

الباب الخامس

الحاصل الايوني للماء والرقم الهيدروجيني

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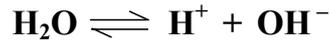
(Heydeweller, Kohlrausch) -

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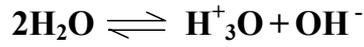
H^+

:

OH^-



Hyronium Ion (H_3O^+)



:

$$K = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$$

$$3 / 0.997 \quad 25$$

:

997

$$/ 55.4 = \frac{997 \text{ جم / لتر}}{18 \text{ جم / مول}}$$

$\text{OH}^- \text{ H}^+$

$\text{OH}^- \text{ H}^+$

$$[\text{H}^+][\text{OH}^-] = K [\text{H}_2\text{O}]$$

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

: K_w

K_w

H^+

OH^-

$$K_w = [\text{H}^+][\text{OH}^-]$$

$$1 \times 10^{-14} =$$

K_w

(25)

$\text{OH}^- \quad \text{H}^+$

$$1 \times 10^{-14} = K_w = [\text{H}^+][\text{OH}^-]$$

$$[H^+] = [OH^-]$$

$$[H^+]^2 = [OH^-]^2$$

$$[H^+] = \sqrt{10^{-14}} = 10^{-7} \quad /$$

$$[OH^-] = \sqrt{10^{-14}} = 10^{-7} \quad /$$

(Self dissociation)

. (Autoprotolysis)

$$[H^+] > 1 \times 10^{-7} \quad :$$

$$[OH^-] < 1 \times 10^{-7}$$

$$[H^+] < 1 \times 10^{-7} \quad :$$

$$[OH^-] > 1 \times 10^{-7}$$

K_w

K_w

(°)	K_w
صفر	0.114×10^{-14}
10	0.292×10^{-14}
20	0.681×10^{-14}
25	1.00×10^{-14}
30	1.46×10^{-14}
40	2.98×10^{-14}
45	4.93×10^{-14}
50	6.16×10^{-14}
60	9.61×10^{-14}

الرقم الهيدروجيني أو الدالة الحامضية pH :

10

[H⁺]

[H⁺]

pH

)

.(

/ 0.001

pH

. pOH

: pH

/ -

: 10 / -

$$\text{pH} = \log \frac{1}{[\text{H}^+]}$$

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

0.001

(3)

/

(3)

³-10

(3)

:

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

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

$$\therefore - \log [\text{H}^+] = \text{pH}$$

pOH

/ -
/ -

:

$$pOH = -\log [OH^-]$$

$$pOH = +\log \frac{1}{[OH^-]}$$

$$\therefore [OH^-] = 10^{-pOH}$$

pH

$$- 10^{-14}$$

pH

$$. 14 \quad 0$$

pOH

/ -

$$= pH$$

$$[H^+] = 1$$

$$= pH$$

$$/ - 10^{-14}$$

$$10^{-7}$$

$$14$$

$$. 7$$

pH

pOH

/

$$- 1$$

$$. 14 = pOH$$

$$/ - 10^{-14} =$$

OH⁻

H⁺

$$. 7$$

pOH

pH

$$10^{-7}$$

$$10^{-7}$$

$$10^{-7}$$

$$7$$

pH

$$. 7$$

pOH

$$\begin{array}{r} 7 \\ .7 \end{array} \quad \begin{array}{l} \text{pOH} \\ \text{pH} \end{array} \quad \begin{array}{l} 10^{-7} \\ 10^{-7} \end{array}$$

$$\begin{array}{r} 7 \\ 7 \\ .7 \end{array} \quad \begin{array}{l} \text{pH} \\ \text{pH} \\ \text{pH} \end{array} \quad \begin{array}{l} 14 \\ 14 \\ 14 \end{array}$$

