



-1-4

-2-4

3-4

pH

-4-4

$pK_A$   $K_A$

-5-4

-

-6-4

-7-4

-

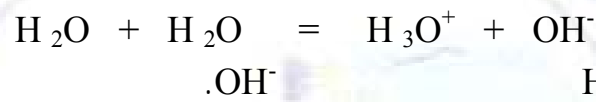
:

-1-4

$$[H_3O^+] = 10^{-7} \text{ mol/L} \quad 25^\circ\text{C} \quad \text{pH} = 7$$



:



$$[H_3O^+] = [OH^-] = 10^{-7} \text{ mol/L} \quad 25^\circ\text{C}$$

:

-2-4

$$m = 1000 \text{ g} \quad 1 \text{ L}$$

$$n = \frac{m}{M} = \frac{1000}{18} = 55,6 \text{ mol}$$

:

$$n_{H_3O^+_{eq}} = [H_3O^+]V = 10^{-7} \text{ mol}$$

$$n_{OH^-_{eq}} = [OH^-]V = 10^{-7} \text{ mol}$$

:25°C

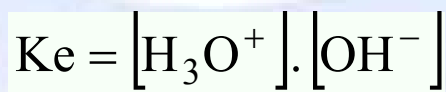
		$2 \text{H}_2\text{O}$	=	$\text{H}_3\text{O}^+_{(\text{aq})}$	+ $\text{OH}^-_{(\text{aq})}$
	التقدم : 0	55,6		0	0
	$X_{\text{max}}$ : التقدم	$55,6 - 2X_{\text{max}} = 0$		$X_{\text{max}} = 27,8$	$X_{\text{max}} = 27,8$
	$X_{\text{eq}}$ :	$55,6 - 2X_{\text{eq}} \approx 55,6$		$X_{\text{eq}} = 10^{-7}$	$X_{\text{eq}} = 10^{-7}$

$$\tau = \frac{X_{\text{eq}}}{X_{\text{max}}} = 3,6 \cdot 10^{-9}$$

$\tau < 1$

3-4

.Ke



درجة الحرارة (°C)	0	25	50	100
Ke	$0,10 \times 10^{-14}$	$1,0 \times 10^{-14}$	$5,5 \times 10^{-14}$	$55 \times 10^{-14}$
pKe = - log Ke	15	14	13,3	12,3

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} \quad \text{pH} = -\log [\text{H}_3\text{O}^+]$$

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

$$-\log K_e = -\log([\text{H}_3\text{O}^+][\text{OH}^-]) = -\log[\text{H}_3\text{O}^+] - \log[\text{OH}^-]$$

