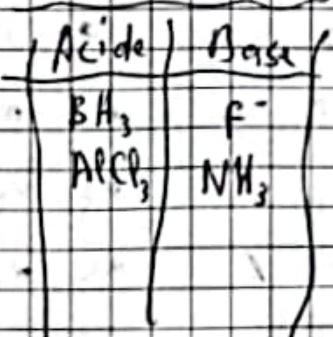


Serie N°2:

Ex 1: Brønsted

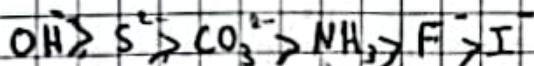
Acide	Base
NH_3^+	F^-
HSO_4^-	NH_3
CH_3NH_2^+	HSO_4^-
HS^-	HS^-
H_2PO_4^-	H_2PO_4^-
HF	

Lewis:



Les ampholytes: HSO_4^- , H_2PO_4^- , HS^-

Ex 2:



Ex 3 = $(\text{NH}_3^+, \text{NH}_2)$

$(\text{H}_2\text{SO}_4 / \text{HSO}_4^-)$

$(\text{C}_2\text{H}_5\text{COO}^- / \text{C}_2\text{H}_5\text{COO}^-)$

$(\text{H}_2\text{PO}_4^- / \text{HPO}_4^{2-})$

$(\text{Al}(\text{ClO}_4)_3^- / \text{Al}(\text{ClO}_4)_3^-)$

Ex 4:

$$1) \text{ a) } M = \frac{n}{V} \Rightarrow \frac{m}{MV} = \frac{1}{4} \text{ (verso x 10)}$$

$$M = 0,286 \text{ mol/l}$$

$$\text{b) } C_1 V_1 = C_2 V_2$$

$$C_2 = \frac{C_1 V_1}{V_2} = \frac{2 \times 150}{500}$$

$$C_2 = 0,6 \text{ mol/l}$$

$$\text{c) } n_1 = C_1 V_1 = 0,003 \text{ mol}$$

$$n_2 = C_2 V_2 = 0,008 \text{ mol} \Rightarrow n_T = 0,011 \text{ mol}$$

$$c = \frac{n_T}{V_T} = \frac{0,011}{200 \times 10^{-3}} = 0,055 \text{ mol/l}$$

$$\text{d) } C_m = 3 \text{ g/l}$$

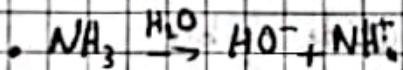
$$C_m = \frac{m}{V}$$

$$C.m = \frac{m}{M} \quad c = \frac{m}{MV} = \frac{C_m}{M}$$

$$c = \frac{3}{60} = 0,05 \text{ mol/l}$$

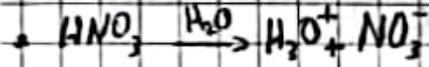
$$2) \text{ a) } \text{pH} = 14 + \log(0,286) = 13,45$$

$$[\text{pH} = 13,45] \quad \text{NaOH H}_2\text{O}, \text{Na}^+, \text{HO}^-$$

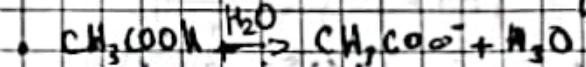


$$\text{pH} = 7 + \frac{1}{2} (\rho K_a + \log C_A) = 7 + \frac{1}{2} (9,25 + \log 0,055)$$

$$[\text{pH} = 11,77]$$



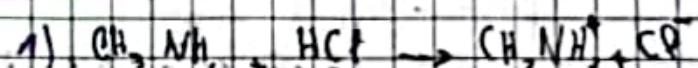
$$\text{pH} = -\log C_A = -\log 0,055 \quad [\text{pH} = 1,95]$$



$$\text{pH} = \frac{1}{2} (\rho K_a - \log C_A) = \frac{1}{2} (4,36 - \log 0,055)$$

