SORPTION OF GAS BY THE POROUS MATTER.

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Sorption of the gases by the porous matters such as charcoal, silica gel etc. are generally considered to be one of the adsorption phenomena. Thus the molecules of the gas condense on the surface of the charcoal. Some authors consider that the gas molecules condense to liquid in the capillary. But it is highly improbable that, except the easily condensable vapours, the gas liquefies at a temperature so appart from its normal boiling point. McBain considered that a small part of the gas diffuse into the mass of charcoal while the most part are adsorbed on the surface of the charcoal, and he used the term "sorption" for such a case.(1)

The author measured the sorption amount by various kinds of charcoals of air(2) and of carbon dioxide as well as the sorption velocity by sugar charcoal of carbon dioxide.(3) It was known that the sorption velocity of gas by the granular charcoal is smaller than that by the powder one, while the sorption amounts by both charcoals are quite the same. We saw, moreover, that the amounts of sorptions of carbon dioxide by various kinds of charcoals are not so different each other notwithstanding the divergence of the materials from which the charcoals were made. According to the results of these observations, the author concluded that the sorption of gas by charcoal is to be ascribed to the dissolution and not to the adsorption.

By the experiments of the sorption of gases by chabazite,(4) it can naturally be supposed that the gas molecules enter into the crystal of the dehydrated chabazite in the places where the water molecules has formerly situated. There are vacant cavities in the dehydrated chabazite crystal, each of which was formerly filled with water molecule. If such dehydrated chabazite is brought in contact with gas, the gas molecules enter into the mass of the crystal and take possession of the cavities which were left unoccupied. Thus the crystal is still a homogeneous phase in the sence used in phase rule.

The author consider that the same can be said in the case of charcoal and silica gel. Charcoal has a great number of molecular cavities which were left when it was produced by the decomposition of carbohydrate etc. Silica gel has also molecular cavities left by the departure of water molecules in the process of dehydration.

Now the gas molecule dash into one of these molecular cavities and it is attracted and captured by the surrounding charcoal atoms or silica molecules. The gas molecule settles into the molecular cavity and make a homogenous solid solution. So the sorption process is not quite the same with the ordinary dissolution process, while the product is a solid solution. The phenomena neither be called "absorption" nor "adsorption." We will use the term "sorption" for this case, having the different meaning

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(1) McBain, *Z. physik. Chem.*, **68** (1909), 471.

(2) Sameshima and Hayashi, *Science Reports of the Tohoku Imperial University*, **12** (1924), 289.

(3) Sameshima, this Bulletin, **2** (1927), 1.

(4) Sameshima, this Bulletin, **4** (1929), 96.

from that used by McBain. Our " sorption " means the entering of the gas molecule into the molecular cavities and forming a solid solution.

It is well known fact that the more easily condensable gas are sorped the more, and this is considered to be one of the reasons of the adsorption hypothesis. This relation, however, hold never strictly but only approximately. According to the author's theory, the easily condensable gas molecule is liable to be captured more easily than the non-condensable gas molecule. In other words, the more active gas molecule is the more difficult to be prisoned. In the process of the ordinary dissolution, the solute molecule push aside the solvent molecules, or the solvent molecules make room for the solute molecule. So the molecular affinity between solute and solvent molecules is the most important factor for the ordinary dissolution.

Some authors describe that the rapidity of sorption of gases by the porous matters is to be due to the surface adsorption. They said that if it be a diffusion phenomena, then the sorption will proceed more slowly.(1) This statement is correct, however, only in the case of the diffusion into a compact solid body. In a case of the porous body such as charcoal, the contact surface between gas and solid is very large, and therefore, the "diffusion" goes on very rapid. By powdering the charcoal, the surface area will increase so the sorption velocity will also increase. This was already proved experimentally.(2)

Other reason of the adsorption hypothesis consists in the non-expansion of the adsorbent body. The expansions of charcoals by the sorptions of carbon dioxide and water vapour are observed recently by Meehan,(3) and Bangham and Fakhoury.(4) The amounts of expansions of charcoals determined by these authors are rather small, i.e. in the order of 0.1%. This can be explained by the present author's theory that the CO_2 molecules enter into the cavities of charcoal.

It is known that the sorption isotherm generally deviates from the Henry's law. This can easily be understood from the difference between the author's theory and the ordinary dissolution process. In the case of the sorption of hydrogen by charcoal, the Henry's law is applicable.(5) Recently, Magnus and co-workers(6) have determined the sorption isotherms by purified charcoal and silica gel of carbon dioxide at low pressures and known that the Henry's law is applicable.

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(1) Zsigmondy, " Kolloidchemie," 4ed. (1924), p. 85.

(2) Sameshima, this Bulletin, **2** (1927), 1.

(3) Meehan, *Proc. Roy. Soc.* (London), A, **115** (1927), 199.

(4) Bangham and Fakhoury, *Nature*, **122** (1928), 681.

(5) Titoff, *Z. physik. Chem.*, **74** (1910), 641.

(6) Magnus and co-workers, *Z. anorg. allg. Chem.*, **174** (1928), 142; **179** (1929), 215.

Summary.

The mechanism of the sorptions of gases by charcoal, silica gel and chabazite etc. are discussed. The author's theory for these cases is as follows: The gas molecules enter into the molecular cavities in the solid body and form a homogeneous solid solution.

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