Serie N°2 :

Ex1 : Bronsted

Acide	Base
NH_4^+	F^-
HSO_4^-	NH_3
$CH_3NH_3^+$	HSO_4^-
HS^-	HS^-
$H_2PO_4^-$	$H_2PO_4^-$
HF	

Lewis :

Acide	Base
BH_3	F^-
$AlCl_3$	NH_3

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

Ex2 :

$OH^- > S^{2-} > CO_3^{2-} > NH_3 > F^- > I^-$

Ex3 : (NH_4^+ , NH_3)

(H_2SO_4 / HSO_4^-)

$(H_3PO_4 / H_2PO_4^-)$

$(C_6H_5COOH / C_6H_5COO^-)$

$(H_2PO_4^- / HPO_4^{2-})$

$(H_2CrO_4 / HCrO_4^-)$

Ex4 :

1) a) $M = \frac{n}{V} = \frac{m}{MV} = \frac{4}{40 \times 350 \times 10^{-3}}$

$M = 0,286$ M mol/l

b) $C_1V_1 = C_2V_2$

$C_2 = \frac{C_1V_1}{V_2} = \frac{2 \times 150}{500}$

$C_2 = 0,6$ mol/L

c) $n_1 = C_1V_1 = 0,003$ mol

$n_2 = C_2V_2 = 0,008$ mol

$\Rightarrow n_T = 0,011$

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

d) $C_m = 3$ g/l $\quad C_m = \frac{m}{V}$

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

$C = \frac{3}{60} = 0,05$ mol/L

2) • $pH = 14 + \log(0,286) = 13,45$

$\boxed{pH = 13,45}$ $NaOH \xrightarrow{H_2O} Na^+ + HO^-$

• $NH_3 \xrightarrow{H_2O} HO^- + NH_4^+$

$pH = 7 + \frac{1}{2}(pK_a + \log C_b) = 7 + \frac{1}{2}(9,25 + \log 0,1$

$\boxed{pH = 11,77}$

• $HNO_3 \xrightarrow{H_2O} H_3O^+ + NO_3^-$

$pH = -\log C_A = -\log 0,055$ $\boxed{pH = 1,25}$

• $CH_3COOH \xrightarrow{H_2O} CH_3COO^- + H_3O^+$

$pH = \frac{1}{2}(pK_a - \log C_A) = \frac{1}{2}(4,76 - \log 0,0$

$\boxed{pH = 3,03}$

Ex5 :

1) $CH_3NH_2 + HCl \longrightarrow CH_3NH_3^+ + Cl^-$

2) nature :

$V_{eq} = 100$ ml

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

$\Rightarrow pH = pK_a = 10,7$

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

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

$\log C_B = 2(11,85 - 7 - \frac{1}{2} \times 10,7)$

$C_B = 0,1$ mol/L

b) $C_a V_a = C_b V_b$

$C_a = \frac{C_b V_b}{V_a} = \frac{0,1 \times 50}{100} = 0,05$ M

c) $C_{salt} = \frac{n_a}{V_t} = \frac{n_b}{V_t} = \frac{0,1 \times 50}{150}$

$C_{salt} = 0,033$ M

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

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

$pH = \frac{1}{2}[10,7 - \log(\frac{1}{30})]$

$pH = 6,08$

b) • 80 ml of HCl (Base faible)

$pH = pK_a + \log(\frac{n_b - n_a}{n_a})$

$pH = 10,7 + \log(\frac{0,1 \times 50 - 0,05 \times 80}{0,05 \times 80})$

$pH = 10,1$

• 150 ml of HCl (acide fort)

$pH = -\log(\frac{n_a - n_b}{V_t})$

$pH = -\log(\frac{0,05 \times 150 - 0,1 \times 50}{150})$

$pH = 1,8$

$pH = 14 + \log C_B$

$\log C_B = pH - 14$

$C_B = 0,63$ M

Ex 6 :

1/ $HF + H_2O \rightleftharpoons F^- + H_3O^+$

(HF/F^-) (H_3O^+/H_2O)

2) $HF, F^-, H_3O^+, OH^- / C = 1,25 \times 10^{-3}$ M

3) déduire la valeur de pK_a

$HF + H_2O \rightleftharpoons F^- + H_3O^+$

	c /	0	0
	$c - x$ /	x	x
	$c - x_f$ /	x_f	x_f
	$c - \alpha c$ /	αc	αc

$K_a = \frac{[H_3O^+][F^-]}{[HF]}$

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

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

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

$pK_a = 2,9 - \log \frac{0,5^2}{0,5} = 3,2$

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

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

$= \frac{10^{-3,2}(1 - 0,95)}{0,95^2} = 3,5 \times 10^{-5}$ mol/L

5) $pH = -\log \alpha c' = -\log(0,95 \times$

Ex 7 :

