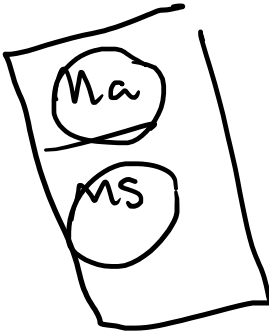


# Esercizi pH e solubilità



Tampeni

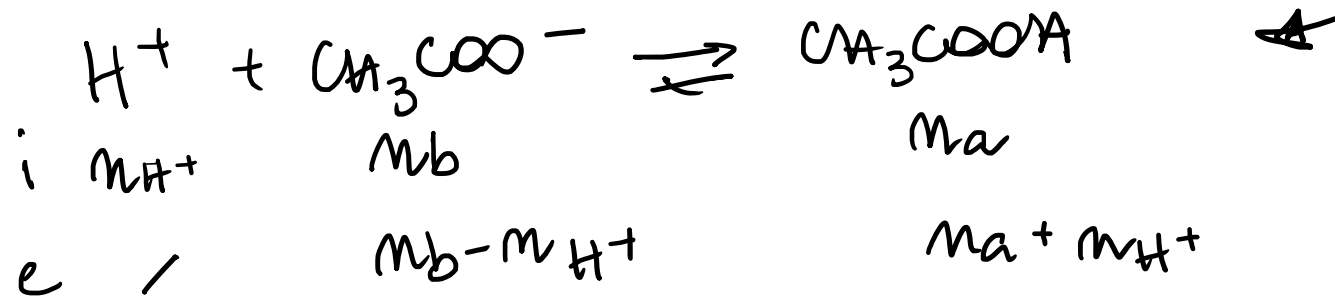
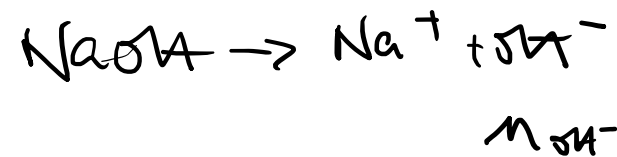
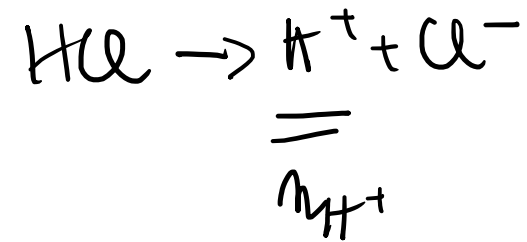
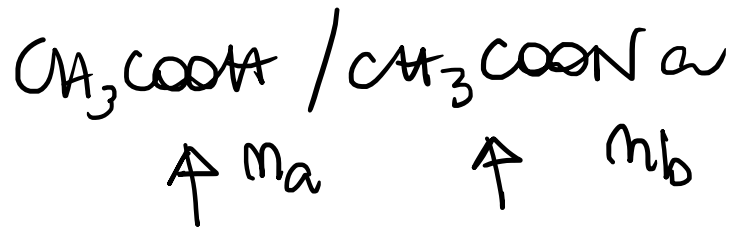
$$[\text{H}_3\text{O}^+] = K_a \cdot \frac{[\text{Na}]}{[\text{MS}]} \Rightarrow 1$$


$$[\text{H}_3\text{O}^+] = K_a \Rightarrow \text{pH} = \text{p}K_a$$

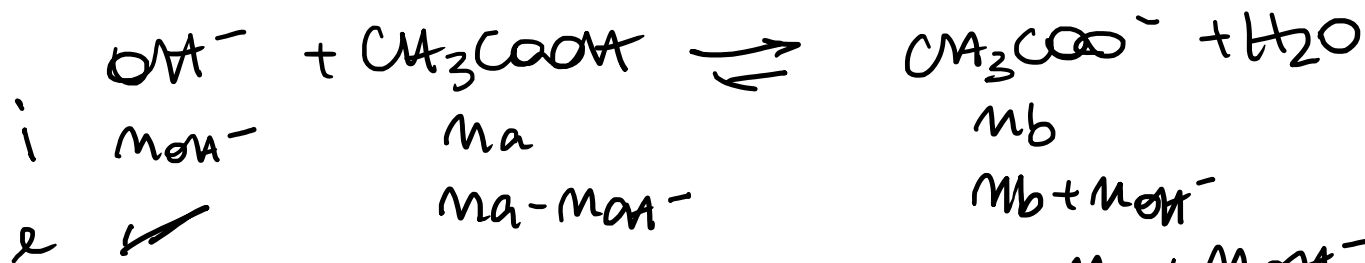
CAPACITĂ TAMPONANTĂ

$$\text{pH} = \text{p}K_a \pm 1$$

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$$[\text{H}_3\text{O}^+] = N_a \cdot \frac{m_a + m_{\text{H}^+}}{m_b - m_{\text{H}^+}}$$



