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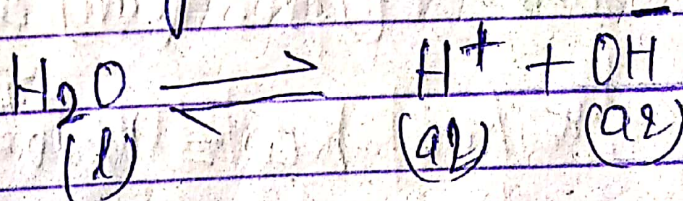
Day-I(H) Physical (parts-II)

Chapter - Ionic Equilibrium

Topics - Ionic product of water
&
pH, pOH & pK_w

Ionic Product of water & Ionization Constant for water

Conductivity measurement of water indicates that water is very weak electrolyte. Pure water is ^{likely to be} ionized & it is weakly ionised to give H⁺(aq) & OH⁻(aq) ions



Its ionization constant may be expressed as

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

water concentration is very high ab

55.5 mol/lit. A very small fraction of it undergoes ionization. Hence the concentration of H_2O may be taken as constant & combines with $K_a(H_2O)$ to give another constant called K_w .

$$K_a(H_2O) \times [H_2O] = [H^+] [OH^-]$$

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

K_w is known as Ionic-product of water.

In pure water $[H^+]$ is found experimentally equal to 1×10^{-7} at 298K. In water $[H^+] = [OH^-]$

$$\text{Thus, } [H^+] = [OH^-] = 1 \times 10^{-7} \text{ at } 298K$$

$$\text{Thus } K_w = 1 \times 10^{-7} \times 1 \times 10^{-7}$$

$$K_w = 1 \times 10^{-14} \text{ mol}^2/\text{lit}^2$$

Thus degree of dissociation of

$$\text{Water, } \alpha = \frac{1 \times 10^{-7}}{55.5} = 1.8 \times 10^{-9}$$

The value of K_w is Temp. dependence, thus it has different value at diff. Temp.

Temp (K)	K_w
273	0.113×10^{-14}
283	0.292×10^{-14}
298	1.008×10^{-14}
323	5.474×10^{-14}
373	56×10^{-14}

$$pK_w = -\log K_w$$

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

$$= -x - 14 \log 10$$

$$\boxed{pK_w = 14} \text{ at } 298 \text{ K.}$$

pH :- Concept of K_w unable to classify solution either acidic, basic or neutral.

Thus if $[H^+]$ is expressed upon log-scale, the nature of solution may be decided.

Definition - The pH is defined as negative log of activity / concentration of H^+

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

Thus $[H^+] = 10^{-pH}$

Take log both side,

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

$$\text{or, } \log [H^+] = -pH \times 1$$

$$\therefore \boxed{pH = -\log [H^+]} \\ = \log \frac{1}{[H^+]}$$

Similarly, for base which gives $[OH^-]$

$$\boxed{p(OH) = -\log [OH^-]}$$

In pure water $[H^+] = [OH^-] = 1 \times 10^{-7}$

Thus pH & p(OH) for water is 7 (for neutral)

$$\text{Thus } \boxed{pH + p(OH) = 14}$$

$$\text{or, } pH + p(OH) = pK_w$$

Remember, $[H^+]$ for Acid $> 10^{-7}$ $\Rightarrow pH < 7$
 $[OH^-]$ for base $< 10^{-7}$ $\Rightarrow p(OH) > 7$
 For neutral $[H^+] = [OH^-] = 10^{-7}$ $\Rightarrow pH = 7$

— x — y —