text{H}_3\text{O}^+]}{K_{a6}}$$

$$K_{a5} = \frac{[\text{HY}^{-3}][\text{H}_3\text{O}^+]}{[\text{H}_2\text{Y}^{-2}]}$$

$$[Hy^{-3}] = \frac{[y^{-4}][H_3O^+]}{K_{a6}} \quad K_{a5} = \frac{[Hy^{-3}][H_3O^+]}{[H_2y^{-2}]}$$

$$K_{a5} = \frac{[y^{-4}][H_3O^+][H_3O^+]}{[H_2y^{-2}]K_{a6}}$$

$$\frac{[H_2y^{-2}]}{[y^{-4}]} = \frac{[H_3O^+]^2}{K_{a6}K_{a5}} = \beta_{p2}[H_3O^+]^2$$



$$\alpha_y(\text{H}_3\text{O}^+) = 1 + \beta_1 [\text{H}_3\text{O}^+] + \beta_2 [\text{H}_3\text{O}^+]^2 + \beta_3 [\text{H}_3\text{O}^+]^3 + \beta_4 [\text{H}_3\text{O}^+]^4 + \beta_5 [\text{H}_3\text{O}^+]^5 + \beta_6 [\text{H}_3\text{O}^+]^6$$

$$\beta_3 = \frac{1}{K_{a6} K_{a5} K_{a4}}$$

$$\beta_4 = \frac{1}{K_{a6} K_{a5} K_{a4} K_{a3}}$$

$$\beta_5 = \frac{1}{K_{a6} K_{a5} K_{a4} K_{a3} K_{a2}}$$

$$\beta_6 = \frac{1}{K_{a6} K_{a5} K_{a4} K_{a3} K_{a2} K_{a1}}$$

$$K_F = \frac{[M y^{-4+m}]}{[M+m] [y^{-4}]}$$

$$K_F' = \frac{[M y^{-4+m}]}{[M+m'] [y^{-4}]}$$

$$\alpha_{M(OH)} = \frac{[M+m']}{[M+m]}$$

$$\alpha_{L(H_3O^+)} = \frac{[y^{-4}]}{[y^{-4}]}$$

$$K_{F1} = \frac{[M y^{-4+m}]}{\alpha_M [M+m] \alpha_y [y^{-4}]}$$

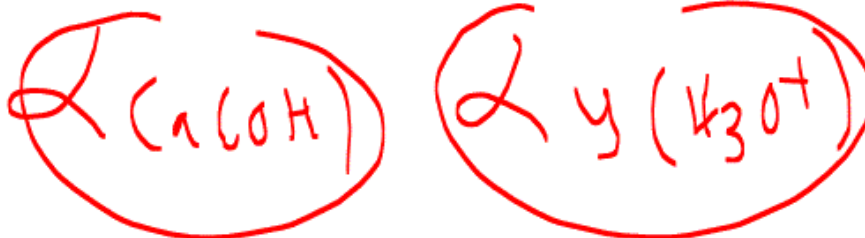
$\alpha_M (OH)$ 
 $\alpha_y (430^+)$

$$K_{F1} = \frac{K_F}{\alpha_M(OH) \alpha_y(430^+)}$$

$$K_{F_{CaY}} = 10^{10.7}$$

$$pH = 3$$

$$K_{F'} = 10^{10.7}$$



$$= 10^{10.7}$$


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$$\alpha_{\text{y}(\text{H}_3\text{O}^+)} = 1 + 10^{10.35} [\text{H}_3\text{O}^+] +$$

$$\beta_1 = \frac{1}{K_{a6}} = \frac{1}{10^{-10.35}} = 10^{10.35}$$

$$\beta_2 = \frac{1}{K_{a6} K_{a5}} = \frac{1}{10^{-10.35} 10^{-6.35}} = 10^{16.7}$$

$$\beta_3 = \frac{1}{K_{a6} K_{a5} K_{a4}} = 10^{19.25}$$

$$\beta_4 = 10^{21.25}$$

$$\beta_5 = 10^{22.75}$$

$$\beta_6 = 10^{22.75}$$

$$\alpha_y(\text{H}_3\text{O}^+) = 1 + 10^{10.35} [\text{H}_3\text{O}^+] + 10^{16.7} [\text{H}_3\text{O}^+]^2 \\ + 10^{19.25} [\text{H}_3\text{O}^+]^3 + 10^{21.25} [\text{H}_3\text{O}^+]^4 \\ + 10^{22.75} [\text{H}_3\text{O}^+]^5 + 10^{22.75} [\text{H}_3\text{O}^+]^6$$