$$[\text{pH} = 3,03]$$

Ex 5 =



b) nature =

$$V_{eq} = 100 \text{ mL}$$

$$V = \frac{1}{2} V_{eq} = 50 \text{ mL}$$

$$\rightarrow pH = pK_a = 10.7$$

$$3) \text{ a) } pH = 7 + \frac{pK_a + \log C_B}{2}$$

$$\Leftrightarrow [pH - 7 - \frac{1}{2} pK_a] = \log C_B$$

$$\log C_B = 9(11.85 - 7 - \frac{1}{2} \times 10.7)$$

$$C_B = 0.1 \text{ mol/L}$$

$$b) C_A V_A = C_B V_B$$

$$C_A = \frac{C_B V_B}{V_A} = \frac{0.1 \times 50}{100} = 0.05 \text{ M}$$

$$c) C_{\text{salt}} = \frac{n_A}{V_f} = \frac{n_B}{V_f} = \frac{0.1 \times 50}{150}$$

$$C_{\text{salt}} = 0.033 \text{ M}$$

4) a) Au point équivalent la nature de sel est acide faible

$$pH = \frac{1}{2} [pK_a - \log(C_{\text{sel}})]$$

$$pH = \frac{1}{2} [10.7 - \log(\frac{1}{30})]$$

$$pH = 6.08$$

b) • 80 mL of HCl (Base faible)

$$pH = pK_a + \log \left(\frac{n_L - n_B}{n_B} \right)$$

$$pH = 10.7 + \log \left(\frac{0.1 \times 50 - 0.05 \times 80}{0.05 \times 80} \right)$$

$$pH = 10.1$$

• 150 mL of HCl (acide fort)

$$pH = -\log \left(\frac{n_A - n_B}{V_f} \right)$$

$$pH = -\log \left(\frac{0.05 \times 150 - 0.1 \times 50}{150} \right)$$

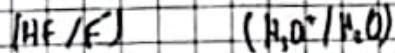
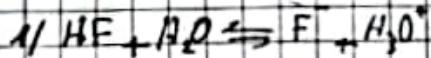
$$pH = 1.8$$

$$pH = 14 + \log C_A$$

$$\log C_A = pH - 14$$

$$C_A = 0.063 \text{ M}$$

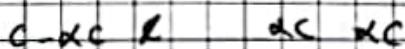
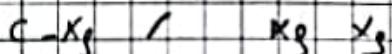
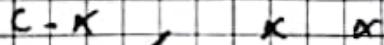
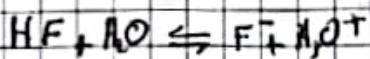
Ex 6:



$$2) \text{HF}, \text{F}^-, \text{H}_3\text{O}^+, \text{OH}^- / C = 1.25 \times 10^{-3} \text{ M}$$

~~on calcule~~

3) déduire la valeur de pK_a



$$K_a = \frac{[\text{H}_3\text{O}^+] [\text{F}^-]}{[\text{HF}]}$$

$$K_a = \frac{(\alpha C)^2}{C - \alpha C} = \frac{\alpha^2 C}{1 - \alpha}$$

$$pK_a = -\log \frac{\alpha^2 C}{1 - \alpha}$$

$$pK_a = -\log C - \log \frac{\alpha^2}{1 - \alpha}$$

$$pK_a = 2.9 - \log \frac{0.5}{0.5} = 3.2$$

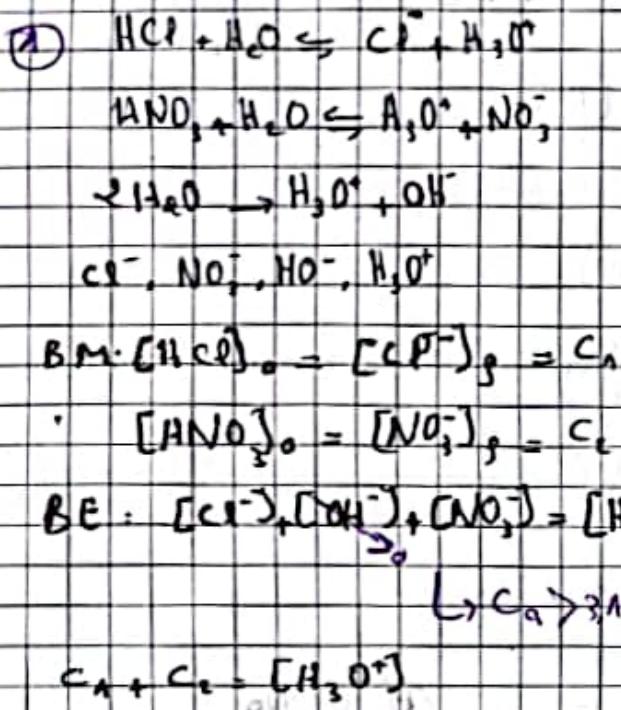
$$4) K_a = \frac{\alpha^2 C}{1 - \alpha}$$