$$\text{p}K_e = \text{pH} - \log[\text{OH}^-]$$

$$\text{pH} = \text{p}K_e + \log[\text{OH}^-]$$

$$\log[\text{OH}^-] = \text{pH} - \text{p}K_e$$

$$[\text{OH}^-] = 10^{\text{pH} - \text{p}K_e}$$

$$: \quad \text{p}K_e = 14 \quad 25^\circ\text{C}$$

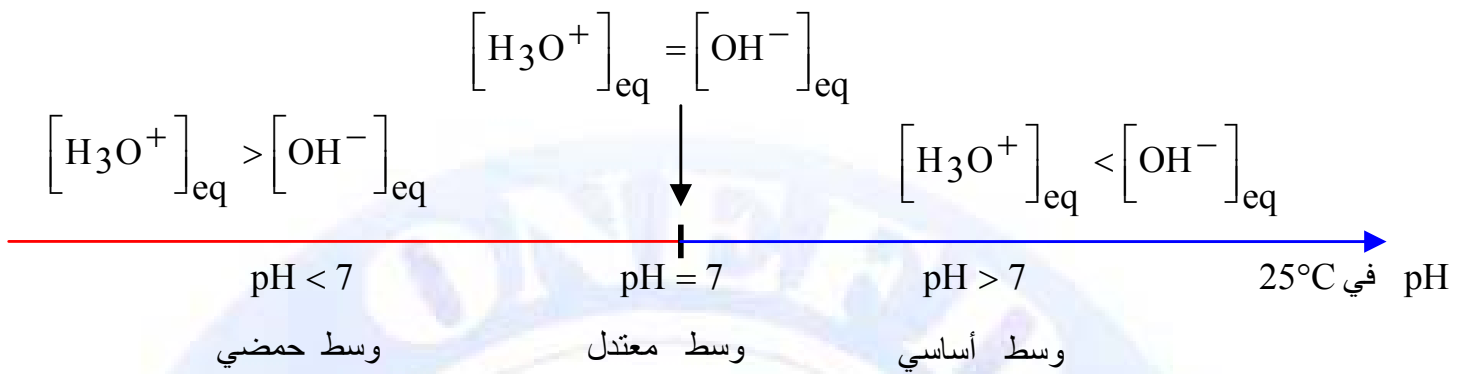
$$\text{pH} = 14 + \log[\text{OH}^-]$$

$$[\text{OH}^-] = 10^{\text{pH} - 14}$$

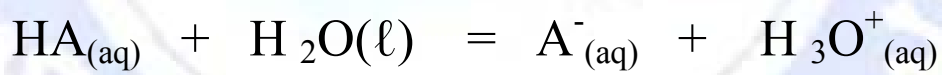
$$n_{\text{H}_3\text{O}^+} = n_{\text{OH}^-} \quad \bullet$$

$$N_{\text{H}_3\text{O}^+} > N_{\text{OH}^-} \quad \bullet$$

$$N_{\text{H}_3\text{O}^+} < N_{\text{OH}^-} \quad \bullet$$



#### -5-4 $K_A$ $pK_A$ :



$$K_A = \frac{[H_3O^+]_{eq} \cdot [A^-]_{eq}}{[AH]_{eq}}$$

$$K_A = \frac{[H_3O^+]_{eq} \cdot [\text{أساس}]_{eq}}{[\text{حمض}]_{eq}}$$

$$pK_A = -\log K_A$$

**pK<sub>A</sub> pH**

:

$$K_A = \frac{[H_3O^+]_{eq} \cdot [أساس]_{eq}}{[حمض]_{eq}}$$

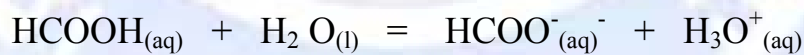
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$$-\log K_A = pK_A = -\log[H_3O^+]_{eq} - \log \frac{[أساس]_{eq}}{[حمض]_{eq}}$$

