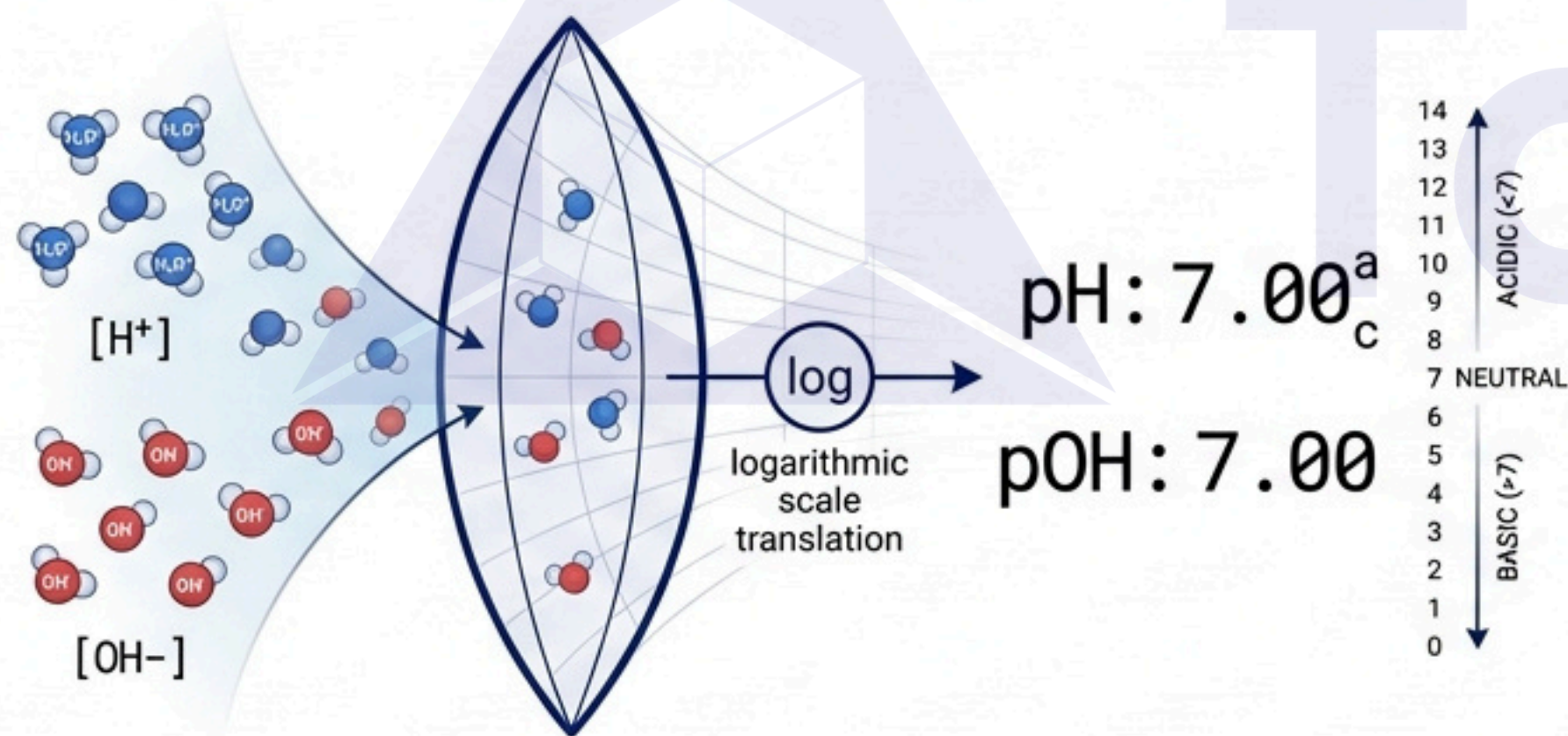


pH Scale and Related Quantities

Formula Deck & Conceptual Review

THE LOGARITHMIC LENS



KEY FORMULAS & RELATIONSHIPS

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

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

$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14}$$

$$\text{pH} + \text{pOH} = 14 \text{ (at } 25^\circ\text{C)}$$

The pH and pOH scales use a base-10 logarithmic function to compress the wide range of $[\text{H}^+]$ and $[\text{OH}^-]$ concentrations into a manageable 0-14 scale, providing a direct measure of acidity and basicity.

The Problem with Raw Concentration

Raw [H+] in a Soft Drink

0.003800
0.000001
3.88E-3 M
0.000001
10⁻³ M
3.8E-3 M
3.8E-3
10⁻³
0.003800
3.8 x 10⁻³ M

Working with decimals and negative exponents is prone to human error. Comparing 10⁻⁷ and 10⁻¹² mentally is not intuitive.