$$C' = \frac{K_a (1 - \alpha)}{\alpha^2} = \frac{10^{-pK_a} (1 - \alpha)}{\alpha^2}$$

$$= \frac{10^{-3.2} (1 - 0.33)}{0.95^2} = 3.5 \times 10^{-5} \text{ mol/L}$$

$$5) pH = -\log \alpha C' = -\log(0.95 \times)$$

EX 7 -



$$\frac{C_a V_a}{V_T} + \frac{C_b V_b}{V_T} = [\text{H}_3\text{O}^+]$$

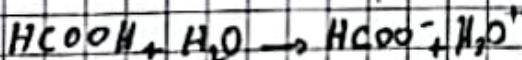
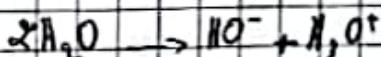
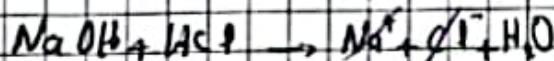
$$[\text{H}_3\text{O}^+] = \frac{0.1 \times 50}{130} + \frac{0.02 \times 80}{130}$$

$$[\text{H}_3\text{O}^+] = 0.05 \text{ M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = 1.3$$

(2) HCOOH (Acide faible)

NaCl (sol) $\text{pH} = 7$



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{HCOO}^-]}{[\text{HCOOH}]}$$

$$\text{BM: } [\text{HCOOH}]_0 = [\text{HCOO}^-]_0 + [\text{HCOOH}]$$

$$\text{BE: } [\text{HCOO}^-] + [\text{Cl}^-] + [\text{OH}^-] =$$

$$[\text{Na}^+] + [\text{H}_3\text{O}^+]$$

$$[\text{HCOO}^-] + [\text{H}_3\text{O}^+] = [\text{H}_3\text{O}^+]$$

$$[\text{HCOO}^-] > 3.16 \times 10^{-7}$$

$$[\text{HCOO}^-] = \frac{C_a V_a}{V_T} = \frac{0.2 \times 10^{-2}}{22}$$

$$[\text{HCOO}^-] = 6.18 \times 10^{-2}$$

$$\alpha \ll 1 \quad K_a = \frac{K_w}{C}$$

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{10^{-5.75}}{0.2}}$$

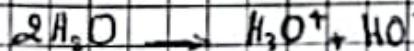
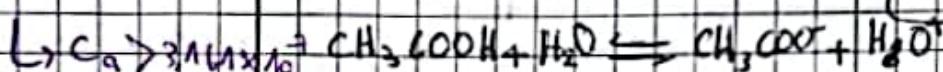
$$\alpha = 0.03$$

$$(3) \text{ HCOOH} \quad \left\{ \begin{array}{l} C_a = 0.4 \text{ M} \\ V_a = 50 \text{ ml} \end{array} \right.$$

$$\text{CH}_3\text{COOH} \quad \left\{ \begin{array}{l} V_1 = 2 \text{ ml} \\ V_2 = 50 \text{ ml} \end{array} \right.$$

$$K_a = 10^{-5}$$

$$\text{HCOOK} + \text{H}_2\text{O} \rightleftharpoons \text{HCOO}^- + \text{H}_3\text{O}^+ \quad C_2 = 0.01$$