، نعوض في العلاقة السابقة، لنجد:  $pH = -\log [H_3O^+]$

$$pH = pK_A + \log \frac{[أساس]_{eq}}{[حمض]_{eq}}$$

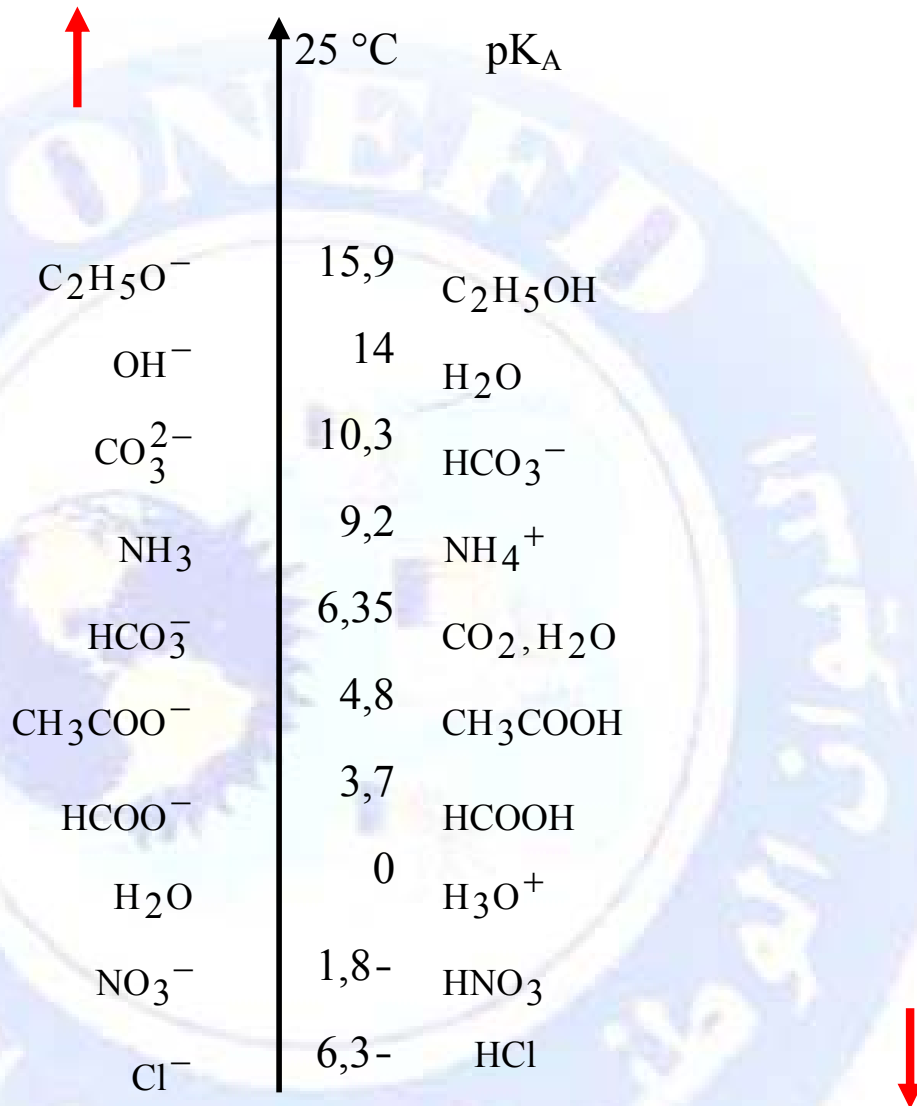
**:1**



$$K_A = \frac{[H_3O^+]_{eq} \cdot [HCOO^-]_{eq}}{[HCOOH]_{eq}}$$

$$pK_A = 3,7$$

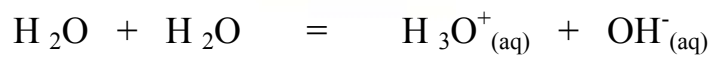
$$K_A = 1,9 \cdot 10^{-4} : 25^\circ\text{C}$$



:2

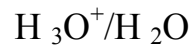
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H<sub>2</sub>O/OH<sup>-</sup>



$$K_{A_1} = [\text{H}_3\text{O}^+][\text{OH}^-] = 10^{-14} \quad 25^\circ\text{C}$$

$$pK_{A_1} = -\log K_{A_1} = 14$$

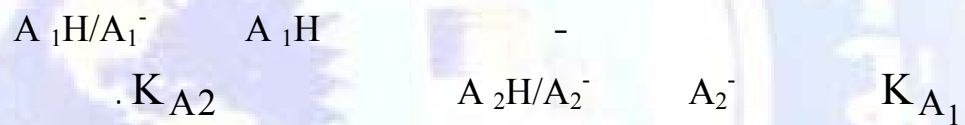


$$K_{A_2} = \frac{[\text{H}_3\text{O}^+]}{[\text{H}_3\text{O}^+]} = 1 \quad 25^\circ\text{C}$$

$$\text{p}K_{A_2} = -\log K_{A_2} = 0$$

: -

-6-4



$$K = Q_{\text{eq}} = \frac{[\text{A}_1^-]_{\text{eq}} \cdot [\text{A}_2\text{H}]_{\text{eq}}}{[\text{A}_1\text{H}]_{\text{eq}} \cdot [\text{A}_2^-]_{\text{eq}}}$$

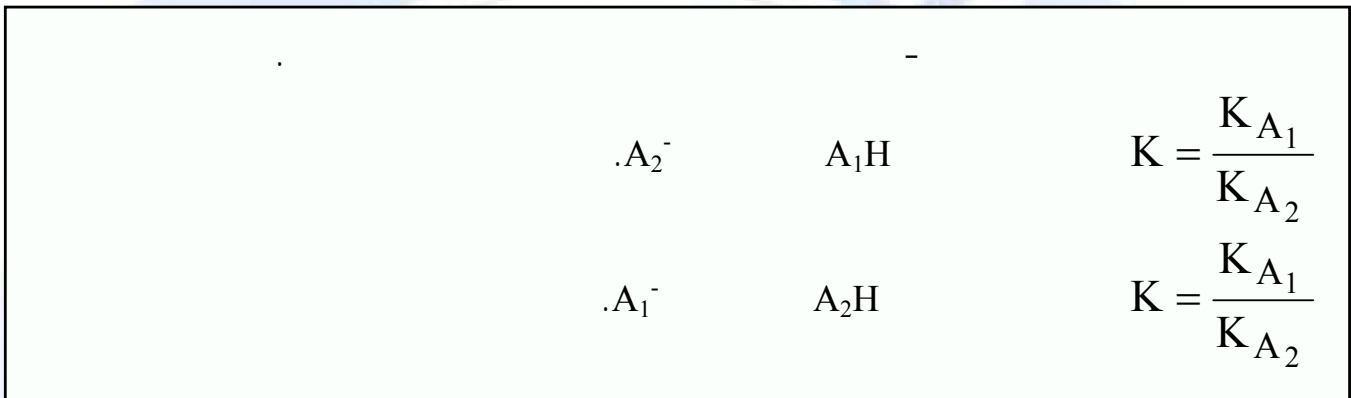
$$K = \frac{[\text{A}_1^-]_{\text{eq}} \cdot [\text{H}_3\text{O}^+]_{\text{eq}} \cdot [\text{A}_2\text{H}]_{\text{eq}}}{[\text{A}_1\text{H}]_{\text{eq}} \cdot [\text{A}_2^-]_{\text{eq}} \cdot [\text{H}_3\text{O}^+]_{\text{eq}}}$$