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$$\text{pH} = 3$$

$$\alpha_y(\text{H}_3\text{O}^+) = 1 + 10^{10.35} 10^{-3} + 10^{16.7} 10^{-6} + 10^{19.25} 10^{-9} \\ + 10^{21.35} 10^{-12} + 10^{22.85} 10^{-15} + 10^{22.85} 10^{-18}$$

$$\alpha_y(\text{H}_3\text{O}^+) = \left( 1 + 10^{7.35} + 10^{10.7} + 10^{10.35} + 10^{9.35} \right. \\ \left. + 10^{7.85} + 10^{4.85} \right)$$

$$= 10^{10.77}$$

$$\text{pH} = 3$$

$$\alpha_{\text{Ca}(\text{OH})} = 1 + 10^{1.3} [\text{OH}^-] \\ = 1 + 10^{1.3} [10^{-11}] = 1 + 10^{-9.7} \\ \approx 1 = 10^0$$

$$K_{F'} = \frac{10^{10.7}}{10^0 \cdot 10^{10.77}}$$

$$K_{F'} = 10^{-0.07}$$



**Perfil de pH (sin amortiguador)**

Ca+2 0.01

pH= 3

|                  |     | $\beta_1$ | $[H_3O^+]$   | $\beta_2$ | $[H_3O^+]^2$  | $\beta_3$ | $[H_3O^+]^3$  | $\beta_4$ | $[H_3O^+]^4$  | $\beta_5$ | $[H_3O^+]^5$  | $\beta_6$ | $[H_3O^+]^6$  |       |
|------------------|-----|-----------|--------------|-----------|---------------|-----------|---------------|-----------|---------------|-----------|---------------|-----------|---------------|-------|
| $\alpha[H_3O^+]$ | =   | 1         | + 2.2387E+10 | 0.001     | + 3.98107E+16 | 0.000001  | + 1.77828E+19 | 1E-09     | + 1.77828E+21 | 1E-12     | + 5.62341E+22 | 1E-15     | + 5.62341E+22 | 1E-18 |
| $\alpha[H_3O^+]$ | =   | 1         | + 22387211.4 |           | + 39810717055 |           | + 17782794100 |           | + 1778279410  |           | + 56234132.52 |           | + 56234.13252 |       |
| $\alpha[H_3O^+]$ | =   | 5.95E+10  |              |           |               |           |               |           |               |           |               |           |               |       |
|                  | LOG | =         | 10.7741553   |           |               |           |               |           |               |           |               |           |               |       |


|                 |     | $\beta_1$ | $[OH^-]$     | $\beta_2$ | $[OH^-]^2$ | $\beta_3$ | $[OH^-]^3$ | $\beta_4$ | $[OH^-]^4$ | $\beta_5$ | $[OH^-]^5$ | $\beta_6$ | $[OH^-]^6$ |       |
|-----------------|-----|-----------|--------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-------|
| $\alpha Ca(OH)$ | =   | 1         | + 19.9526231 | 1.00E-11  | + 0        | 1.00E-22  | + 0        | 1E-33     | + 0        | 1E-44     | + 0        | 1E-44     | + 0        | 1E-44 |
| $\alpha Ca(OH)$ | =   | 1         | + 1.9953E-10 |           | + 0        |           | + 0        |           | + 0        |           | + 0        |           | + 0        |       |
| $\alpha Ca(OH)$ | =   | 1         |              |           |            |           |            |           |            |           |            |           |            |       |
|                 | LOG | =         | 8.6653E-11   |           |            |           |            |           |            |           |            |           |            |       |

| K'ML=       |     | Cuantitividad |                                |
|-------------|-----|---------------|--------------------------------|
| 50118723363 | =   | 0.843         | E= 10.8912478                  |
| 59450468157 |     |               | %Q= -989.12478 NO CUANTITATIVO |
|             | LOG | =             | -0.074155                      |