Zes espèces: HCOOK , HCOO^- , CH_3COOH , CH_3COO^- , H_3O^+ , OH^-

$$\text{BM: } C'_1 = [\text{HCOOK}] + [\text{HCOO}^-] \quad (1)$$

$$C'_2 = [\text{CH}_3\text{COOH}] + [\text{CH}_3\text{COO}^-] \quad (2)$$

$$\text{BE: } [\text{H}_3\text{O}^+] = [\text{HCOO}^-] + [\text{CH}_3\text{COO}^-] + [\text{HO}^-] \quad (3)$$

$$K_{a_1} = \frac{[\text{HCOO}^-][\text{H}_3\text{O}^+]}{[\text{HCOOH}]} \quad (4)$$

$$K_{a_2} = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]} \quad (5)$$

$$C'_1 \text{ et } C'_2 > 3.16 \times 10^{-7} \text{ M}$$

$$[\text{H}_3\text{O}^+] \gg [\text{HO}^-]$$

Acides faibles

$$\alpha_1 = \sqrt{\frac{K_{a_1}}{C'_1}} = \sqrt{\frac{10^{-5.75}}{0.11}} = 0.04$$

$$\alpha_2 = \sqrt{\frac{K_{a_2}}{C'_2}} = \sqrt{\frac{10^{-4.75}}{0.01}} = 0.01$$

$$\alpha_1 = \alpha_2 \ll 0.05$$

on néglige $[\text{CH}_3\text{COO}^-]$ et $[\text{HCOO}^-]$

$$① \rightarrow C'_1 = [HCOOH]$$

$$② \rightarrow C'_2 = [CH_3COO^-]$$

$$③ \rightarrow [H_3O^+] = [CH_3COO^-] + [ACOO^-]$$

$$④ \rightarrow [HCOO^-] = \frac{K_{ac}}{[H_3O^+]} [HCOOH]$$

$$⑤ \rightarrow [CH_3COO^-] = \frac{K_{ac} [CH_3COOH]}{[H_3O^+]}$$

$$[H_3O^+] = \frac{K_{ac} [HCOOH]}{[H_3O^+]} + \frac{K_{ac} [CH_3COO^-]}{[H_3O^+]}$$

$$[H_3O^+]^2 = C'_1 K_{ac} + C'_2 K_{ac}$$

$$[H_3O^+] = \sqrt{C'_1 K_{ac} + C'_2 K_{ac}}$$

$$pH = -\frac{1}{2} \log(C'_1 K_{ac} + C'_2 K_{ac})$$

$$pH = 2.35$$

$$⑥ NaOH \left\{ \begin{array}{l} C_1 = 0.1 M \\ V_1 = 100 \text{ mL} \end{array} \right. \left\{ \begin{array}{l} C_2 = 1 M \\ V_2 = 25 \text{ mL} \end{array} \right.$$

$$\begin{aligned} C'_1 &= \frac{C_1 V_1}{V_T} \quad | \quad NaOH \rightleftharpoons Na^+ + OH^- \\ C'_2 &= \frac{C_2 V_2}{V_T} \quad | \quad C_2 H_5 NH_2 + H_2O \rightleftharpoons C_2 H_5 NH_3^+ + OH^- \\ &\quad | \quad 2H_2O \rightleftharpoons H_3O^+ + OH^- \end{aligned}$$

$$BE = [Na^+] + [H_3O^+] + [C_2H_5NH_3^+] - [OH^-]$$

B.M.:

$$[NaOH] = [Na^+] = C'_1$$

$$[C_2H_5NH_3^+] = [C_2H_5NH_2^+] + [C_2H_5NH_3^+] = C'_2$$

on néglige $[H_3O^+]$

$$[Na^+] + [C_2H_5NH_3^+] = [OH^-]$$

$$\alpha = \sqrt{\frac{k_b}{C'_1}} = \sqrt{\frac{K_e}{K_{ac} C'_1}} =$$

$$\alpha = 0.04 \quad \sim 0.05$$

$$\text{donc } C'_1 = [C_2H_5NH_3^+]$$

$$[Na^+] = C'_1$$

$$[C_2H_5NH_2^+] = \alpha C'_1$$

$$[OH^-] = C'_1 + \alpha C'_1$$

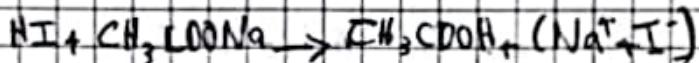
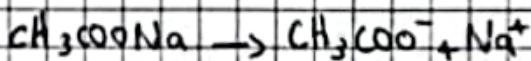
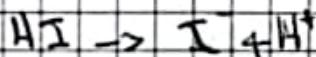
$$\frac{K_e}{[H_3O^+]} = C'_1 + \alpha C'_1$$

