

Acid-Base Balance

Fundamental Concepts

Hydrogen ion concentration has a widespread effect on the function of the body's enzyme systems. Even extremely low concentrations of Hydrogen ion will be highly reactive. Since enzymes function optimally over a very narrow pH range, the hydrogen ion concentration in arterial blood is tightly regulated. The usual reference range for normal pH in arterial blood is between 7.35 and 7.45.

pH and hydrogen ion concentration		
Blood pH		[H ⁺] (nmoles/L)
7.00	<i>more acidic</i> ↑	100
7.10		79
7.20		63
7.30		50
7.4	Normal	40
7.50	↓ <i>more alkaline</i>	32
7.60		25
7.70		20
8.00		16

An abnormal pH can result in disturbances in a wide range of body systems, such as, abnormal respiratory and cardiac function, and derangements in blood clotting and drug metabolism.

Some common pH values	
Solution	pH
Gastric Juice	1.6 - 1.8
	5.5 - 7.0
Urine	6.2 - 7.4
Saliva	

Example: What is the hydrogen ion concentration of a solution that has a pH of 3.7?

To calculate the concentration use the equation:

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

Therefore, $[H^+] = 10^{-pH} \Rightarrow [H^+] = 10^{-3.7} \Rightarrow 0.000200$, and the units are in moles per liter.

The Modified Henderson-Hasselbalch Equation

To see how pH relates to acid-base homeostasis, it is necessary to look at the relationship of the respiratory system (carbon dioxide, CO_2) and the metabolic system (bicarbonate ion, HCO_3^-). The modified Henderson-Hasselbalch equation gives us a practical way to measure pH based on Arterial carbon dioxide tension or pressure and concentration of carbonic acid.

$$pH = 6.10 + \log \left(\frac{[HCO_3^-]}{0.03 \times P_aCO_2} \right)$$

Where $[HCO_3^-]$ is the concentration of bicarbonate ion (in millimoles per liter); P_aCO_2 is the arterial carbon dioxide tension or pressure (in millimeters of mercury, Hg); and 0.03 is a constant measured in millimoles per liter per millimeter of mercury. All dimensional units cancel leaving a pure number.

Example: Suppose $[HCO_3^-] = 30$ mmole/L and the carbon dioxide pressure is 43 mm Hg. What is the pH level?

$$pH = 6.10 + \log \left(\frac{30}{0.03 \times 43} \right) \Rightarrow pH = 6.10 + \log \left(\frac{30}{1.29} \right) \Rightarrow pH = 6.10 + \log(23.255814)$$

$$pH = 6.10 + (1.366532) \Rightarrow pH \approx 6.10 + 1.37 \Rightarrow pH \approx 7.47$$

Therefore the pH is about 7.47.

In practice, we measure pH directly using a device called a "pH electrode"; however, the modified Henderson-Hasselbalch equation shows how bicarbonate and carbon dioxide determine pH.