$$K_{A_2} = \frac{[A_2^-]_{eq} \cdot [H_3O^+]_{eq}}{[A_2H]_{eq}} \quad K_{A_1} = \frac{[A_1^-]_{eq} \cdot [H_3O^+]_{eq}}{[A_1H]_{eq}} :$$

$$K = \frac{K_{A_1}}{K_{A_2}} :$$

:



: -7-4

:

$$K_A = \frac{C \cdot \tau^2}{1 - \tau}$$

:

(pK<sub>A1</sub> = 3,7)

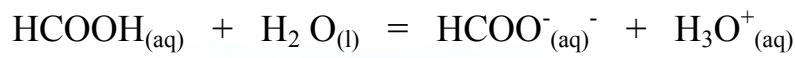
C = 0,01 mol/L

. pH<sub>2</sub> = 3,4    pH<sub>1</sub> = 2,9 :

pH    .(pK<sub>A2</sub> = 4,8)

K<sub>A1</sub> > K<sub>A2</sub>    pK<sub>A1</sub> < pK<sub>A2</sub>

:



$$[\text{HCOO}^-]_{\text{eq}} = [\text{H}_3\text{O}^+]_{\text{eq}} = 10^{-2,9} \text{ mol/L} :$$

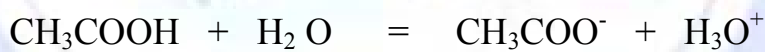
:

$$\tau_1 = \frac{N(\text{HCOO}^-)_{\text{eq}}}{N(\text{HCOOH})_{\text{initial}}}$$

$$\tau_1 = \frac{[\text{HCOO}^-]_{\text{eq}}}{C}$$

$$\tau_1 = \frac{10^{-2,9}}{10^{-2}} = 0,13 = 13\%$$

:



$$[\text{CH}_3\text{COO}^-]_{\text{eq}} = [\text{H}_3\text{O}^+]_{\text{eq}} = 10^{-3,4} \text{ mol/L} :$$

:

$$\tau_2 = \frac{N(\text{CH}_3\text{COO}^-)_{\text{eq}}}{N(\text{CH}_3\text{COOH})_{\text{initial}}}$$

$$\tau_2 = \frac{[\text{CH}_3\text{COO}^-]_{\text{eq}}}{C}$$

$$\tau_2 = \frac{10^{-3,4}}{10^{-2}} = 0,04 = 4\%$$

$$K_{A1} > K_{A2} \quad \tau_1 > \tau_2 :$$

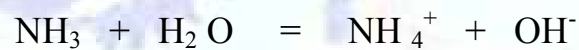
:

$A_2H$	$A_1H$	$\tau_1 > \tau_2$	$pK_{A1} < pK_{A2}$
$pH$	$K_A$	$\tau$	

:

$$\begin{array}{l}
 (pK_{A1} = 9,2) \quad C = 0,01 \text{ mol/L} \\
 \cdot pH_2 = 9,0 \quad pH_1 = 10,6 \quad : \quad pH \quad \cdot (pK_{A2} = 11,0) \\
 K_{A1} > K_{A2} \quad pK_{A1} < pK_{A2}
 \end{array}$$

:



