

As a consequence of oxygen uptake of alveolar gas into capillary blood, alveolar oxygen tension falls below that of inspired gas. The rate of oxygen uptake (determined by the body's metabolic oxygen consumption) is related to the average rate of metabolic CO₂ production, and their ratio—the “respiratory quotient” ($R = \dot{V}_{CO_2}/\dot{V}_{O_2}$)—depends largely on the fuel being metabolized. For a typical American diet, R is usually around 0.85. Together, these phenomena allow the estimation of alveolar oxygen tension, according to the following relationship, known as the *alveolar gas equation*:

$$P_{aO_2} = F_{IO_2} \times (P_{bar} - P_{H_2O}) - P_{aCO_2}/R$$

The alveolar gas equation also highlights the influences of inspired oxygen fraction F_{IO_2} , barometric pressure (P_{bar}), and vapor pressure of water ($P_{H_2O} = 47$ mmHg at 37°C) in addition to alveolar ventilation (which sets P_{aCO_2}) in determining P_{aO_2} . An implication of the alveolar gas equation is that severe arterial hypoxemia rarely occurs as a pure consequence of alveolar hypoventilation at sea level while an individual is breathing air. The potential for alveolar hypoventilation to induce severe hypoxemia with otherwise normal lungs increases as P_{bar} falls with increasing altitude.

■ GAS EXCHANGE

Diffusion For oxygen to be delivered to the peripheral tissues, it must pass from alveolar gas into alveolar capillary blood by diffusing through alveolar membrane. The aggregate alveolar membrane is highly optimized for this process, with a very large surface area and minimal thickness. Diffusion through the alveolar membrane is so efficient in the human lung that in most circumstances hemoglobin of a red blood cell becomes fully oxygen saturated by the time the cell has traveled just one-third the length of the alveolar capillary. Thus, the uptake of alveolar oxygen is ordinarily limited by the amount of blood transiting the alveolar capillaries rather than by the rapidity with which oxygen can diffuse across the membrane; consequently, oxygen uptake from the lung is said to be “perfusion limited” rather than diffusion limited. CO₂ also equilibrates rapidly across the