$$[\text{H}_3\text{O}^+] = N_a \cdot \frac{m_a - m_{\text{OH}^-}}{m_b + m_{\text{OH}^-}}$$

②

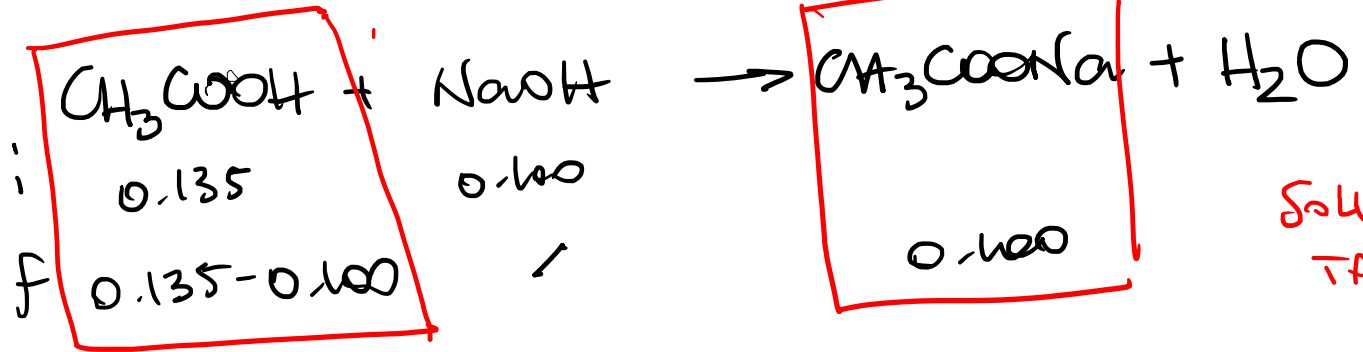
Ex 1

pH = ?

0.900 L CH<sub>3</sub>COOH 0.150 M  
0.100 L NaOH 1.00 M

200 mL HCl 1 M  
→ 100 mL della sol. finale.

$$K_{a, \text{CH}_3\text{COOH}} = 1.76 \cdot 10^{-5}$$



SOLUZIONE  
TAMPONE  
ACIDA

$$\text{mol CH}_3\text{COOH} = 0.150 \frac{\text{mol}}{\text{L}} \cdot 0.900 \text{ L} = 0.135 \text{ mol}$$

$$\text{mol NaOH} = 1 \frac{\text{mol}}{\text{L}} \cdot 0.100 \text{ L} = 0.100 \text{ mol}$$

$$[\text{H}_3\text{O}^+] = K_a \cdot \frac{m_a}{m_b} = 1.76 \cdot 10^{-5} \cdot \frac{0.035}{0.100} = 6.16 \cdot 10^{-6} \text{ M}$$

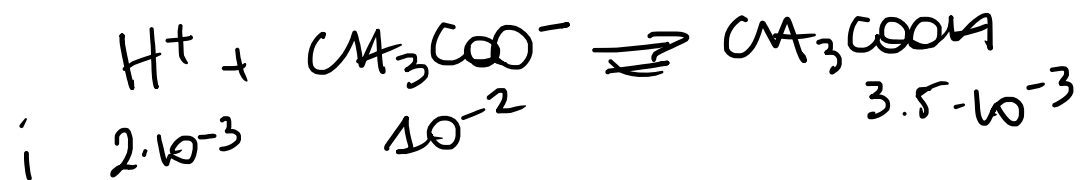
$$\text{pH} = -\log [\text{H}_3\text{O}^+] = 5.21$$

$$\left( \text{p}K_a = 4.74 \right)$$

(2)