:

$$[\text{H}^+] \times [\text{OH}^-] = K_w = 1 \times 10^{-14}$$

$$[\text{OH}^-] = \frac{10^{-14}}{[\text{H}^+]}$$

$$[\text{H}^+] = \frac{10^{-14}}{[\text{OH}^-]}$$

:

$$10^{-14} = [\text{OH}^-] \cdot [\text{H}^+] \\ \text{p} K_w = 14 = \text{pOH} + \text{pH}$$

$$\begin{array}{r} 14 \\ 14 \\ 10^{-14} \end{array} \quad \begin{array}{l} \text{pOH} \\ \text{pOH} \\ \text{pH} \end{array} \quad \begin{array}{l} 14 \\ 14 \\ 10^{-14} \end{array}$$

:

pOH pH

. 0.005

pH

pOH

نوع المحلول	الـ pOH رقم القاعدة	[OH ⁻] تركيز أيون الهيدروكسيل بالجم - أيون/لتر	الـ pH رقم الحموضة	[H ⁺] تركيز أيون الهيدروجين بالجم- أيون / لتر
حامضي قوي جداً	14	10 ⁻¹⁴	صفر	1
حامضي قوي جداً	13	10 ⁻¹³	1	10 ⁻¹
حامضي قوي	12	10 ⁻¹²	2	10 ⁻²
حامضي متوسط	11	10 ⁻¹¹	3	10 ⁻³
حامضي متوسط	10	10 ⁻¹⁰	4	10 ⁻⁴
حامضي ضعيف	9	10 ⁻⁹	5	10 ⁻⁵
حامضي ضعيف	8	10 ⁻⁸	6	10 ⁻⁶
متعادل	7	10 ⁻⁷	7	10 ⁻⁷
قاعدي ضعيف	6	10 ⁻⁶	8	10 ⁻⁸
قاعدي ضعيف	5	10 ⁻⁵	9	10 ⁻⁹
قاعدي متوسط	4	10 ⁻⁴	10	10 ⁻¹⁰
قاعدي متوسط	3	10 ⁻³	11	10 ⁻¹¹
قاعدي قوي	2	10 ⁻²	12	10 ⁻¹²
		10 ⁻¹	23	10 ⁻¹³
قاعدي قوي جداً	صفر	1	14	10 ⁻¹⁴

:

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

$$5 \times 10^{-3} = [\text{H}^+]$$

$$10^{-14} = [\text{OH}^-] (5 \times 10^{-3})$$

$$2 \times 10^{-12} = \frac{10^{-14}}{5 \times 10^{-2}} = [\text{OH}^-]$$

$$2 \times 10^{-12} =$$

$$5 \times 10^{-3} = [\text{H}^+] = \text{pH}$$

$$0.7 - 3 = 5 - 3 =$$

$$2 \times 10^{-12} = \text{pOH} = 2.3 = \text{pH} \therefore$$

$$11.7 = \text{pOH} \quad 0.3 - 12 = 2 - 12 =$$

$$. 11.7 \quad \text{pOH} \quad 2.3 \quad \text{pH}$$

:

pOH

$$.4.4 \quad \text{pH}$$

:

$$\text{pOH} = 14 - \text{pH} = 14 - 4.4$$

$$\frac{1}{[\text{H}^+]} = 4.4 \quad \frac{1}{[\text{H}^+]} = \text{pH}$$

:

$$3.98 \times 10^{-5} = [\text{H}^+] \quad 0.000398 = \frac{1}{25120} = \frac{1}{[\text{H}^+]} = 25120$$

$$3.98 \times 10^{-5} \times =$$

:

$$10^{-4.4} = [\text{H}^+] \quad 10 = [\text{H}^+] = \text{pH}$$

() (-)

:

$$-4.4 = 10^{-4.4}$$

$$3.98 \times 10^{-5} = 0.00003981 = [\text{H}^+] \quad 0.00003981$$

: $[\text{OH}^-]$

$$\frac{1}{[\text{OH}^-]} = 9.6 \quad \frac{1}{[\text{OH}^-]} = \text{pOH} \therefore$$

$$\frac{1}{[\text{OH}^-]} = 39810000 \quad :$$

$$/ \quad \frac{1}{39810000} = [\text{OH}^-]$$

$$. 4 \times 10^{-9} =$$

:

: pOH pH

. 0.01

-

. 0.135

0.01

-

. 0.01

-

. 0.125

0.01

-

()