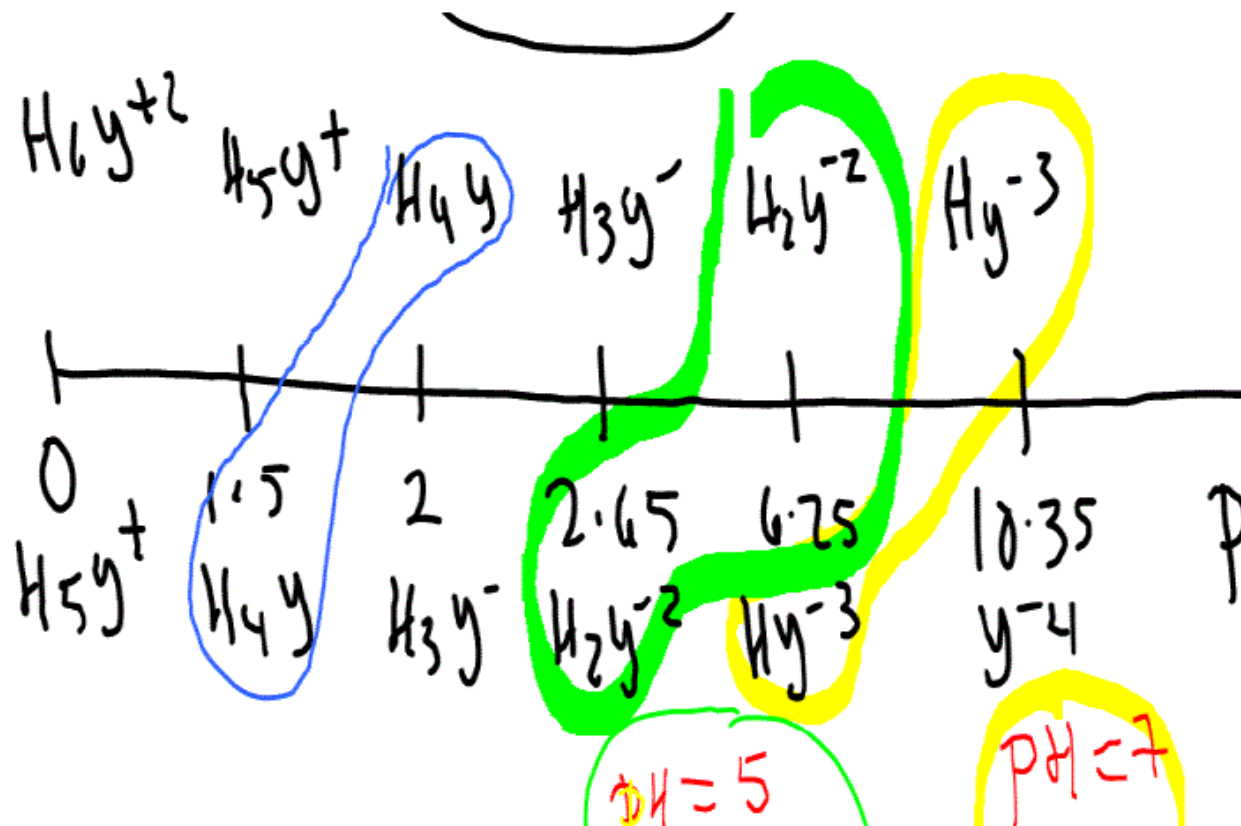
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|        |                         |                         |               |
|--------|-------------------------|-------------------------|---------------|
| Inicio | $\text{Co}$             |                         |               |
| Ay     |                         | $x \text{Co}$           |               |
| APE    | $\text{Co}(1-x)$        | $\sim 0$                | $x \text{Co}$ |
| PE     | $\varepsilon \text{Co}$ | $\varepsilon \text{Co}$ | $\text{Co}$   |
| DPE    | $\sim 0$                | $\text{Co}(x-1)$        | $\text{Co}$   |