$$n_{\text{HCl}} = 0.002 \text{ mol}$$



$$\begin{array}{l} \text{e} \\ \text{e} \end{array} \quad \begin{array}{l} / \\ / \end{array} \quad \begin{array}{l} 10^{-2} - 2 \cdot 10^{-3} \quad 3.5 \cdot 10^{-3} + 2 \cdot 10^{-3} \end{array}$$

$$[\text{H}_3\text{O}^+] = 1.76 \cdot 10^{-5} \cdot \frac{3.5 \cdot 10^{-3} + 2 \cdot 10^{-3}}{10^{-2} - 2 \cdot 10^{-3}} = 1.2 \cdot 10^{-5} \text{ M}$$

$$\text{pH} = -\lg [\text{H}_3\text{O}^+] = \boxed{4.92}$$

Ex 2

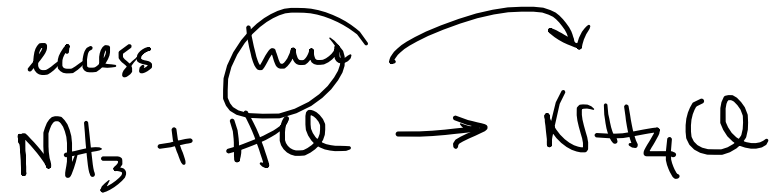
$$V_{\text{mL}} = ? \quad 8 \cdot 10^{-1} \text{ M } \text{NH}_3$$

$$V_{\text{mL}} = ? \quad 7.8 \cdot 10^{-1} \text{ M } \text{HCl}$$

$$\Delta L \text{ Tampon } 0.300 \text{ M}$$

$$\text{pH} = 9.5$$

$$K_b \text{NH}_3 = 1.79 \cdot 10^{-5}$$



$$[\text{OH}^-] = K_b \cdot \frac{C_b}{C_s} = K_b \cdot \frac{n_b}{n_s}$$

$$\text{pH} = 9.5$$

$$[\text{H}^+] = 10^{-4.5} = 3.16 \cdot 10^{-5} \text{ M}$$

$$\left\{ \frac{C_s}{C_b} = \frac{K_b}{[\text{OH}^-]} = \frac{1.79 \cdot 10^{-5}}{3.16 \cdot 10^{-5}} = 5.66 \cdot 10^{-1} \right.$$
$$C_b + C_s = 0.300 \text{ M}$$

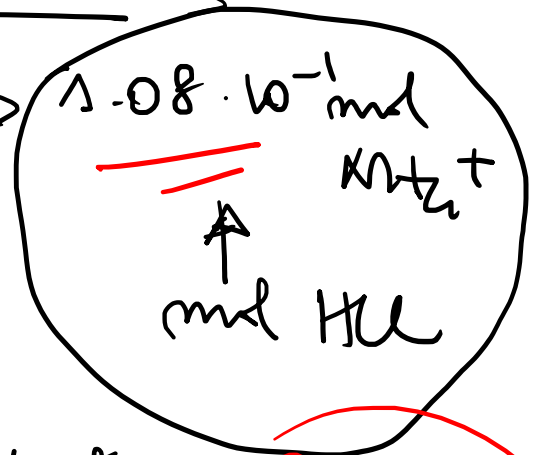
$$\frac{C_s}{C_b} = 5.66 \cdot 10^{-1} = \frac{0.300 - C_b}{C_b} \Rightarrow C_b = 1.92 \cdot 10^{-1} \text{ M}$$

$1.92 \cdot 10^{-1} \text{ mol NH}_3$

(5)