The “Macro-Lens” Requirement

[H⁺] → 0 to 14 Scale

We need a mathematical tool to translate infinitesimally small concentrations into a simple, practical scale of integers.



Instead of writing 0.00000001 M, we need a scale that uses **simple whole numbers**.



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Defining the pH Scale

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

The Operator

Stands for the negative logarithm to base 10 (-log).

The Input

The hydronium/hydrogen ion concentration in mol/L.

Pure Water at 25°C

$$[\text{H}^+] = 1.0 \times 10^{-7} \text{ M} \rightarrow \text{pH} = -\log(10^{-7}) = 7$$

Result: A clean, whole number integer.

Expanding the 'p' Operator

pOH

The Base Counterpart

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

Applied to hydroxyl ion concentration.

pK_w

The Water Constant

$$\text{pK}_w = -\log(K_w)$$

$$\text{pH} + \text{pOH} = \text{pK}_w = 14 \text{ (at 298K)}$$

Supporting formulal badges

pK_a

Acid Strength

$$\text{pK}_a = -\log(K_a)$$

Lower pK_a = Stronger Acid

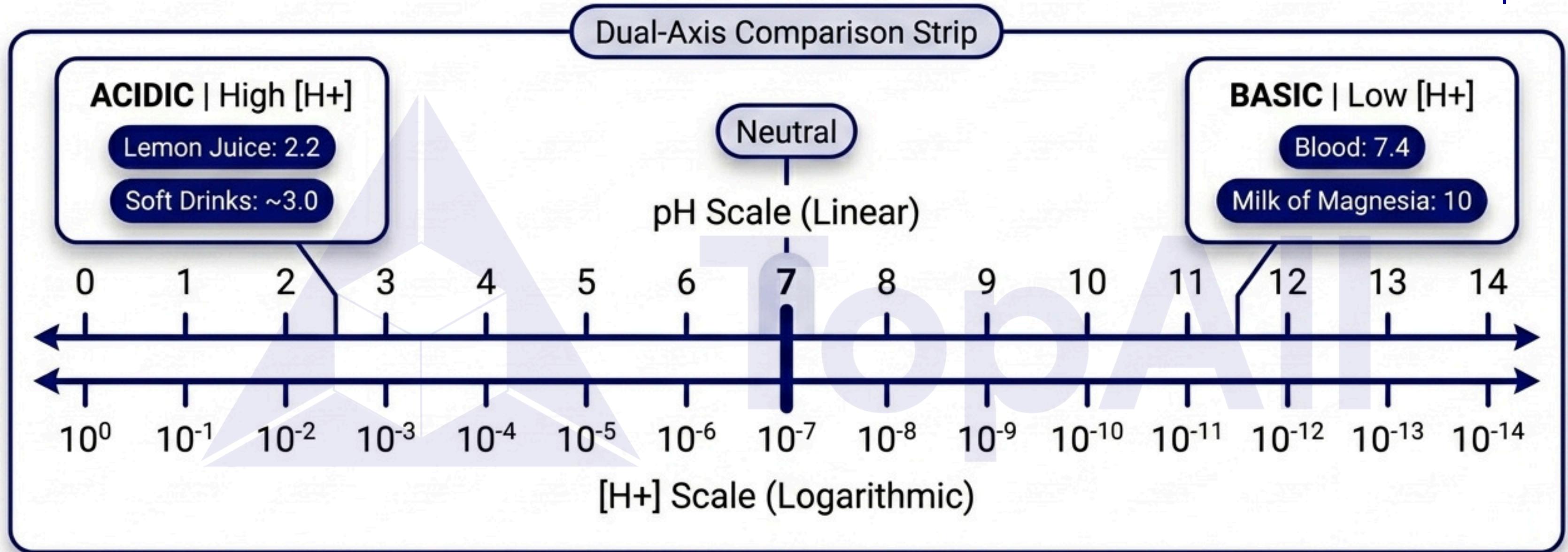
pK_b

Base Strength

$$\text{pK}_b = -\log(K_b)$$

Mathematical Symmetry: $\text{pK}_a + \text{pK}_b = \text{pK}_w = 14$

Reading the pH Scale



The Inverse Rule: Because of the negative sign in the formula, as the physical concentration goes **UP**, the **pH value goes DOWN**.

Logarithmic Chemistry Made Practical



The 10x Rule

Because the scale is logarithmic base-10, a change of exactly 1 pH unit equals a 10-fold change in $[H^+]$ concentration.



Core Equilibria at 298K

$$K_w = K_a \times K_b$$

$$pK_w = pK_a + pK_b = 14$$



The 'p' Inverse

The 'p' operator universally reverses magnitude. A high value of 'p-anything' (pH, pK_a, pK_b) always means a low value of the original chemical quantity.



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