$$K_F^1 = 10^{-0.07} = \frac{[CaH_2y]}{[Ca^{+2}][H_2y^{-2}]}$$

$$= 10^{-0.07} = \frac{\cancel{C_0}}{\epsilon C_0 \epsilon \cancel{C_0}}$$

$$\epsilon^2 = \frac{1}{10^{-0.07} C_0}$$

$$\epsilon^2 = \frac{1}{10^{-0.07} 10^{-2}} = \frac{1}{10^{-2.07}}$$

$$\epsilon = \sqrt{\frac{1}{10^{-2.07}}} = 10^{2.07/2}$$

$$\epsilon = 10^{1.035}$$

$$\begin{aligned} \% Q &= (1 - \epsilon) 100 \\ &= -983 \end{aligned}$$

**pH = 6**

**Perfil de pH (sin amortiguador)**

Ca+2 0.01

|                    |     |          |            |            |            |   |             |            |   |             |            |   |             |            |   |             |            |   |             |            |  |
|--------------------|-----|----------|------------|------------|------------|---|-------------|------------|---|-------------|------------|---|-------------|------------|---|-------------|------------|---|-------------|------------|--|
| pH=                | 6   |          |            |            |            |   |             |            |   |             |            |   |             |            |   |             |            |   |             |            |  |
| $\alpha_{L(H_2O)}$ | =   | 1        | +          | $\beta_1$  | $[H_2O]^1$ | + | $\beta_2$   | $[H_2O]^2$ | + | $\beta_3$   | $[H_2O]^3$ | + | $\beta_4$   | $[H_2O]^4$ | + | $\beta_5$   | $[H_2O]^5$ | + | $\beta_6$   | $[H_2O]^6$ |  |
| $\alpha_{L(H_2O)}$ | =   | 1        | +          | 2.2387E+10 | 0.000001   | + | 3.98107E+16 | 1E-12      | + | 1.77828E+19 | 1E-18      | + | 1.77828E+21 | 1E-24      | + | 5.62341E+22 | 1E-30      | + | 5.62341E+22 | 1E-36      |  |
| $\alpha_{L(H_2O)}$ | =   | 62216.71 |            |            |            |   |             |            |   |             |            |   |             |            |   |             |            |   |             |            |  |
|                    | LOG | =        | 4.79390706 |            |            |   |             |            |   |             |            |   |             |            |   |             |            |   |             |            |  |

|                   |     |   |            |            |          |   |           |          |   |           |          |   |           |          |   |           |          |   |           |          |  |
|-------------------|-----|---|------------|------------|----------|---|-----------|----------|---|-----------|----------|---|-----------|----------|---|-----------|----------|---|-----------|----------|--|
| $\alpha_{Ca(OH)}$ | =   | 1 | +          | $\beta_1$  | $[OH]$   | + | $\beta_2$ | $[OH]^2$ | + | $\beta_3$ | $[OH]^3$ | + | $\beta_4$ | $[OH]^4$ | + | $\beta_5$ | $[OH]^5$ | + | $\beta_6$ | $[OH]^6$ |  |
| $\alpha_{Ca(OH)}$ | =   | 1 | +          | 19.9526231 | 1.00E-08 | + | 0         | 1.00E-16 | + | 0         | 1E-24    | + | 0         | 1E-32    | + | 0         | 1E-32    | + | 0         | 1E-32    |  |
| $\alpha_{Ca(OH)}$ | =   | 1 | +          | 1.9953E-07 |          |   |           |          |   |           |          |   |           |          |   |           |          |   |           |          |  |
| $\alpha_{Ca(OH)}$ | =   | 1 |            |            |          |   |           |          |   |           |          |   |           |          |   |           |          |   |           |          |  |
|                   | LOG | = | 8.6653E-08 |            |          |   |           |          |   |           |          |   |           |          |   |           |          |   |           |          |  |

|       |     |             |           |       |              |                 |
|-------|-----|-------------|-----------|-------|--------------|-----------------|
| K'ML= |     | 50118723363 | =         | 8E+05 | Cantidad     |                 |
|       |     | 62216.72543 |           |       | $\epsilon$ = | 0.01114175      |
|       |     |             |           |       | %Q=          | 98.8858246      |
|       |     |             |           |       |              | NO CUANTITATIVO |
|       | LOG | =           | 5.9060929 |       |              |                 |



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$$pH = 6$$

$$K_f' = \frac{10^{10.7}}{\alpha_{M(OH)} \alpha_{Y(H_3O^+)}}$$

$$= \frac{10^{10.7}}{10^0 10^{4.79}} = 10^{5.91}$$

**Perfil de pH (sin amortiguador)**

Ca+2 0.01

pH= 6

|                  |   |          | $\beta_1$ | $[H_3O^+]$ |          | $\beta_2$ | $[H_3O^+]^2$ |       | $\beta_3$ | $[H_3O^+]^3$ |       | $\beta_4$ | $[H_3O^+]^4$ |       | $\beta_5$ | $[H_3O^+]^5$ |       | $\beta_6$ | $[H_3O^+]^6$ |       |
|------------------|---|----------|-----------|------------|----------|-----------|--------------|-------|-----------|--------------|-------|-----------|--------------|-------|-----------|--------------|-------|-----------|--------------|-------|
| $\alpha[H_3O^+]$ | = | 1        | +         | 2.2387E+10 | 0.000001 | +         | 3.98107E+16  | 1E-12 | +         | 1.77828E+19  | 1E-18 | +         | 1.77828E+21  | 1E-24 | +         | 5.62341E+22  | 1E-30 | +         | 5.62341E+22  | 1E-36 |
| $\alpha[H_3O^+]$ | = | 1        | +         | 22387.2114 |          | +         | 39810.71706  |       | +         | 17.7827941   |       | +         | 0.001778279  |       | +         | 5.62341E-08  |       | +         | 5.62341E-14  |       |
| $\alpha[H_3O^+]$ | = | 62216.71 |           |            |          |           |              |       |           |              |       |           |              |       |           |              |       |           |              |       |
|                  |   | LOG      | =         | 4.79390706 |          |           |              |       |           |              |       |           |              |       |           |              |       |           |              |       |

