

pH - Potential of Hydrogen Ions

Aim: Determining the pH and hydronium ion concentration of acidic and basic solutions.

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pH of Acids

- pH scale measures the H⁺/H₃O⁺ concentration in a given sample
- Acids have a more [H⁺] than [OH⁻] and a pH range of 0-6.9
- The lower the pH, the stronger the acid.

stronger acid
more [H⁺] so it
has a lower pH

$$\text{pH} = 1$$

$$[\text{H}^+] = 1 \times 10^{-1} \text{ M}$$

$$[\text{H}^+] = 0.1 \text{ M}$$

vs.

$$\text{pH} = 6$$

$$[\text{H}^+] = 1 \times 10^{-6} \text{ M}$$

$$[\text{H}^+] = 0.000001 \text{ M}$$

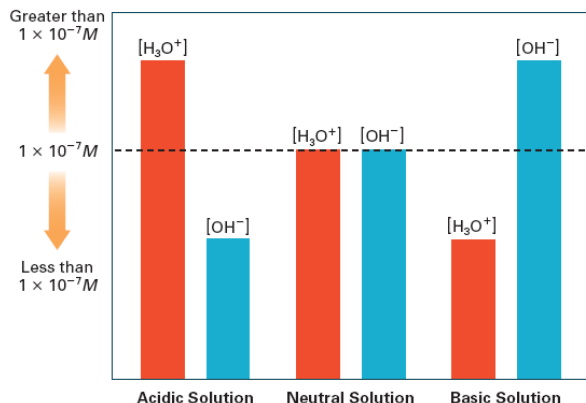
pH of Bases

Bases have less [H⁺] than [OH⁻] and a pH range of 7.1-14.

-The higher the pH, the stronger the base.

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Neutral Solutions



A neutral solution has a **pH of 7**

In a solution that is neutral the $[H^+] = [OH^-]$

$[H^+] = 1 \times 10^{-7}$ therefore the **pH=7**

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Converting from $[H^+]$ to pH

- The pH of a solution is equal to the negative log of its H^+ concentration, $[H^+]$

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

The $[H^+]$ concentration is usually given in scientific notation.

- To simplify the calculation; the exponent on the 10 of the H^+ concentration **EQUALS the pH**

$[H^+] = 1 \times 10^{pH}$

Ex 1) What is the pH of solutions below?

a) $[H^+] = 1 \times 10^{-11}$

pH = 11

Acidic/Basic
More $[H^+]$ or $[OH^-]$?

b) $[H_3O^+] = 1 \times 10^{-5}$

pH = 5

Acidic/Basic
More $[H^+]$ or $[OH^-]$?

c) $[H^+] = 1 \times 10^{-3}$

pH = 3

Acidic/Basic
More $[H^+]$ or $[OH^-]$?

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From pH to [H⁺]

Oppositely, the pH value can be used as the exponent on the 10 for the H₃O⁺ concentration

$$[H^+] = 1 \times 10^{-pH}$$

Ex 2) What is the [H₃O⁺] of a solution that has a pH of 6?

$$[H_3O^+] = 1 \times 10^{-6}, \text{ acidic}$$

Ex 3) Determine the [H₃O⁺] concentration of solutions below:

a) pH = 12

$$[H^+] = \frac{1 \times 10^{-12}}{\text{acidic/basic/neutral}}$$

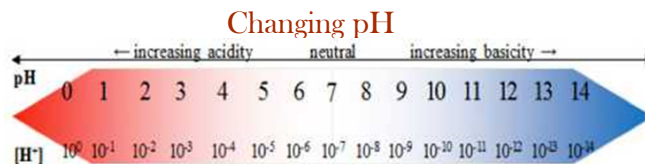
b) pH = 7

$$[H^+] = \frac{1 \times 10^{-7}}{\text{acidic/basic/neutral}}$$

c) pH = 1

$$[H^+] = \frac{1 \times 10^{-1}}{\text{acidic/basic/neutral}}$$

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- Any pH change of a value of 1 changes the [H⁺] ~~changes~~ by a power of 10 (exponent value changes by 1).

pH 8 to a pH 7

Does [H⁺] increase or decrease?

$$1 \times 10^{-8} \rightarrow 1 \times 10^{-7}$$

[H⁺] increases by 1 power of 10. more acidic.
pH = 7 is 10x more acidic than pH = 8

$$.0000001 \text{ M} \rightarrow .0000001 \text{ M}$$

pH 6 to a pH 4

Does [H⁺] increase or decrease?

$$1 \times 10^{-6} \rightarrow 1 \times 10^{-4}$$

[H⁺] increases by 2 powers of 10. more acidic.
pH of 4 is 100x more than pH 6

pH 2 to a pH 5

Does [H⁺] increase or decrease?

$$1 \times 10^{-2} \rightarrow 1 \times 10^{-5}$$

[H⁺] decreases by 3 powers of 10. less acidic.
pH of 5 is 1000x less acidic than pH of 2

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Base your answer to the next 3 questions on the information below and on your knowledge of chemistry.

A sample of normal rainwater has a pH value of 5.6 due to dissolved carbon dioxide gas from the atmosphere. Acid rain is formed when other gases, such as sulfur dioxide, dissolve in rainwater, which can result in lake water with a pH value of 4.6. The equation below represents the reaction of water with SO₂(g).



State how many times greater the hydronium ion concentration in the lake water is than the hydronium concentration in the sample of normal rainwater.

Lake water vs. Rainwater
 pH = 4.6 pH = 5.6
 $[\text{H}^+] = 1 \times 10^{-4.6}$ $[\text{H}^+] = 1 \times 10^{-5.6}$
 10x more acidic than rainwater

State the color of methyl orange in a sample of normal rainwater. pH = 5.6

Table M
Common Acid-Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1-4.4	red to yellow
bromthymol blue	6.0-7.6	yellow to blue
phenolphthalein	8-9	colorless to pink
litmus	4.5-8.3	red to blue
bromcresol green	3.8-5.4	yellow to blue
thymol blue	8.0-9.6	yellow to blue

Source: *The Merck Index*, 14th ed., 2006, Merck Publishing Group

Above 4.4,
 ∴ methyl orange turns yellow in rainwater.