Acidic and Basic Solutions

- The pH scale describes the acidity and basicity of dilute acid and base solutions.
- In pure water, there are proton transfers between water molecules that form hydronium ions and hydroxide ions.

$$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

- The reaction is reversible, and at equilibrium, the product of the hydronium ion and hydroxide ion concentrations expressed in mol/L is about 10^{-14}.

$$[H_3O^+][OH^-] = 10^{-14}$$

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- We consider acidic and basic solutions to be dilute if they have a concentrations of 1 mol/L or less.
- Because the product of the concentrations of H_3O^+ and OH^- is 10^{-14}, as the concentration of H_3O^+ decreases from 1 mol/L to 10^{-14} mol/L, the concentration of OH^- increases from 10^{-14} mol/L to 1 mol/L.
- See the table at the right.

$[H_3O^+]$ (mol/L)	$[OH^-]$ (mol/L)
1	10^{-14}
10^{-1}	10^{-13}
10^{-2}	10^{-12}
10^{-3}	10^{-11}
10^{-4}	10^{-10}
10^{-5}	10^{-9}
10^{-6}	10^{-8}
10^{-7}	10^{-7}
10^{-8}	10^{-6}
10^{-9}	10^{-5}
10^{-10}	10^{-4}
10^{-11}	10^{-3}
10^{-12}	10^{-2}
10^{-13}	10^{-1}
10^{-14}	1

$[H_3O^+][OH^-] = 10^{-14}$

- When the H_3O^+ concentration is greater than the OH^- concentration, the solution is acidic. (Note that even in a dilute solution of acid, there are some hydroxide ions.)
- When the OH^- concentration is greater than the H_3O^+ concentration, the solution is basic.
- When the concentrations are equal, both 10^{-7} mol/L, we say the solution is neutral in the acid/base sense.

$[H_3O^+]$ (mol/L)	$[OH^-]$ (mol/L)
1	10^{-14}
10^{-1}	10^{-13}
10^{-2}	10^{-12}
10^{-3}	10^{-11}
10^{-4}	10^{-10}
10^{-5}	10^{-9}
10^{-6}	10^{-8}
10^{-7}	10^{-7}
10^{-8}	10^{-6}
10^{-9}	10^{-5}
10^{-10}	10^{-4}
10^{-11}	10^{-3}
10^{-12}	10^{-2}
10^{-13}	10^{-1}
10^{-14}	1

pH

- To avoid the small numbers associated with describing acidic and basic solutions in terms of mol/L, pH is defined as

  $$pH = -\log[H_3O^+]$$

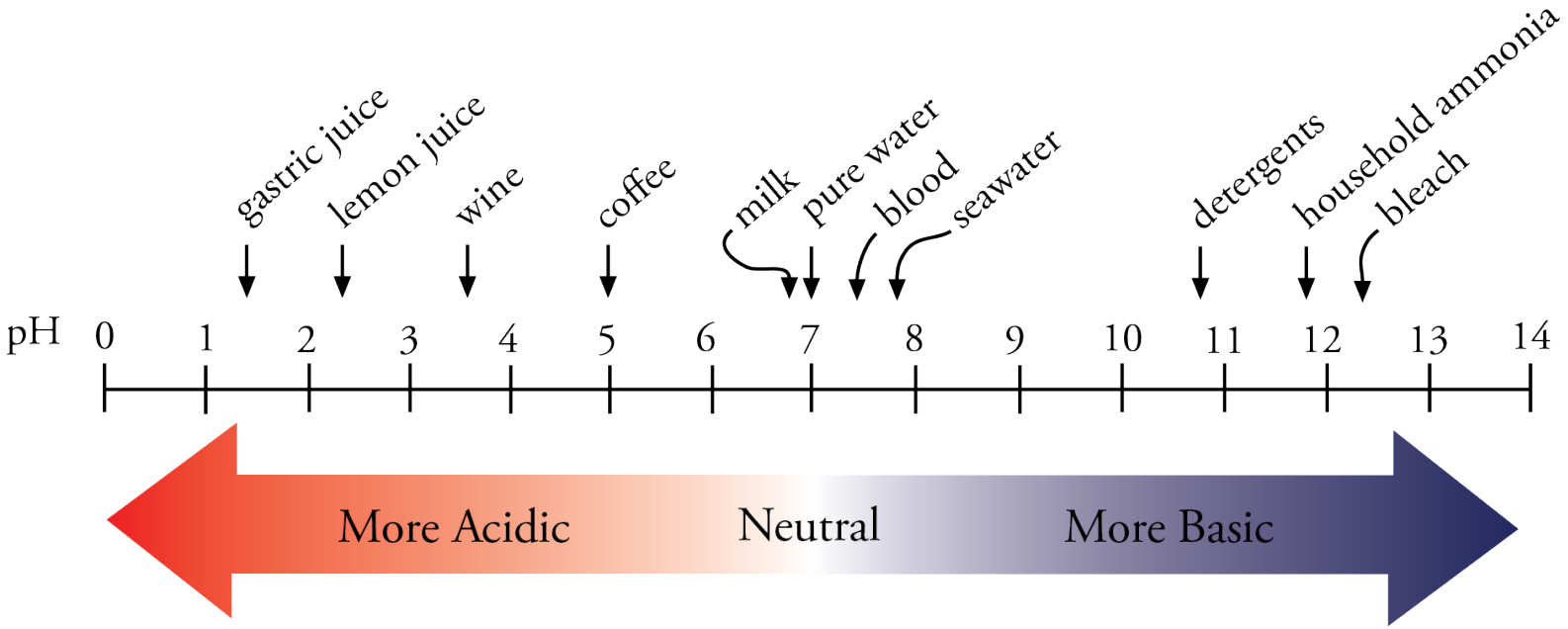
- An acidic solution that has an H_3O^+ concentration of 10^{-3} mol/L has a pH of 3 ($-\log 10^{-3} = 3$).
- A basic solution that has an OH^- concentration of 10^{-3} mol/L, and therefore an H_3O^+ concentration of 10^{-11} mol/L, has a pH of 11 ($-\log 10^{-11} = 11$).

$[H_3O^+][OH^-] = 10^{-14}$

- Dilute acidic solutions with H_3O^+ concentrations of 1 to 10^{-6} mol/L have a pHs of 0 to 6.
- Dilute basic solutions with OH^- concentrations of 10^{-6} to 1 mol/L have H_3O^+ concentrations of 10^{-8} to 10^{-14} mol/L and pHs of 8-14.
- Neutral solutions with H_3O^+ and OH^- concentrations 10^{-7} mol/L have a pH of 7.

$[H_3O^+]$ (mol/L)	$[OH^-]$ (mol/L)	pH
1	10^{-14}	0
10^{-1}	10^{-13}	1
10^{-2}	10^{-12}	2
10^{-3}	10^{-11}	3
10^{-4}	10^{-10}	4
10^{-5}	10^{-9}	5
10^{-6}	10^{-8}	6
10^{-7}	10^{-7}	7
10^{-8}	10^{-6}	8
10^{-9}	10^{-5}	9
10^{-10}	10^{-4}	10
10^{-11}	10^{-3}	11
10^{-12}	10^{-2}	12
10^{-13}	10^{-1}	13
10^{-14}	1	14

pH Range



Acidic solutions have pH values less than 7.

Basic solutions have pH values greater than 7.