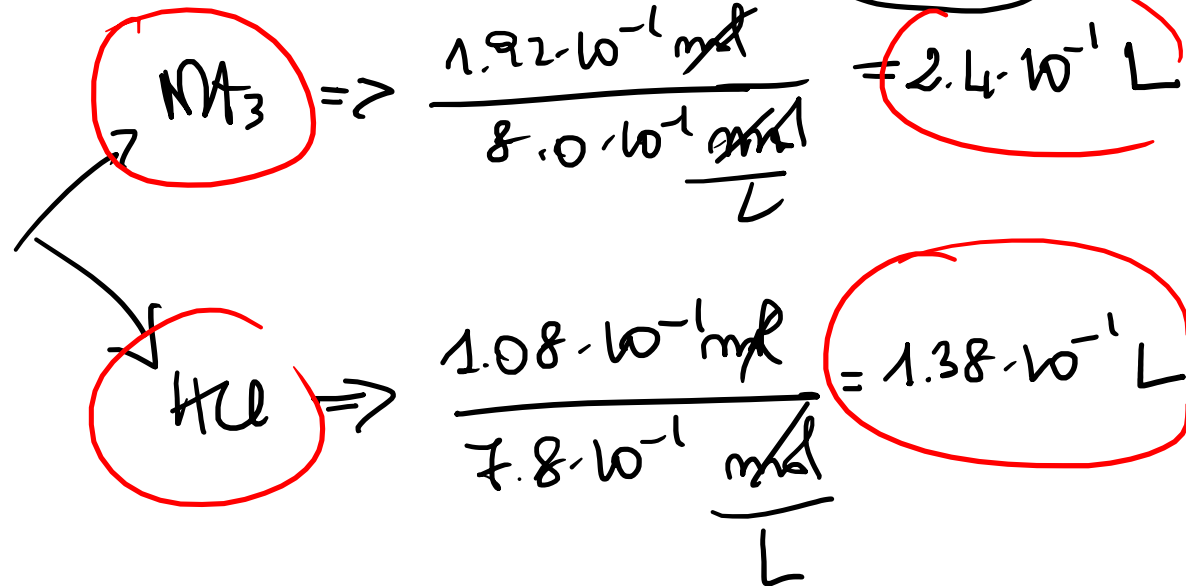
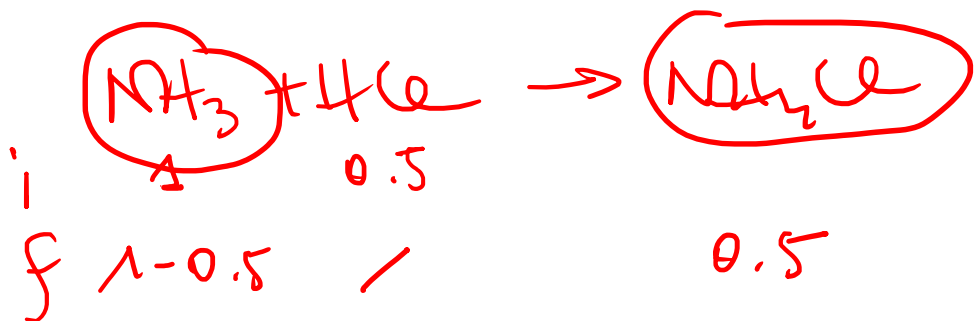
$$C_b = [\text{NH}_3] = 1.92 \cdot 10^{-1} \text{ M} \Rightarrow 1 \text{ L} \Rightarrow \underline{1.92 \cdot 10^{-1} \text{ mol NH}_3}$$

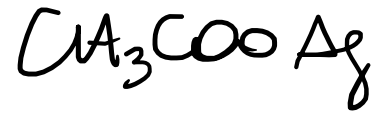
$$C_s = [\text{NH}_4^+] = (0.200 - 1.92 \cdot 10^{-1}) = 1.08 \cdot 10^{-1} \text{ M} \Rightarrow \underline{1.08 \cdot 10^{-1} \text{ mol NH}_4^+}$$



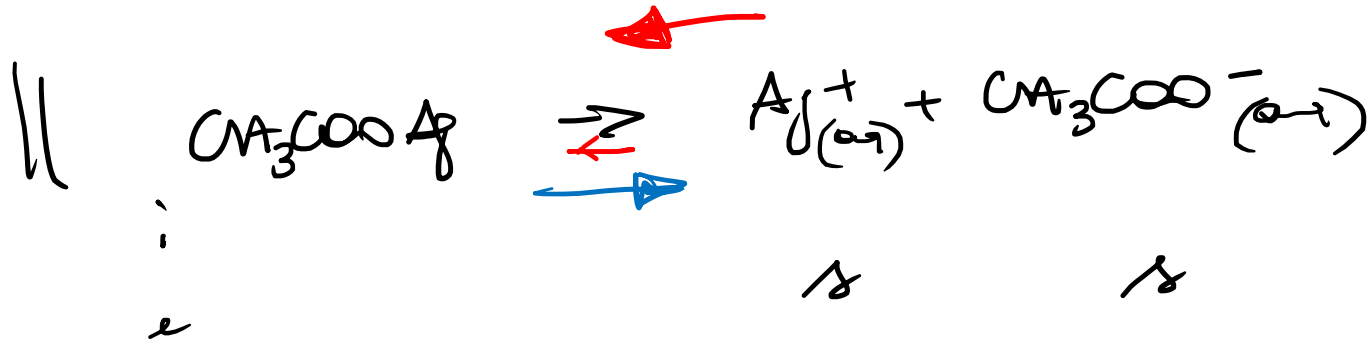
$$[\text{OH}^-] = K_b \cdot \frac{n_b}{n_s}$$