① $HCl + H_2O \leftrightharpoons Cl^- + H_3O^+$

$HNO_3 + H_2O \leftrightharpoons H_3O^+ + NO_3^-$

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

$Cl^-, NO_3^-, HO^-, H_3O^+$

BM : $[HCl]_0 = [Cl^-]_f = C_1$

$[HNO_3]_0 = [NO_3^-]_f = C_2$

BE : $[Cl^-] + [OH^-] + [NO_3^-] = [H_3O^+]$

$\hookrightarrow C_a > 3,16 \times 10^{-7}$

$C_1 + C_2 = [H_3O^+]$

$\frac{C_a V_a}{V_T} + \frac{C_a' V_2}{V_T} = [H_3O^+]$

$[H_3O^+] = \frac{0,1 \times 50}{130} + \frac{0,02 \times 80}{130}$

$[H_3O^+] = 0,05\ M$

$pH = -\log [H_3O^+] = 1,3$

② $HCOOH$ (Acide faible)

$NaCl$ (sel) $pH = 7$

$NaOH + HCl \rightarrow Na^+ + Cl^- + H_2O$

$2H_2O \rightarrow HO^- + H_3O^+$

$HCOOH + H_2O \rightarrow HCOO^- + H_3O^+$

$K_a = \frac{[H_3O^+][ACOO^-]}{[HCOOH]}$

BM : $[HCOOH]_0 = [HCOO^-]_f + [HCOOH]$

BE : $[HCOO^-] + [Cl^-] + [HO^-] = [Na^+] + [H_3O^+]$

$[HCOO^-] + [HO^-] = [H_3O^+]$

$[HCOOH] > 3,16 \times 10^{-7}$

$[HCOOH] = \frac{C_a V_a}{V_T} = \frac{0,2 \times 12}{32}$

$[HCOOH] = 6,48 \times 10^{-2}$

$\alpha < < 1$ $\quad K_a = \alpha^2 C$

$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{10^{-3,75}}{0,2}}$

$\alpha = 0,03$

③ $HCOOH \begin{cases} C_1 = 0,4\ M \\ V_1 = 20\ ml \end{cases}$ $\quad CH_3COOH \begin{cases} V_2 = 2 \times 1 \\ V_2 = 50\ m \end{cases}$

$\alpha < 5\% = 0,05$ $\quad C_1' = \frac{C_1 V_1}{V_T} = 0,1$

$HCOOH + H_2O \leftrightharpoons HCOO^- + H_3O^+$ $\quad C_2' = 0,01$

$\hookrightarrow CH_3COOH + H_2O \leftrightharpoons CH_3COO^- + H_3O^+$

$2H_2O \rightarrow H_3O^+ + HO^-$

Les espèces : $HCOOH, HCOO^-, CH_3COOH, CH_3COO^-, H_3O^+, HO^-$

BM : $C_1' = [HCOOH] + [HCOO^-]$ (1)

$C_2' = [CH_3COOH] + [CH_3COO^-]$ (2)

BE : $[H_3O^+] = [HCOO^-] + [CH_3COO^-] + [HO^-]$ (3)

$K_{a_1} = \frac{[HCOO^-][H_3O^+]}{[HCOOH]}$ (4)

$K_{a_2} = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$ (5)

C_1' et $C_1' >> 3,16 \times 10^{-7}\ M$

$[H_3O^+] >> [HO^-]$

2 acides faibles

$\alpha_1 = \sqrt{\frac{K_{a_1}}{C_1'}} = \sqrt{\frac{10^{-3,75}}{0,1}} = 0,04$

$\alpha_2 = \sqrt{\frac{K_{a_2}}{C_2'}} = \sqrt{\frac{10^{-4,76}}{0,01}} = 0,04$

$\alpha_1 = \alpha_2 << 0,05$

on néglige $[CH_3COO^-]$ et $[HCOO^-]$

① $C_1' = [HCOOH]$

② $C_2' = [CH_3COOH]$

③ $[H_3O^+] = [CH_3COO^-] + [HCOO^-]$

④ $[HCOO^-] = \frac{K_{a1}[HCOOH]}{[H_3O^+]}$

⑤ $[CH_3COO^-] = \frac{K_{a2}[CH_3COOH]}{[H_3O^+]}$

$$[H_3O^+] = \frac{K_{a1}[HCOOH]}{[H_3O^+]} + \frac{K_{a2}[CH_3COOH]}{[H_3O^+]}$$

