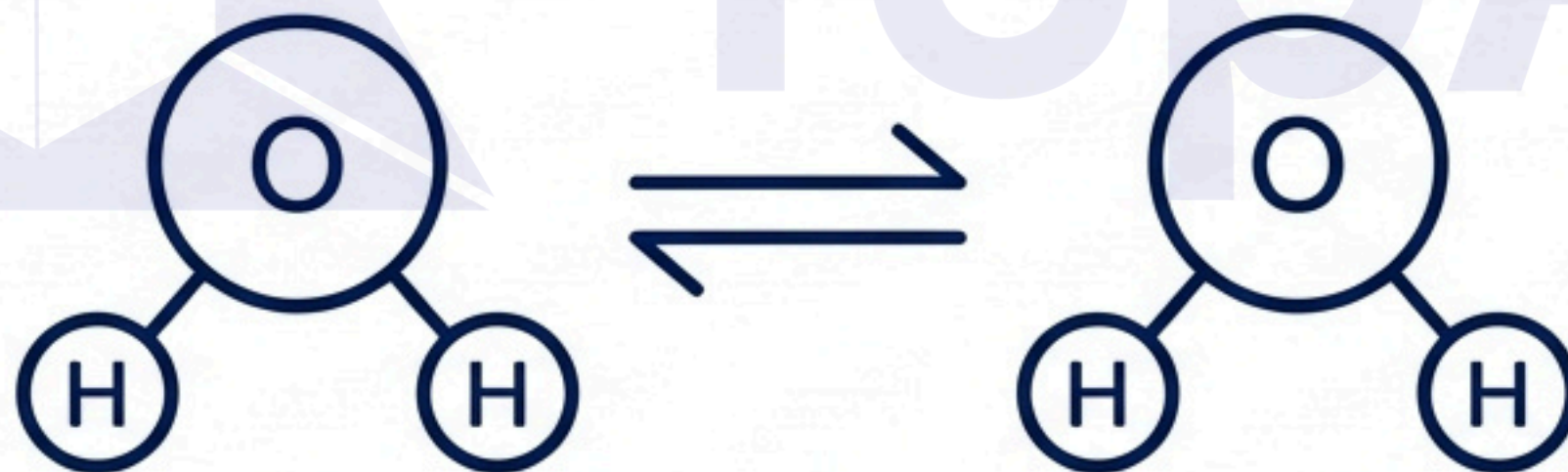


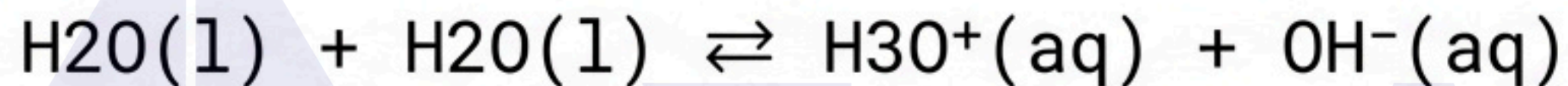
Ionization of Water

From qualitative Brønsted-Lowry behavior to the quantitative fundamentals of K_w and pK_w .



The Dual Role of Water

Pure water is unique. In a process called auto-ionization, it acts as both an acid and a base simultaneously.



Water as Acid

- Donates a proton (H^+)

Hydroxyl Ion (OH^-)

Conjugate Base

Water as Base

- Accepts a proton (H^+)

Hydronium Ion (H_3O^+)

Conjugate Acid



**You've Learned the Theory.
Let's Test Them Now.**

$$E=mc^2$$



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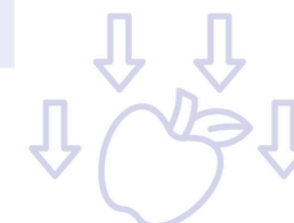
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The Ionic Product of Water (K_w)

Step 1: The baseline dissociation constant.

$$K = [\text{H}_3\text{O}^+][\text{OH}^-] / [\text{H}_2\text{O}]$$

Step 2: Pure water's concentration (55.55M) is constant. It is omitted from the denominator and incorporated into a new constant.

Step 3: This creates the Ionic Product of Water.

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

At 298K, experimental data reveals:

$$[\text{H}^+] = 1.0 \times 10^{-7} \text{ M}$$

$$[\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}$$

$$K_w = 1.0 \times 10^{-14} \text{ M}^2$$

The pKw Relation

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 10^{-14}$$



Take negative logarithm
(-log) of both sides

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



Apply logarithm rules

$$-\log K_w = (-\log[\text{H}_3\text{O}^+]) + (-\log[\text{OH}^-]) = -\log(10^{-14})$$

$$\text{p}K_w = \text{pH} + \text{pOH} = 14 \text{ (at 298K)}$$

Because the scale is logarithmic, a 1-unit change in pH means a 10-fold change in $[\text{H}^+]$ concentration.

Water self-ionizes, but only slightly



The ratio is roughly 1.8×10^{-9} . Only ~2 in every 1 billion water molecules are ionized at room temperature. The equilibrium lies heavily towards undissociated water.

Comparison Strip

Acidic $[\text{H}_3\text{O}^+] > [\text{OH}^-]$ $\text{pH} < 7$ **Neutral** $[\text{H}_3\text{O}^+] = [\text{OH}^-]$ $\text{pH} = 7$ **Basic** $[\text{H}_3\text{O}^+] < [\text{OH}^-]$ $\text{pH} > 7$

Remember: Temperature changes K_w , but pure water always remains neutral because $[\text{H}^+]$ always equals $[\text{OH}^-]$.



You've Learned the Theory.

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