$$M = \frac{\text{mol}}{V} \Rightarrow \frac{\text{mol}}{M} = V$$

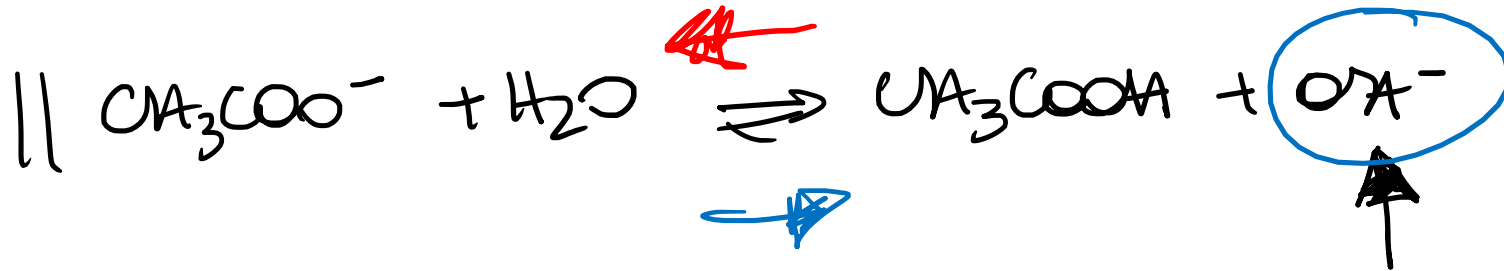




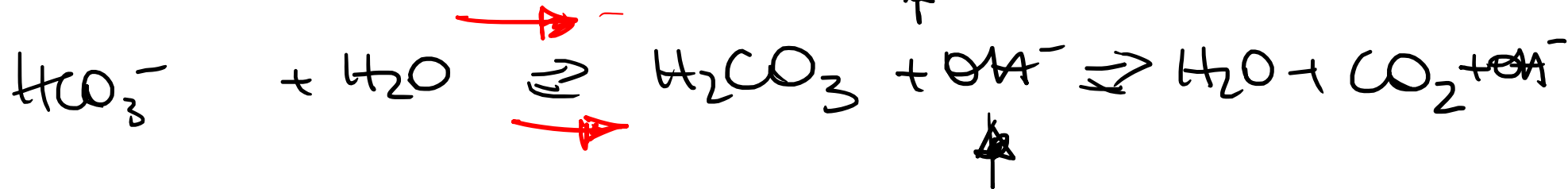
$$K_{ps} = 1.94 \cdot 10^{-3}$$



$$s = \sqrt{K_{ps}}$$







EX 3

$\Delta = ?$

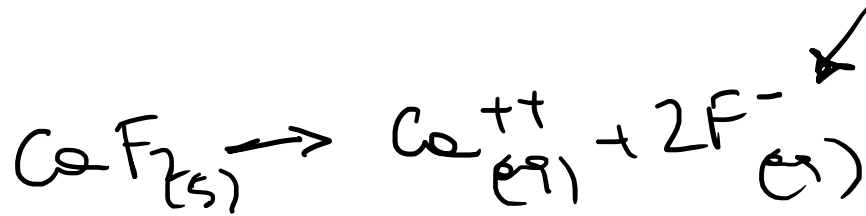
$\text{CaF}_2$  in una soluzione 2M HCl  
in una soluzione acquosa (acqua pura)