:

- 0.01

$$2 = 10^{-2} \quad - = \text{pH} \therefore$$

$$10^{-2} = 0.01 = [\text{H}^+]$$

$$12 = 2 - 14 = \text{pOH} \therefore$$

: ()

.0.135

$$1.35 \times 10^{-3} \quad 0.01 \times \frac{135}{1000} = [\text{H}^+]$$

$$2.87 = 0.13 - 3 = 1.35 \quad - 3 = 1.35 \times 10^{-2} \quad - = \text{pH} \therefore$$

$$\text{pOH} = 11.14 \quad \text{pOH}$$

$$2.87$$

$$\text{pH}$$

$$= 2.87 - 14$$

: ()

$$- \quad 0.01$$

$$2 = 10^{-2} \quad - = \text{pOH}$$

$$0.01 = [\text{OH}^-]$$

$$12 = \text{pH}$$

$$2 = \text{pOH}$$

: ()

:

$$1.25 \times 10^{-3} = [\text{OH}^-] \quad \frac{125}{1000} \times 0.01 = [\text{OH}^-]$$

$$1.25 \times 10^{-3} \quad - = [\text{OH}^-] \quad - = \text{pOH}$$

$$2.9 = 1.25 - 3 =$$

$$11.1 = 2.9 - 14 = \text{pH}$$

$$2.9$$

$$\text{pOH}$$

:

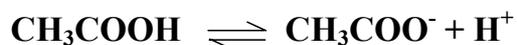
$$0.1$$

$$^{\circ}25$$

$$\therefore 1.35 = \sqrt{1.85}$$

$$1.85 \times 10^{-5}$$

:



:

$$K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} = 1.85 \times 10^{-5}$$

=

0.1

$$1.85 \times 10^{-5} = \frac{[\text{H}^+]^2}{0.1}$$

$$\sqrt{1.85 \times 10^{-6}} = [\text{H}^+]$$

$$1.35 \times 10^{-3} =$$

:

pOH pH

$$0.0001 \quad ()$$

$$0.00002 \quad ()$$

:

$$10^{-4} = [\text{OH}^-] \quad 0.0001 \quad [\text{OH}^-] \quad ()$$

$$4 = 10^{-4} = \text{pOH}$$

$$10 = 4 - 14 = \text{pH} :$$

$$2 \times 10^{-5} = [\text{OH}^-] \quad ()$$

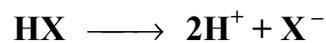
$$4.7 = 0.3 - 5 = 2 - 5 = 2 \times 10^{-5} = \text{pOH}$$

$$9.3 = 4.7 - 14 = \text{pH}$$

الرقم الهيدروجيني للأحماض القوية والقواعد القوية :

0.2

HX



$$1 = \text{pH} \quad \therefore \quad / \quad 0.2 = [\text{H}^+]$$

[⁺H]

$$1 \times 10^{-8}$$

$$1 \times 10^{-8} = [\text{H}^+]$$

$$= [\text{OH}^-]$$

$$10^{-14} = [\text{H}^+] [\text{OH}^-] \quad 10^{-8} + X = [\text{H}^+]$$

$$10^{-14} = X \cdot 10^{-8} + X^2 \quad 10^{-14} = (10^{-8} + X) X$$

$$0.9515 \times 10^{-7} = X$$

$$10^{-8} + 0.9515 \times 10^{-7} = [\text{H}^+]$$

$$6.978 = \text{pH} \quad \therefore \quad 1.0515 \times 10^{-7} =$$

$$[\text{H}^+]$$

$$/ \quad 10^{-7}$$

$$(\text{pH} < 7)$$

12.4 $\text{B}(\text{OH})_2$:

$$4 \times 10^{-13} = [\text{H}^+] \quad 12.4 = \text{pH}$$

$$/ \quad 0.025 = \frac{10^{-14}}{4 \times 10^{-13}} [\text{OH}^-] =$$

$$B(OH)_2 = \frac{0.025}{2} = 0.0125 \quad /$$

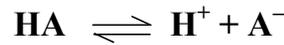
الرقم الهيدروجيني للأحماض الضعيفة والقواعد الضعيفة :