|                 |   |     | $\beta_1$ | $[OH^-]$   |          | $\beta_2$ | $[OH^-]^2$ |          | $\beta_3$ | $[OH^-]^3$ |       | $\beta_4$ | $[OH^-]^4$ |       | $\beta_5$ | $[OH^-]^5$ |       | $\beta_6$ | $[OH^-]^6$ |       |
|-----------------|---|-----|-----------|------------|----------|-----------|------------|----------|-----------|------------|-------|-----------|------------|-------|-----------|------------|-------|-----------|------------|-------|
| $\alpha Ca[OH]$ | = | 1   | +         | 19.9526231 | 1.00E-08 | +         | 0          | 1.00E-16 | +         | 0          | 1E-24 | +         | 0          | 1E-32 | +         | 0          | 1E-32 | +         | 0          | 1E-32 |
| $\alpha Ca[OH]$ | = | 1   | +         | 1.9953E-07 |          | +         | 0          |          | +         | 0          |       | +         | 0          |       | +         | 0          |       | +         | 0          |       |
| $\alpha Ca[OH]$ | = | 1   |           |            |          |           |            |          |           |            |       |           |            |       |           |            |       |           |            |       |
|                 |   | LOG | =         | 8.6653E-08 |          |           |            |          |           |            |       |           |            |       |           |            |       |           |            |       |


  

**Quantidad**

|                    |             |     |             |
|--------------------|-------------|-----|-------------|
| K <sup>'</sup> ML= | 50118723363 | =   | 8E+05       |
|                    | 62216.72543 |     |             |
|                    |             | LOG | = 5.9060929 |

|     |            |                 |
|-----|------------|-----------------|
| E=  | 0.01114175 |                 |
| %Q= | 98.8858246 | NO CUANTITATIVO |

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**Perfil de pH (sin amortiguador)**

Ca+2 0.01

pH= 12

|                      |     |          |            |                    |   |                      |   |                      |   |                      |   |                      |   |                      |
|----------------------|-----|----------|------------|--------------------|---|----------------------|---|----------------------|---|----------------------|---|----------------------|---|----------------------|
| $\alpha_{L(H_3O^+)}$ | =   | 1        | +          | $\beta_1 [H_3O^+]$ | + | $\beta_2 [H_3O^+]^2$ | + | $\beta_3 [H_3O^+]^3$ | + | $\beta_4 [H_3O^+]^4$ | + | $\beta_5 [H_3O^+]^5$ | + | $\beta_6 [H_3O^+]^6$ |
| $\alpha_{L(H_3O^+)}$ | =   | 1        | +          | 2.2387E+10 1E-12   | + | 3.98107E+16 1E-24    | + | 1.77828E+19 1E-36    | + | 1.77828E+21 1E-48    | + | 5.62341E+22 1E-60    | + | 5.62341E+22 1E-72    |
| $\alpha_{L(H_3O^+)}$ | =   | 1.022387 |            |                    |   |                      |   |                      |   |                      |   |                      |   |                      |
|                      | LOG | =        | 0.00961543 |                    |   |                      |   |                      |   |                      |   |                      |   |                      |

|                   |     |          |            |                     |   |                    |   |                    |   |                    |   |                    |   |                    |
|-------------------|-----|----------|------------|---------------------|---|--------------------|---|--------------------|---|--------------------|---|--------------------|---|--------------------|
| $\alpha_{Ca(OH)}$ | =   | 1        | +          | $\beta_1 [OH^-]$    | + | $\beta_2 [OH^-]^2$ | + | $\beta_3 [OH^-]^3$ | + | $\beta_4 [OH^-]^4$ | + | $\beta_5 [OH^-]^5$ | + | $\beta_6 [OH^-]^6$ |
| $\alpha_{Ca(OH)}$ | =   | 1        | +          | 19.9526231 1.00E-02 | + | 0 1.00E-04         | + | 0 0.000001         | + | 0 1E-08            | + | 0 1E-08            | + | 0 1E-08            |
| $\alpha_{Ca(OH)}$ | =   | 1.199526 |            |                     |   |                    |   |                    |   |                    |   |                    |   |                    |
|                   | LOG | =        | 0.07900975 |                     |   |                    |   |                    |   |                    |   |                    |   |                    |


  

|        |     |             |           |       |
|--------|-----|-------------|-----------|-------|
| $K'ML$ | =   | 50118723363 | =         | 4E+10 |
|        |     | 1.226380327 |           |       |
|        | LOG | =           | 10.611375 |       |

**Cantidad**

|            |   |            |              |
|------------|---|------------|--------------|
| $\epsilon$ | = | 4.9467E-05 |              |
| %Q         | = | 99.9950533 | CUANTITATIVO |