$$K_a = 3.5 \cdot 10^{-4}$$

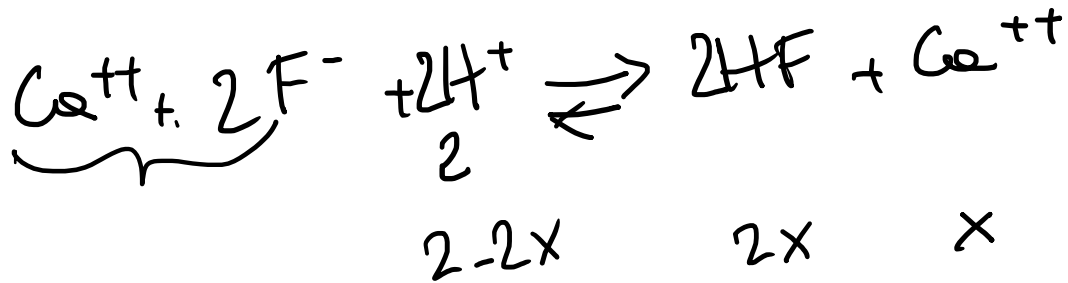
HF

HF = ?

$$K_{ps} \text{CaF}_2 = ~~3.45 \cdot 10^{-11}~~  
1.46 \cdot 10^{-10}$$



$$K_{ps} = [\text{Ca}^{++}][\text{F}^-]^2 = s \cdot (2s)^2 = 4s^3 \Rightarrow s = \sqrt[3]{\frac{1.46 \cdot 10^{-10}}{4}} = ~~1.17 \cdot 10^{-4} M~~ 3.32 \cdot 10^{-4} M$$



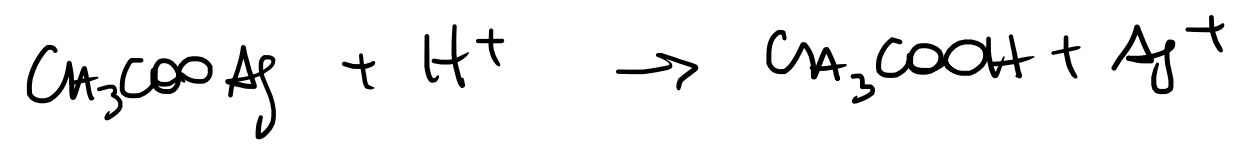
$$K = \frac{[\text{Ca}^{++}][\text{HF}]^2[\text{F}^-]^2}{[\text{CaF}_2][\text{H}^+]^2[\text{F}^-]^2}$$

$$K = \frac{(2x)^2 \cdot x}{2-2x} = 1.17 \cdot 10^{-3}$$

$$x = [\text{Ca}^{++}] = \underline{0.105 M} \quad K = \frac{K_{ps}}{K_a^2} = 1.17 \cdot 10^{-3}$$

(9)

ex 4



$\hat{\quad}$   
 $\sim$   
 $0,1$   
 $0,1-x$   
 $x$   
 $x$

$$K_{ps} = 1,94 \cdot 10^{-3}$$

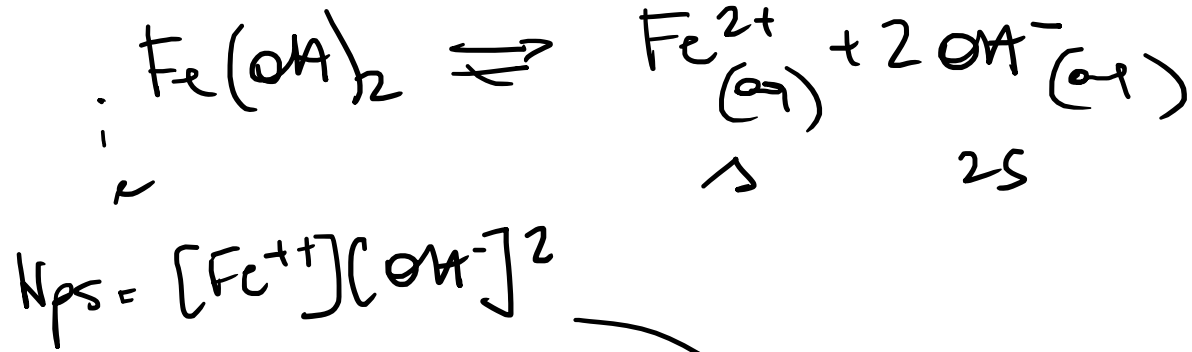
$$K_a \text{CH}_3\text{COOH} = 1,8 \cdot 10^{-5}$$