: 25°C

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

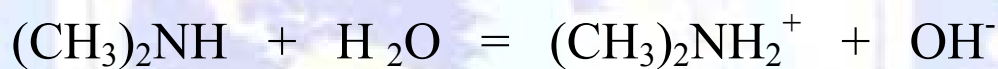
$$[OH^-] = \frac{10^{-14}}{[H_3O^+]} = \frac{10^{-14}}{10^{-9}} = 10^{-5} \text{ mol/L}$$

$$[OH^-]_{eq} = [NH_4^+]_{eq} = 10^{-5} \text{ mol/L} :$$

$$\tau_1 = \frac{n(NH_4^+)_{eq}}{n(NH_3)_{initial}}$$

$$\tau_1 = \frac{[NH_4^+]_{eq}}{C}$$

$$\tau_1 = \frac{10^{-5}}{10^{-2}} = 0,001 \approx 0,1 \%$$



25°C

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

$$[OH^-] = \frac{10^{-14}}{[H_3O^+]} = \frac{10^{-14}}{10^{-10,6}} = 10^{-3,4} \text{ mol/L}$$

$$[OH^-]_{eq} = [(CH_3)_2NH_2^+]_{eq} = 10^{-3,4} \text{ mol/L} :$$

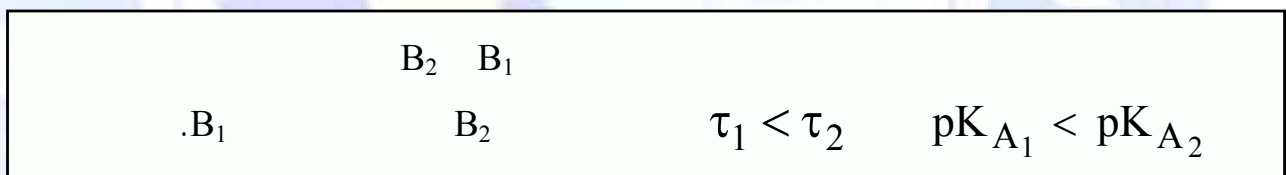
$$\tau_2 = \frac{n((\text{CH}_3)_2\text{NH}_2^+)_{\text{eq}}}{n((\text{CH}_3)_2\text{NH})_{\text{initial}}}$$

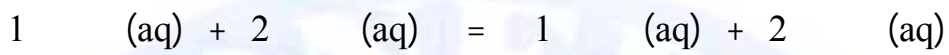
$$\tau_2 = \frac{[(\text{CH}_3)_2\text{NH}_2^+]_{\text{eq}}}{C}$$

$$\tau_2 = \frac{10^{-3,4}}{10^{-2}} = 10^{-1,4} = 0,039 \approx 4\%$$

$$K_{A1} > K_{A2} \quad \tau_1 < \tau_2 :$$

:





$$K = \frac{[\text{أساس}_1]_{\text{aq}} \cdot [\text{حمض}_2]_{\text{aq}}}{[\text{حمض}_1]_{\text{aq}} \cdot [\text{أساس}_2]_{\text{aq}}} \cdot \frac{[H_3O^+]_{\text{aq}}}{[H_3O^+]_{\text{aq}}}$$

$$K = \frac{[\text{أساس}_1]_{\text{aq}} \cdot [H_3O^+]_{\text{aq}}}{[\text{حمض}_1]_{\text{aq}}} \times \frac{[\text{حمض}_2]_{\text{aq}}}{[H_3O^+]_{\text{aq}} \cdot [\text{أساس}_2]_{\text{aq}}} = \frac{K_{A_1}}{K_{A_2}}$$