1

$$/ \quad 1 < [H^+] \quad / \quad 1 = (\quad)$$

$$pH \quad [H^+]$$

$$K_a = 1.8 \times 10^{-5} \quad 2$$



$$\frac{[H^+][A^-]}{[HA]} = K_a = 1.8 \times 10^{-5} \quad [H^+] = [A^-]$$

$$[HA] \quad :$$

:

$$1.8 \times 10^{-5} = \frac{[H^+]}{2}$$

$$/ \quad 6 \times 10^{-3} = [H^+] \quad 36 \times 10^{-6} = [H^+]$$

$$2.22 = 6 - 3 = pH$$

2

pH

$$pH \quad 2.22 =$$

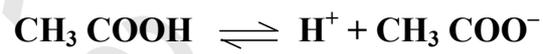
النسبة المئوية للتأين :

HA

0.1
99% 25
1%

CH₃COO⁻ H⁺

CH₃ COOH



100

4.3%

0.1

1.33%

0.01

$$4 \times 10^{-3} = [\text{CH}_3\text{COO}^-] \quad 4 \times 10^{-3} = [\text{H}^+]$$

:

$$0.1 \quad \text{pH}$$

:

:

$$1 = \text{pH} \therefore 10^{-6} = [\text{OH}^-] \quad 0.1 = [\text{OH}^-]$$

$$13 = \text{pOH} - 14 = \text{pH}$$

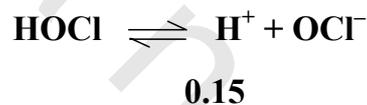
:

$$0.1$$

$$\text{pH} \quad \cdot \text{HOCl}$$

$$3.12 \times 10^{-8}$$

:



$$(X - 0.15)X X$$

$$\frac{X^2}{X - 0.15} = 3.12 \times 10^{-8} = \frac{[\text{H}^+][\text{OCl}^-]}{[\text{HOCl}]}$$

$$X$$

$$7 \times 10^{-5} = [\text{OCl}^-] = [\text{H}^+] = X$$

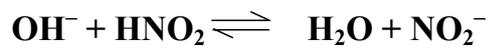
$$14 \times 10^{-10} = \frac{10^{-14}}{10^{-5} \times 7} = [\text{OH}^-]$$

$$4.15 = 7 \times 10^{-5} \quad \text{pH}$$

$$\% 4.7 \times 10^{-2} = 100 \times \frac{7 \times 10^{-5}}{0.15} =$$

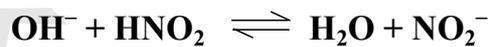
(4)

$$0.7 \times 10^{-4} \times 4.5 = 3.15 \times 10^{-4}$$



$$0.1 = 0.5 \times 0.2 \quad \text{OH}^- :$$

$$0.21 = 0.7 \times 0.3 \quad \text{HNO}_2 :$$



$$0.1 \quad 0.21$$

$$0.1 - 0.21 \quad 0.1$$

$$0.1 - 0.21$$



$$0.22 = \frac{0.1 - 0.21}{0.5} = [\text{HNO}_2]$$

$$0.2 = \frac{0.1}{0.5} = [\text{NO}_2^-]$$



$$0.22$$

$$(X - 0.22)X$$

$$0.2 = \frac{0.1}{0.5} = \text{HNO}_2$$

$$X + 0.2 = \text{NO}_2^-$$

$$X + 0.22 = [\text{HNO}_2]$$

$$X + 0.2 = [\text{NO}_2^-]$$

$$\frac{(X + 0.2)X}{X - 0.22} = \frac{[\text{NO}_2^-][\text{H}^+]}{[\text{HNO}_2]}$$

$$X = [\text{H}^+]$$

$$6 \times 10^{-4} = [\text{H}^+] = X$$

$$3.3 = 6 - 4 = 6 - 10 \quad 4 + = \text{pH} \therefore$$

الأسئلة

-1

-2

-3

-4

-5

* * *