$$[H_3O^+] = \frac{K_e}{C'_1 + \alpha C'_1} \Rightarrow pH = -\log \left(\frac{K_e}{C'_1 + \alpha C'_1} \right)$$

$$pH = 12.95$$

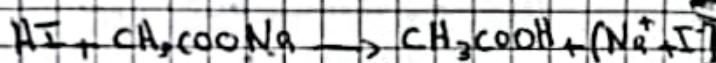
⑤ HI et CH_3COONa

$$\left\{ \begin{array}{l} 0.2 M \\ 50 \text{ mL} \end{array} \right. \quad \left\{ \begin{array}{l} 10^{-3} M \\ 100 \text{ mL} \end{array} \right.$$



$$C'_1 = \frac{C_1 V_1}{V_T} = 0.066 M$$

$$C'_2 = \frac{C_2 V_2}{V_T} = 0.066$$



$$C'_1 \quad C'_2 \quad : \quad : \quad 0.066 \quad 0.066$$

acide faible $\quad pK_a = 4.76$

$$pH = \frac{1}{2} (pK_a - \log C) = 9.97$$

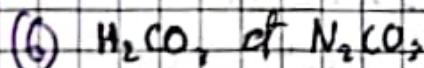
$$\bullet HI + CH_3COONa$$

$$\left\{ \begin{array}{l} 2 \times 10^{-3} \\ 50 \text{ mL} \end{array} \right. \quad \left\{ \begin{array}{l} 10^{-2} \\ 100 \text{ mL} \end{array} \right. \quad \left\{ \begin{array}{l} C = 0 \\ C = 0 \end{array} \right.$$

$$pH = pK_a + \log \frac{[CH_3COO^-]}{C_b}$$

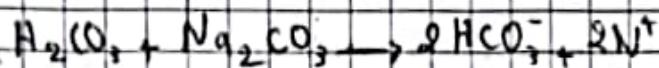
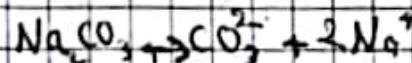
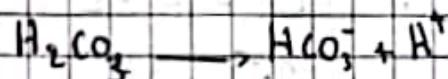
$$= 4.76 + \log \frac{4 \times 10^{-3}}{10^{-3}} \\ = 5.36$$

Ex



$$\left. \begin{array}{l} 2 \times 10^{-2} M \\ 10 \text{ mL} \end{array} \right\} 10^{-2} M \quad C_1 = 0.67 \times 10^{-2} M$$

$$\left. \begin{array}{l} 20 \text{ mL} \end{array} \right\} 2 \times 10^{-2} M \quad C_2 = 0.67 \times 10^{-2} M$$



$$\begin{matrix} C & C & 0 & 0 \\ 0 & 0 & 2c & 2c \end{matrix}$$

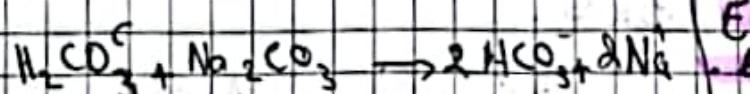
$$pH = (pK_{a1} + pK_{a2}) \frac{1}{2}$$

$$= (6.35 + 10.33) \times \frac{1}{2} \quad (\text{because it's a diacid})$$

$$pH = 8.34$$

$$\bullet H_2CO_3 \left\{ \begin{array}{l} 2 \times 10^{-2} M \\ 25 \text{ mL} \end{array} \right. \quad C_1 = 10^{-2} M$$

$$Na_2CO_3 \left\{ \begin{array}{l} 10^{-2} M \\ 25 \text{ mL} \end{array} \right. \quad C_2 = 0.5 \times 10^{-2}$$



$$\begin{matrix} 10^{-2} & 0.5 \times 10^{-2} & 0 & 0 \end{matrix}$$

$$\begin{matrix} 0.5 \times 10^{-2} & 0 & 2 \times 0.5 \times 10^{-2} & 2 \times 0.5 \times 10^{-2} \end{matrix}$$

$$pH = pK_a + \log \frac{C_b}{C_a}$$

$$= 6.35 + \log 2$$

$$pH = 6.65$$