$$K = \frac{K_{A_1}}{K_{A_2}}$$

$$pH = pK_A + \log \frac{[\text{أساس}]_{\text{aq}}}{[\text{حمض}]_{\text{aq}}}$$

$$[A] > [B]$$

B

A

$$(\log 1 =) \text{pH} = \text{pK}_A$$

$$[ ]_{\text{eq}} = [ ]_{\text{eq}}$$

▪

$$\text{pK}_A > \text{pH}$$

$$[ ]_{\text{eq}} > [ ]_{\text{eq}}$$

▪

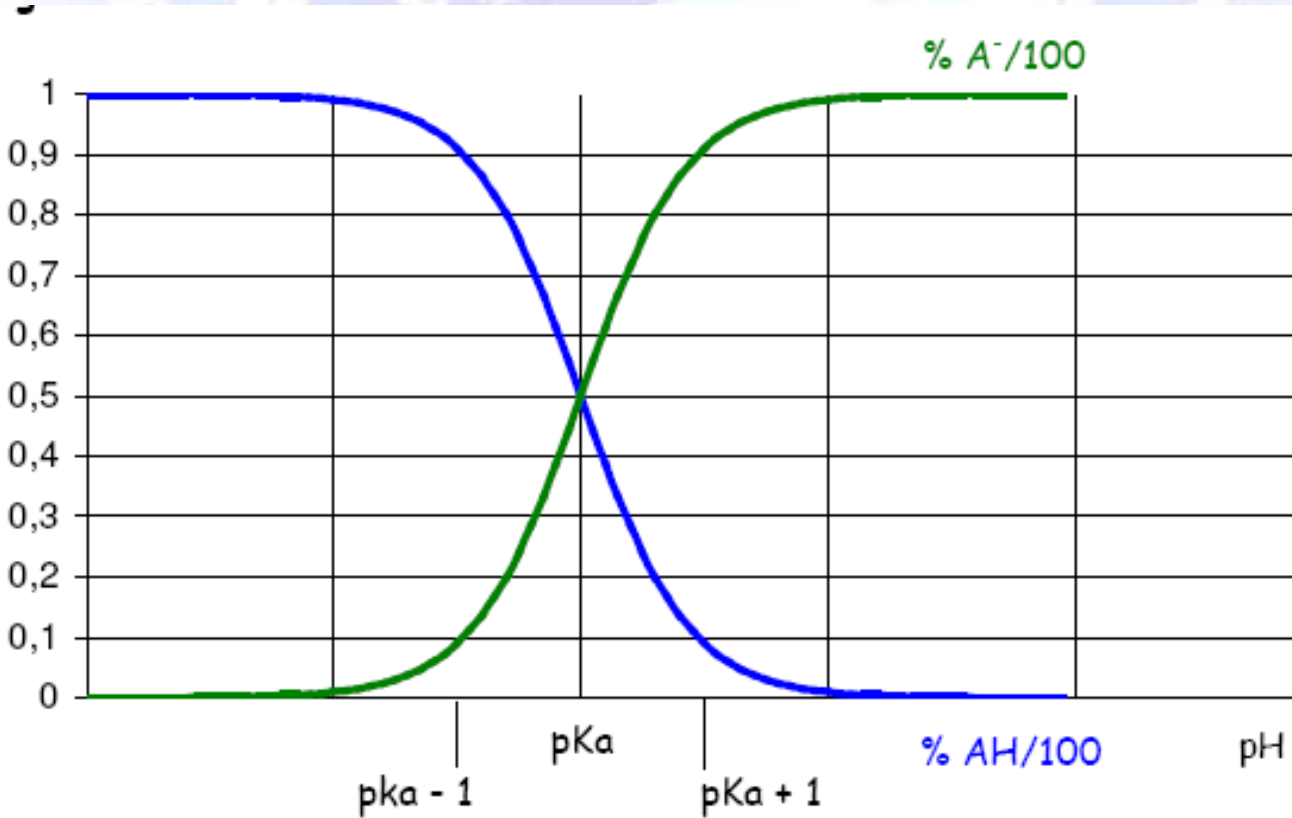
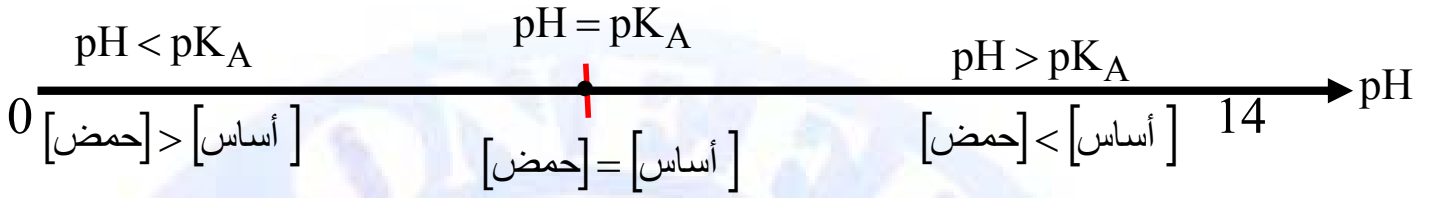
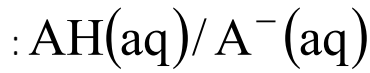
$$\text{pH} < \text{pK}_A$$

$$[ ]_{\text{eq}} < [ ]_{\text{eq}}$$

▪

/

pH



$A^-$

$AH$

$AH/A^-$

.0

pH

:

$$[AH]_{aq} = [A^-]_{aq}$$

$$pH = pK_A$$

:

:

pH

$AH/A^-$

/

$pK_a$

