

concentration of a gas that will dissolve in a liquid is directly proportional to its concentration in the free space above the liquid, may be expressed as $C_1/C_2 = K$, where C_1 and C_2 are the molar concentrations of the gas in the liquid and vapor phases, respectively, and K is the solubility coefficient. This coefficient is different for each vapor, each liquid, and each temperature.

Henderson and Haggard¹ have proposed that this law be expressed in a more convenient form when applied to the absorption of gases through the lungs into the blood. They suggest $C/C_1 = D$, where D is the coefficient of distribution, C is the concentration in the fluid phase (blood), and C_1 is the concentration in the vapor phase in alveolar air, both concentrations to be expressed on a weight per volume basis (milligrams per liter). This form of the law is particularly convenient for the purpose intended, and it is to be hoped that additional data will be collected to establish the coefficient of distribution of more gases and vapors between the atmosphere and the circulating blood. For a miscible or highly soluble material the coefficient of distribution cannot be approximated by calculation, but for a less

TABLE 1
Distribution Coefficients

Solvent	Coefficient of distribution*	Ref. no.
Methyl alcohol	1700	1
Ethyl alcohol	1300	1
Isoamyl alcohol	836	6
Primary n-amyl alcohol	804	6
Secondary isoamyl alcohol	550	6
Acetone	330	7
Methyl n-propyl ketone	167	6
Diethyl ketone	157	6
Methyl isopropyl ketone	101	6
Ethyl ether	15	1
Benzene	6.58*	8
Carbon disulfide	5	9

* The coefficient of distribution here is the ratio of milligrams of solvent per liter of blood to milligrams of solvent per liter of alveolar air.

* Based upon room air rather than alveolar air.

readily soluble vapor it can be approximated from its vapor pressure and solubility at body temperature, 37° C. The coefficient of distribution is constant for the same vapor and liquid at any given temperature regardless of the concentration of vapor in the atmosphere.

The coefficient is known for the solubility of relatively few vapors and gases in blood at body temperature; this being a field that has been insufficiently explored.

¹ H. W. Haggard, D. P. Miller, and L. A. Greenberg, *J. Ind. Hyg. Toxicol.*, 27, 1 (1945).

² A. P. Briggs and P. A. Schaffer, *J. Biol. Chem.*, 48, 413 (1921).

³ H. H. Schrenk, W. P. Yant, S. J. Pearce, F. A. Patty, and R. R. Sayers, *J. Ind. Hyg. Toxicol.*, 23, 20 (1941).

in toxicity studies. It is to be hoped that in the future such studies will include the partial pressure of the vapor or gas under observation in alveolar air, and in the body fluids, at time intervals during accumulation and elimination of vapors, as well as at equilibrium. In computing a coefficient of distribution from room-air vapor concentration data, corrections for changes in temperature and partial pressure of water vapor should be made if comparisons are desired with coefficients based upon alveolar air, because alveolar air approaches saturation with water vapor at 37° C. (47 mm. Hg partial pressure). Some of the coefficients that have been established are given in Table 1.

2. Body Saturation

From the foregoing it is evident that any gas or vapor in the air we breathe tends to pass through the lungs into the blood stream and to be distributed throughout the body. The respiratory tissue in the lungs, which has been estimated to have a surface area of about 55 sq. meters, acts as the exchange surface between blood and air. The blood in the capillaries is said to be separated from the air in the alveoli by two membranes of the utmost delicacy, perhaps only one cell in thickness, so it becomes evident that equilibrium between the blood in the lungs and the alveolar air is reached rapidly. The accumulation of the foreign gas or vapor in the body depends upon a number of factors: concentration in the air, the solubility of the material in the blood and tissues, the length of exposure, the rate of breathing, the rate of circulation, whether the material is reactive, and others.

If a gas is very soluble in the blood, saturation of the body is slow (requiring days), is largely dependent upon the ventilation of the lungs, and is only slightly influenced by changes in circulation; whereas with a very slightly soluble gas, such as nitrogen, saturation is very rapid (being nearly complete within a few minutes), is chiefly dependent upon the rate of circulation, and is little influenced by the rate of breathing. With gases and vapors that are freely soluble in water and nonreactive, or only slowly reactive, in the body, such as acetone and methanol, the absorption and distribution throughout the body are dependent upon the water content of the tissues. Although the fat-soluble vapors may be transported chiefly by the aqueous content of the blood, they tend to concentrate in the fatty tissues. With any nonreactive vapors, although the blood and tissue concentrations, short of equilibrium, are proportional to the vapor concentration and functions of the time of exposure, the rate of saturation is, with constant circulation and breathing, a relation peculiar to each vapor and independent of the concentration of the vapor. In other words, the same time is required for the same vapor to reach a given percentage saturation of the body, regardless of the concentration of the vapor in the atmosphere breathed.

It is not practical to speak of the exact time required for complete saturation, as this is a variable and too indefinite. It is, however, practical to state a time of one percentage saturation such as 50, 60, 70, 80, or even 90 per cent of saturation,