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$$pH = 12$$



Inicio

$C_0$

$X C_0$

Ag

APE

$C_0(1-x)$

$\sim 0$

$X C_0$

PE

$\epsilon C_0$

$\epsilon C_0$

$C_0$

DPE

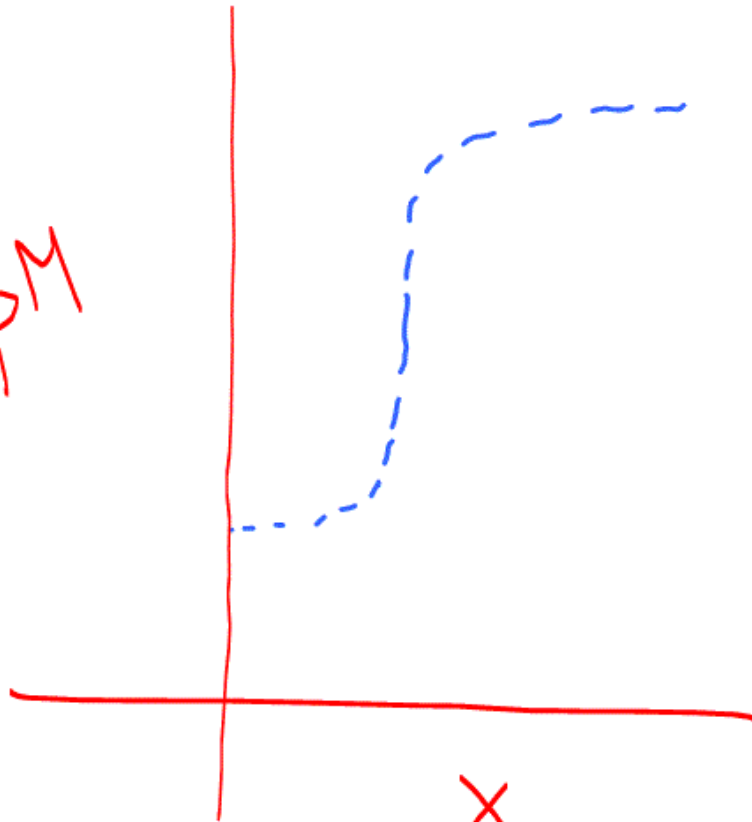
$\sim 0$

$C_0(x-1)$

$C_0$

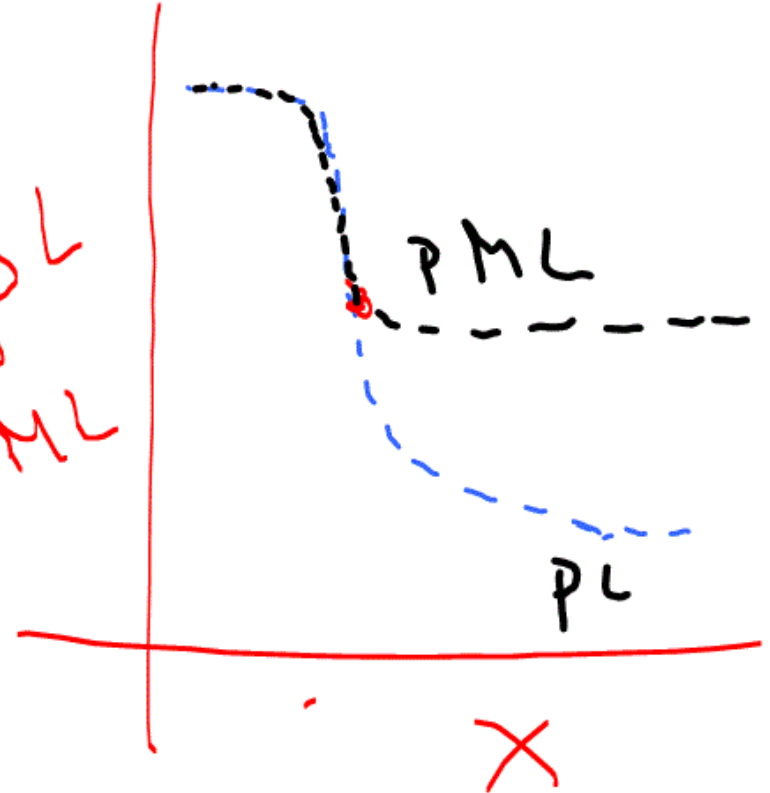
$$X = 0$$

PM

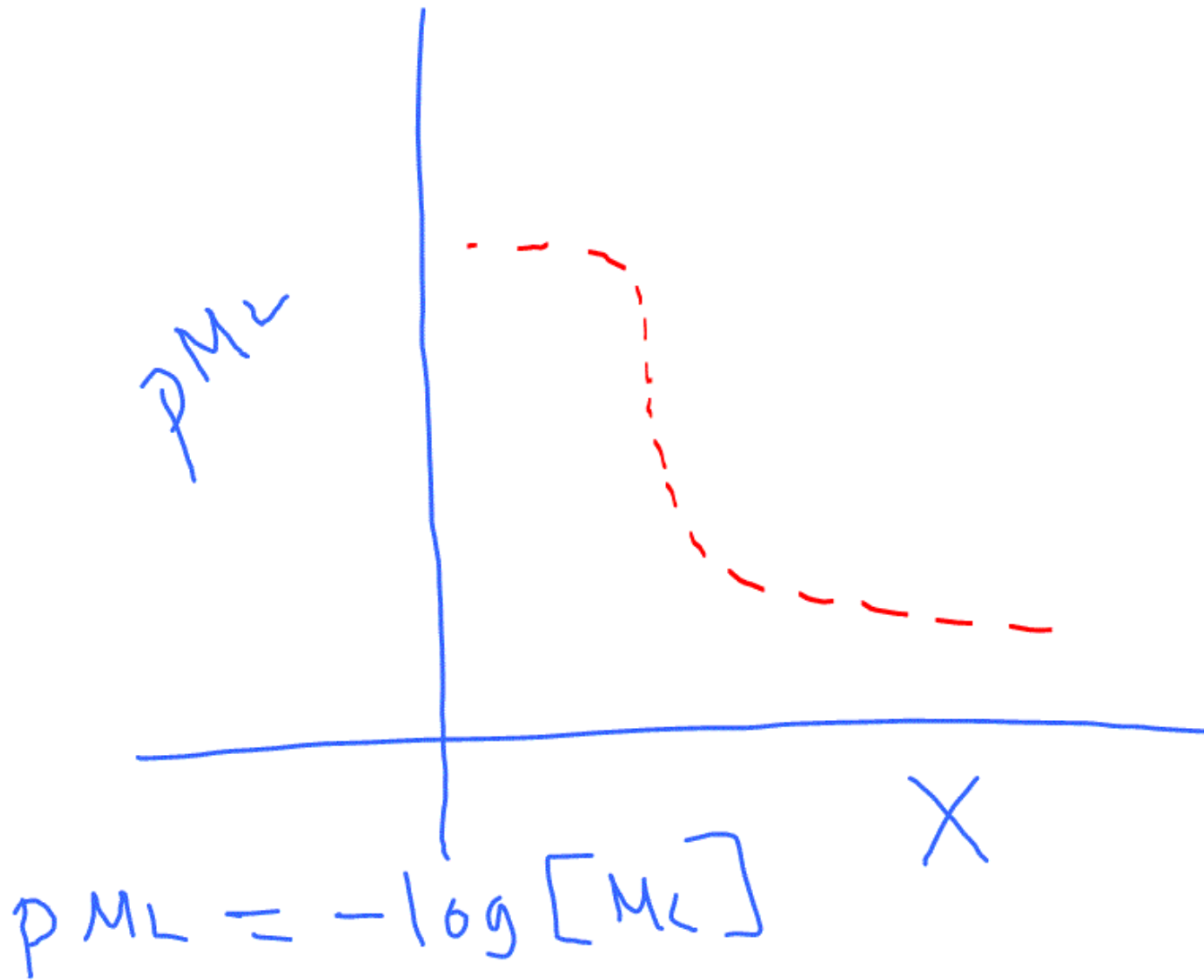


