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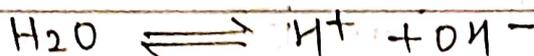
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Class \Rightarrow B.Sc. (Part-1) SubsidiarySubject \Rightarrow ChemistryChapter \Rightarrow Ionic EquilibriumTopic \Rightarrow Ionic Product of waterName \Rightarrow Dr. Amarendra Kumar,
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Ionic product of water

Water is dissociated to a very small extent into hydrogen and hydroxyl ions, as represented by the equation.



More accurately,



Applying the law of chemical equilibrium, its dissociation constant K_c is given by

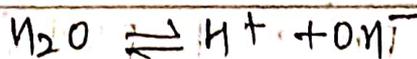
$$K_c = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}]^2}$$

$$\text{or } K_c \times [\text{H}_2\text{O}]^2 = [\text{H}_3\text{O}^+][\text{OH}^-]$$

The product of two constant: $K_c \times [\text{H}_2\text{O}]^2$ must also be a constant. Because of the importance of the ionization equilibrium, it is given the special symbol K_w and is called Ionic product of water or Ionization constant of water.

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

for convenience,



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

since in pure water, the concentration of hydrogen

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and hydroxyl ion must be equal to one another.

$$[H^+] = [OH^-] = 1.0 \times 10^{-7} \text{ mol L}^{-1}$$

Therefore, at 25°C

$$K_w = (1.0 \times 10^{-7}) \times (1.0 \times 10^{-7}) = 1.0 \times 10^{-14} \text{ (at } 25^\circ\text{C)}$$

pH of a solution

Sørensen defined pH of a solution to make comparisons of small values of $[H^+]$ easier.

The negative logarithm to base 10 of the activity (a_H) of Hydrogen ion.

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

where $[H^+]$ is the concentration of hydrogen ions in moles per litre.

$$a_H = \frac{[H^+]}{\text{mol L}^{-1}}$$

By definition,

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

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

To express small concentrations of hydroxide ion, the pOH of a solution can be defined as

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

Similarly for K_w , we can define pK_w as follows

$$pK_w = -\log K_w$$

Remembering that $[H^+][OH^-] = K_w$ and taking logs and reversing signs, we have

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

$$\text{or } pH + pOH = pK_w$$

Since, K_w at 25°C is about 10^{-14} and pK_w is 14. Thus,

$$\boxed{pH + pOH = 14}$$

The sum of pH and pOH is equal to 14 in water or in any aqueous solution at 25°C.

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pH scale

The scale on which pH values are computed is called the pH scale.

Acidic solution \Rightarrow $\text{pH} < 7.00$

Basic solution \Rightarrow $\text{pH} > 7.00$

Neutral solution \Rightarrow $\text{pH} = 7.00$

Acidic solution \Rightarrow $[\text{H}^+] > [\text{OH}^-]$

Basic solution \Rightarrow $[\text{H}^+] < [\text{OH}^-]$

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

pH decreases with the increase of $[\text{H}^+]$.

The lower the pH, higher is the $[\text{H}^+]$ or acidity.

$\rightarrow x \dots$