$\rho = ?$

$$K = \frac{[\text{Ag}^+][\text{CH}_3\text{COOH}][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOAg}][\text{H}^+][\text{CH}_3\text{COO}^-]} = \frac{K_{ps}}{K_a} = \frac{x^2}{0,1-x}$$

EX 5

~~K<sub>ps</sub>~~ = ?



$$K_{ps} = [\text{Fe}^{2+}][\text{OH}^-]^2$$

air

pOH = 14 - 9.06 = 4.94

$$[\text{OH}^-] = 10^{-4.94} = 1.15 \cdot 10^{-5} \text{ M} = 2\text{S}$$

$$\Delta = [\text{Fe}^{2+}] = \frac{1.15 \cdot 10^{-5} \text{ M}}{2} = 5.75 \cdot 10^{-6} \text{ M}$$

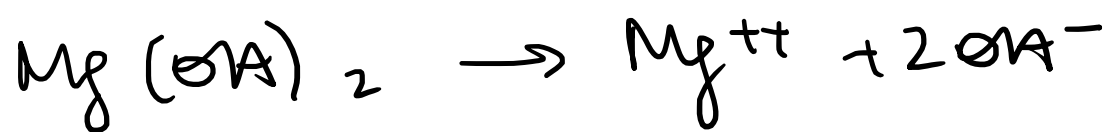
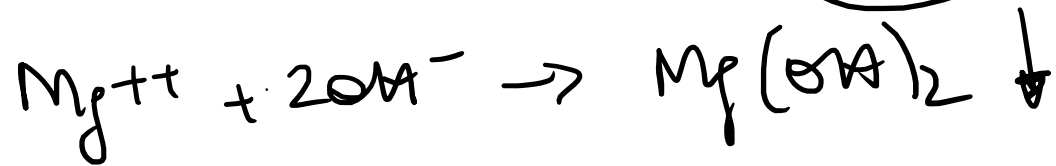
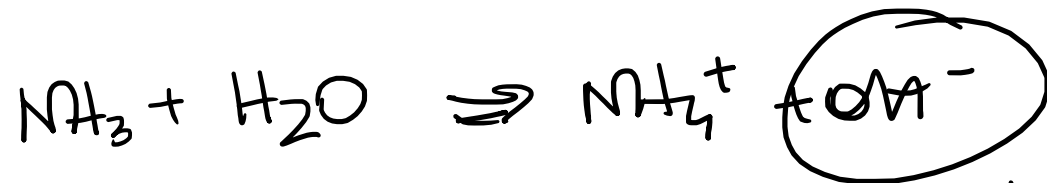
$$K_{ps} = (5.75 \cdot 10^{-6}) (1.15 \cdot 10^{-5})^2 = 7.60 \cdot 10^{-16}$$

(M)

EX6

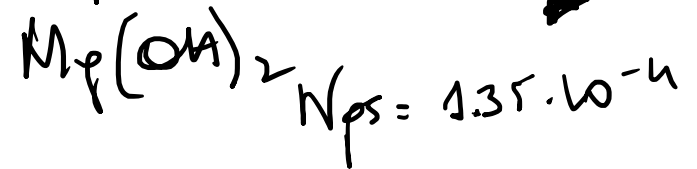
0.50 g  $MgSO_4$

250 mL 0.10 M  $NH_3$  ( $K_b = 1.76 \cdot 10^{-5}$ )



$$Q_{ps} > N_{ps}$$

Verificare se si ha precipitazione



$$[Mg^{++}] = \frac{0.50 \text{ g}}{120.4 \text{ g/mol}} / 0.250 \text{ L} = 1.66 \cdot 10^{-2} \text{ M}$$

$$[OH^-] = \sqrt{K_b \cdot C_b} = \sqrt{1.76 \cdot 10^{-5} \cdot 0.1 \text{ M}} = 1.3 \cdot 10^{-3} \text{ M}$$