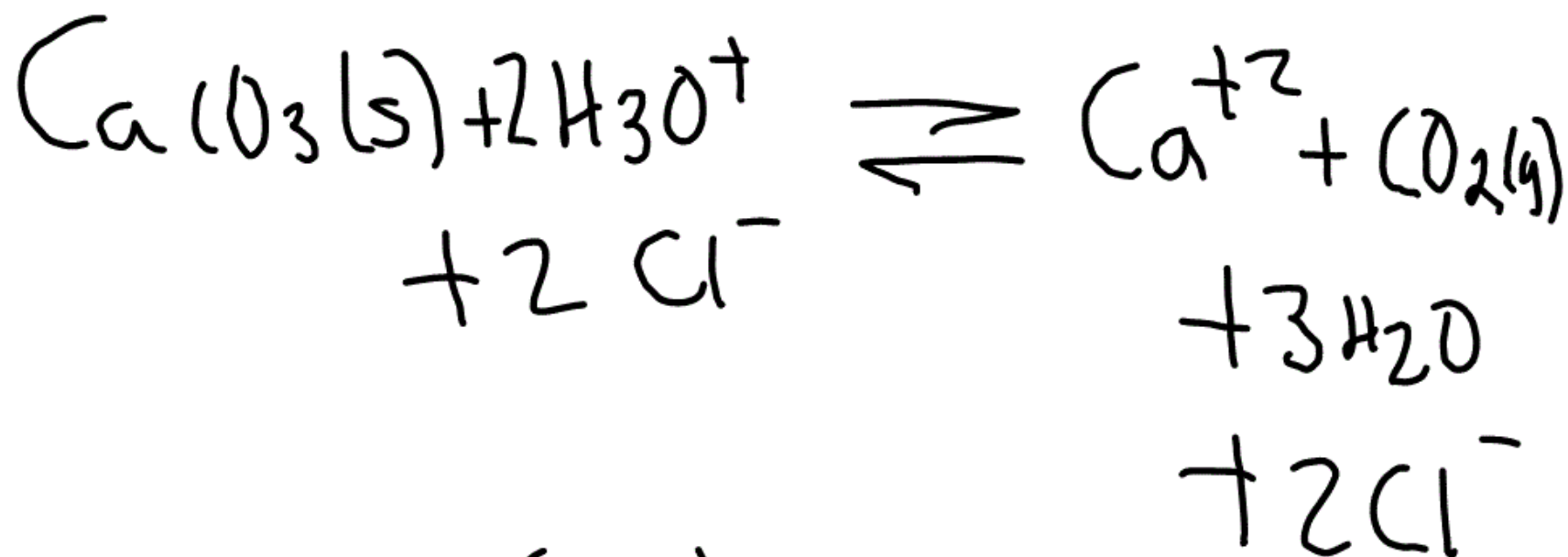
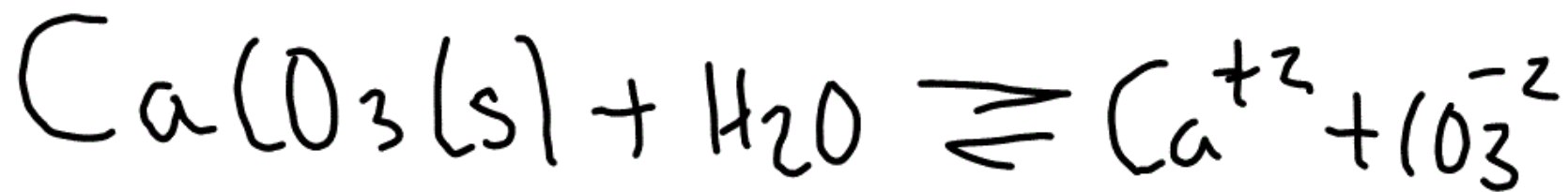
$$PM = -\log[M]$$

PL  
PML



$$PL = -\log[L]$$





pH = ácido

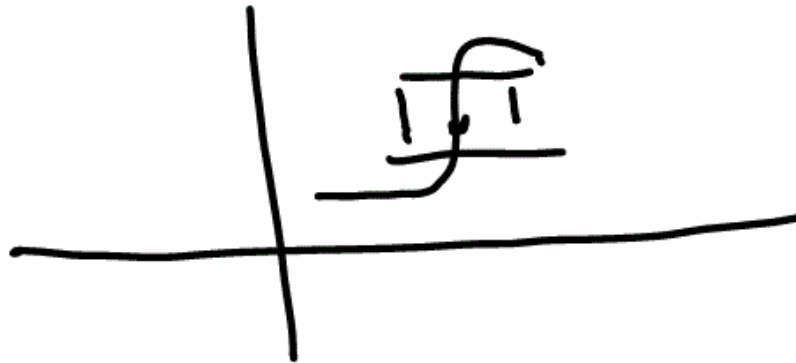
Agregar  $\text{AcO}^-$  ← Indicador  
Agregar  $\text{OH}^-$  (color  
rojo)

↓  
pH  $\approx$  12

calmagita

$$K_{F'}^{M(\text{ind})} = \frac{K_{F_M(\text{ind})}}{\alpha_{\text{Ind}(\text{H}_3\text{O}^+)} \alpha_{M(\text{OH})}}$$

$$\text{PM transición} = K_{F'} \pm 1$$



$$\alpha_{\text{M(ind)}} = 1 + \beta_1 [\text{H}_3\text{O}^+] + \beta_2 [\text{H}_3\text{O}^+]^2$$

$$\ln \left( \frac{p_{\text{Ka}_1}}{p_{\text{Ka}_2}} \right)$$

$$\beta_1 = \frac{1}{K_{a2}}$$

$$\beta_2 = \frac{1}{K_{a2}K_{a1}}$$