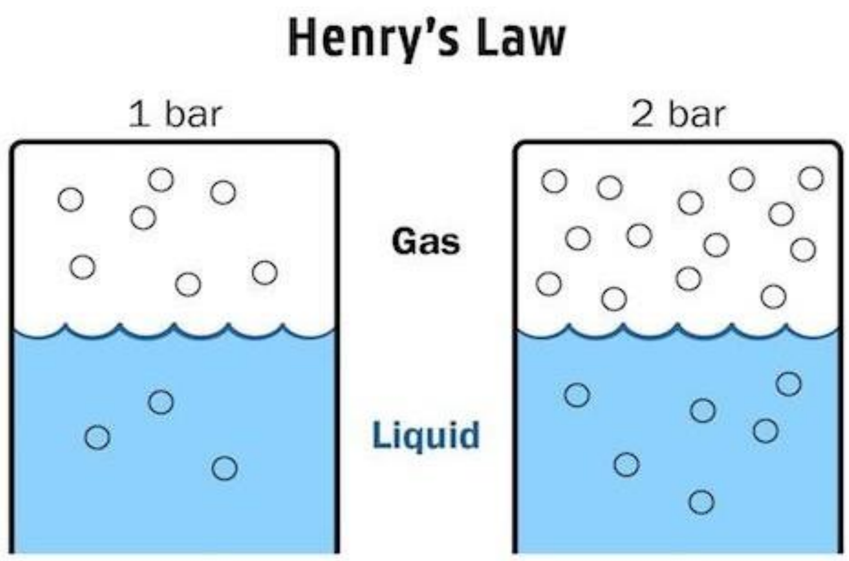
Henry's Law

Henry’s law, statement that the weight of a gas dissolved by a liquid is proportional to the pressure of the gas upon the liquid. The law, which was first formulated in 1803 by the English physician and chemist William Henry, holds only for dilute solutions and low gas pressures.



In a very dilute solution, a solute molecule will (with rare exceptions) have only solvent molecules as near neighbours, and the probability of escape of a particular solute molecule into the gas phase is expected to be independent of the total concentration of solute molecules. In this case the rate of escape of solute molecules will be proportional to their concentration in the solution, and solute will accumulate in the gas until the return rate is equal to the rate of escape. With a very dilute gas this return rate will be proportional to the partial pressure of solute. Thus, we expect that, for a solution very dilute in solute, in equilibrium with a gas at very low pressure, the gas pressure will be proportional to the amount of dissolved gas, the relation known as Henry’s law. While the above argument is to be considered only suggestive, Henry’s law is found experimentally to hold for all dilute solutions in which the molecular species is the same in the solution as in the gas. The most conspicuous apparent exception is the class of electrolytic solutions.

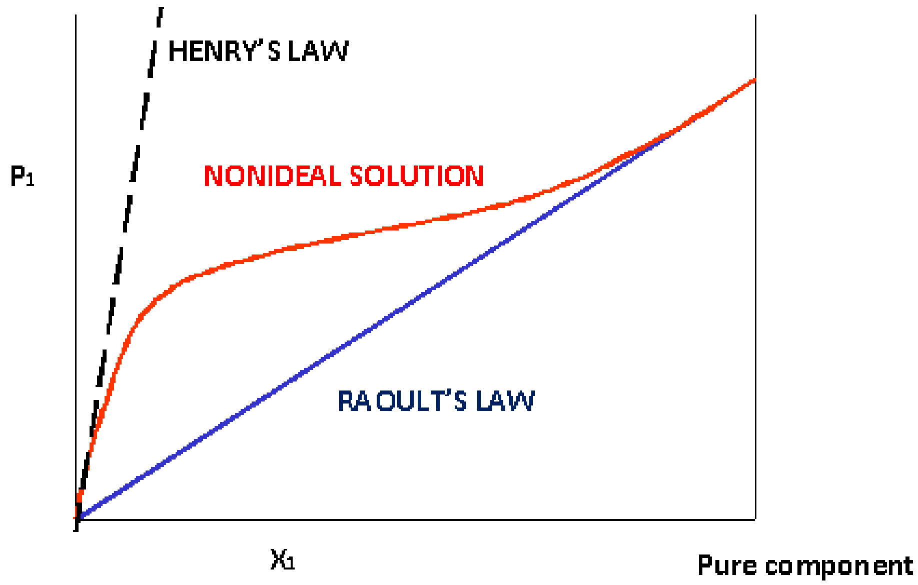


Figure: Positive non-ideal behavior of the vapor pressure of a solution follows Henry's Law at low concentrations and Raoult's Law at high concentrations (pure).

In other word, "At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid." An equivalent way of stating the law is that the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas above the liquid. The above can be expressed by formula called Henry's law

$$C = kP_{gas}$$

where

- ***C*** is the solubility of a gas at a fixed temperature in a particular solvent (in units of M or mL gas/L).
- ***k*** is Henry's law constant (often in units of M/atm).
- P_{gas} is the partial pressure of the gas (often in units of atm).

Example1 : if the concentration of CO_2 dissolved in the sparkling water in a closed soda can is 0.075 m what is the parital pressure of CO_2 (gas) in the can at 25^oC. the Henry Constant for CO_2 at 25 C is 0.34 mol/(kg.bar).

Solution

$$C = kP_{gas}$$

$$0.075\ m = 0.34 \frac{mol}{kg.\ bar} \times (P_{gas})$$

$$P_{gas} = 2.21\ bar$$

Example 2 : A tank filled with water is pressurized with H_2O (g) and H_2 (g). the total pressure in the tank is 5 bar at 0^oC. The parial pressure of H_2O (g) is 0.15 bar. Find the concentration of H_2 (g) in the water. The Henry constant for H_2 (g) in water at 0^oC is $7.8 \times 10^{-4}\ \frac{mol}{kg.bar}$.

Solution:

$$C\ (H_2) = kP_{gas}$$

$$C\ (H_2) = 7.8 \times \frac{10^{-4}\ mol}{kg.\ bar} \times (5 - 0.15\ bar)$$

$$C\ (H_2) = 3.8 \times 10^{-3}$$