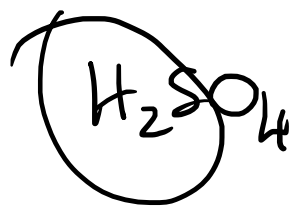
$$N_{ps} = [Mg^{++}][OH^-]^2$$

$$Q_{ps} = (1.66 \cdot 10^{-2})(1.3 \cdot 10^{-3})^2$$

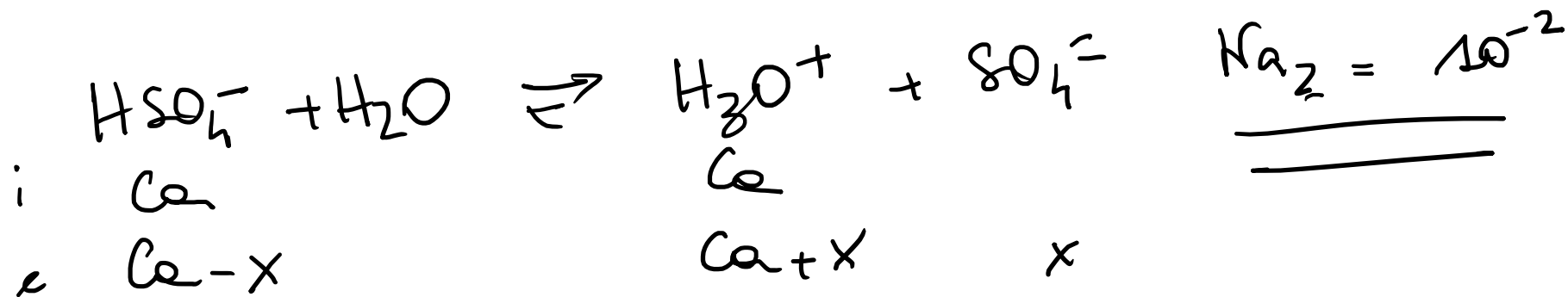
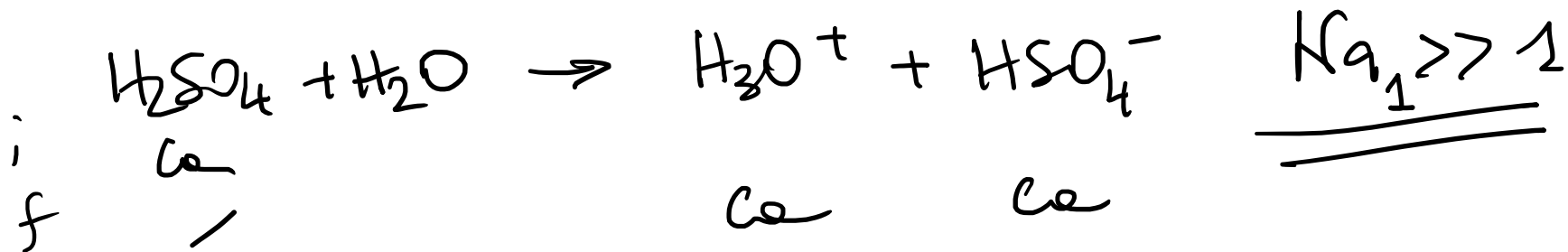
$$Q_{ps} < N_{ps}$$

non si ha precipitazione

(12)



ACIDI POLIPROTICI  $K_{a1} \gg K_{a2} (\gg K_{a3})$



$$K_{a2} = \underline{\underline{10^{-2}}} = \frac{(\cancel{C_0 + x})(x)}{\cancel{C_0 - x}}$$

EX 8

pH = ?



$10^{-4} \text{ M}$   
Ca



$$K_{a1} = 5.62 \cdot 10^{-2}$$

$$K_{a2} = 6.46 \cdot 10^{-5}$$

$$K_{a1} \gg K_{a2}$$

$$K_{a1} \gg C_a$$



i Ca

f /

Ca Ca



i  $10^{-4}$

e  $10^{-4} - x$

$10^{-4}$

$10^{-4} + x$  x

$K_{a2}$

(1/2)

$$K_{a2} = 6.46 \cdot 10^{-5} = \frac{(10^{-4} + x)(x)}{10^{-4} - x} \quad || \quad x = 3.3 \cdot 10^{-5} \text{ M}$$

$$[\text{H}_3\text{O}^+] = (10^{-4} + 3.3 \cdot 10^{-5}) \text{ M} = \underline{1.33 \cdot 10^{-4} \text{ M}}$$

$$\text{pH} = 3.88$$