$$[H_3O^+]^2 = C_1' K_{a1} + C_2' K_{a2}$$

$$[H_3O^+] = \sqrt{C_1' K_{a1} + C_2' K_{a2}}$$

$$pH = \frac{1}{2} \log(C_1' K_{a1} + C_2' K_{a2})$$

pH = 2,35

④ NaOH $\begin{cases} C_1 = 0,1\ M \\ V_1 = 100\ ml \end{cases}$ $C_2H_5NH_2$ $\begin{cases} C_2 = 1\ M \\ V_2 = 25\ ml \end{cases}$

$$C_1' = \frac{C_1 V_1}{V_T}$$

$$C_2' = \frac{C_2 V_2}{V_T}$$

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

$C_2H_5NH_2 + H_2O \rightleftharpoons C_2H_5NH_3^+ + HO^-$

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

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

BM :

$[NaOH] = [Na^+] = C_1'$

$[C_2H_5NH_2]_i = [C_2H_5NH_3^+] + [C_2H_5NH_2] = C_2'$

on néglige $[H_3O^+]$

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

$$\alpha = \sqrt{\frac{K_b}{C_2'}} = \sqrt{\frac{K_e}{K_a C_2'}} =$$

$\alpha = 0,04$ < 0,05

donc $C_2' = [C_2H_5NH_2]$

$[Na^+] = C_1'$

$[C_2H_5NH_3^+] = \alpha C_2'$

$[OH^-] = C_1' + \alpha C_2'$

$$\frac{K_e}{[H_3O^+]} = C_1' + \alpha C_2'$$

$$[H_3O^+] = \frac{K_e}{C_1' + \alpha C_2'} \Rightarrow pH = -\log\left(\frac{K_e}{C_1' + \alpha C_2'}\right)$$

pH = 12,95

⑤ HI et CH_3COONa

$\begin{cases} 0,2\ M \\ 50\ ml \end{cases}$ $\begin{cases} 10^{-1}\ M \\ 100\ ml \end{cases}$

$HI \rightarrow I^- + H^+$

$CH_3COONa \rightarrow CH_3COO^- + Na^+$

$HI + CH_3COONa \rightarrow CH_3COOH + (Na^+ + I^-)$

$$C_1' = \frac{C_1 V_1}{V_T} = 0,066\ M$$

$$C_2' = \frac{C_2 V_2}{V_T} = 0,066$$

$HI + CH_3COONa \rightarrow CH_3COOH + (Na^+ + I^-)$

	C_2'	C_1'	0	0
	0	0	0,066	0,066

acide faible $pK_a = 4,76$

$$pH = \frac{1}{2}(pK_a - \log C) = 2,97$$

• HI et CH_3COONa

$\begin{cases} 2 \times 10^{-3} \\ 50\ ml \end{cases}$ $\begin{cases} 10^{-2} \\ 50\ ml \end{cases}$

$$pH = pKa + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

$$= 4.76 + \log \frac{4 \times 10^{-2}}{10^{-1}}$$

$$= 5.36$$

Ex

⑥ H_2CO_3 et Na_2CO_3

2×10^{-2} M, 10 ml { 10^{-2} M, 20 ml $C_1' = 0,67 \times 10^{-2}$ M

$C_2' = 0,67 \times 10^{-2}$ M

$$H_2CO_3 \longrightarrow HCO_3^- + H^+$$

$$Na_2CO_3 \longrightarrow CO_3^{2-} + 2Na^+$$

$$H_2CO_3 + Na_2CO_3 \longrightarrow 2HCO_3^- + 2Na^+$$

c	c	0	0
0	0	2c	2c

$$pH = (pKa_1 + pKa_2)\frac{1}{2}$$

(because it's a diacide)

$$= (6.35 + 10.33) \times \frac{1}{2}$$

$$pH = 8.34$$

• H_2CO_3 { 2×10^{-2} M, 25 ml $C_1' = 10^{-2}$ M

Na_2CO_3 { 10^{-2} M, 25 ml $C_2' = 0,5 \times 10^{-2}$

E

$$H_2CO_3 + Na_2CO_3 \longrightarrow 2HCO_3^- + 2Na^+$$

10^{-2}	$0,5 \times 10^{-2}$	0	0
$0,5 \times 10^{-2}$	0	$2 \times 0,5 \times 10^{-2}$	$2 \times 0,5 \times 10^{-2}$

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

$$= 6,35 + \log 2$$

$$pH = 6,65$$