

SOME NOTES ON THE ATOMIC CONDITION

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In order to understand present day development of chemical theory it is necessary for the student to have a thorough understanding of the meaning of molecule, ion, atom and electron, and their sometimes complex inter-relationship and interaction. Unfortunately many texts use the words molecule and atom loosely, so that confusion arises in the reader's mind.

A review of the present usage and a few suggestions as to possible conditions in chemical action is the object of this paper.

Of the four terms, molecule is the largest and inclusive one.

We recognize that molecules may be divided or disrupted in three ways.

Molecules may ionize, as in the case of a solution of ammonium sulphate in water. Ammonium sulphate is taken as an illustration, because in this case the ions, ammonium, and sulphate are not elements but semi-molecules capable of further subdivision.

Second, according to common interpretation, both molecules and ions may become momentarily atomic.

In the third place, electrons may be split off or separated from atoms (perhaps the proper word to use here is molecules), as in radium and the other radioactive elements.

Again, we recognize the molecular condition of both elements and compounds as being the stable, or quiescent state, a condition in which the forces within the molecule are in equilibrium.

The common interpretation is also that when chemical action does occur the molecular condition has been disturbed or disrupted, in other words, that chemical action does not go on in the molecular condition. At this point, however, confusion arises. Is it the atomic or the ionic condition in which chemical action takes place?

Let us muster the facts concerning both the ionic and the atomic state as we have observed them. Certain sub-

stances when in solution (usually in water) are said to ionize. These substances are very active chemically and are good conductors of electricity. Substances that are said not to ionize are on the other hand practically non-conductors and almost inactive chemically. To explain these things the ionization theory supposes that these molecules in solution separate into ions; that the ammonium sulphate separates into two ions of ammonium and one of sulphate; and further, that the ammonium ions carry positive charges of electricity and that the sulphate ion, being bivalent, carries two negative charges; and still further, that the two negative charges on the sulphate ion are in reality negative electrons in excess of the actual atoms contained in the semi-molecule and, by inference, that the ammonium ions are positively charged because in reality they lack one electron each.

The peculiarities of ionization are these: that substances do not ionize completely and that in a given solution there is a constant change from molecule to ion and vice versa; that substances ionize more completely in dilute than in concentrated solutions; that only substances that ionize are chemically active; that substances do not necessarily ionize into their elements.

Consider the system sodium chloride in a solution with water. The molecules of sodium chloride are in equilibrium with ions of sodium positively charged and ions of chlorine negatively charged. On addition of the system silver nitrate in a solution with water, which consists of silver nitrate molecules in equilibrium with silver ions positively charged and nitrate ions negatively charged, we have a reaction which may be analyzed into an attempt to establish an equilibrium between not only the ions of silver, sodium, chlorine, and nitrate, but between the molecules of sodium chloride, silver nitrate, and the newly formed sodium nitrate and silver chloride. As silver chloride is only slightly soluble in water, precipitation will occur and new silver chloride will be formed until practically all of either the silver or the chlorine has been eliminated from the system.

In the foregoing the ionic condition answered admirably for all chemical actions involved and the charges of negative and positive electricity that the ions carried explained why sodium nitrate and silver chloride were formed and why no combination occurred between the chlorine and the nitrate and the silver and the sodium.

Again, consider the same system sodium chloride in a solution of water in which is inserted two electrodes connected to a continuous source of current. The theory of reaction is as follows: When the negatively charged chlorine ion touches the positively charged pole it is relieved of its excess electron and becomes for the instant atomic chlorine. If the substance of which the pole is made is zinc or any substance readily attacked by chlorine, a chloride is formed. If, however, our pole is one which is not attacked by chlorine, the atomic chlorine immediately combines with itself making Cl_2 , molecular chlorine.

Note that in the two cases where we have used the same sodium chloride system we have resorted to different conditions to explain chemical action. In the first we were satisfied to say that chemical action went on in the ionic condition and used the electric charge present to explain certain reactions. In the second we resorted to the atom to help us out in our explanation, admitting that it is neutral in electrical charge and offering no other plausible excuse for its very definite chemical action.

But cannot these actions be also explained as going on in the ionic condition? Could we not, for instance, consider that in the zinc electrode a molecule might become ionic under the influence of the potential and in that condition combine with the negative ion of chlorine?

In an explanation of the formation of Cl_2 , molecular chlorine, or H_2 , molecular hydrogen, etc., we must first come to the conclusion that whether the excess electron remains with one or the other of the ions depends upon the tension within the molecule and the force impressed upon it by the solvent. In such a case we could readily imagine the action of our platinum electrode as being catalytic in character; for instance, that a molecule of platinum be-

comes ionized under the influence of the potential and unites with the negative ion chlorine. If under the influence of the solvent and the electrolytic conditions this chlorine compound should be so ionized that the platinum ion would be negatively charged and the chlorine positively, the platinum would immediately be redeposited on the electrode, while the positive ion of chlorine would unite with a negative ion of chlorine to form molecular chlorine, Cl_2 .

Consider now other conditions in which we usually imagine that the atomic state exists.

At very high temperatures molecules are said to dissociate. Do they dissociate into ions or do they dissociate into atoms? If, for instance, a gram molecule of hydrogen were to be dissociated at high temperature, we could hardly imagine it all to be dissociated into positively charged ions, because there is no potential developed. If we imagine it to be dissociated into neutral atoms we have difficulty in explaining the activity of hydrogen at high temperature. But if we consider that the molecule splits up into a negative and a positive ion, the electric charge that we could detect would be zero, yet the extreme activity could be explained by ionization.

The chemical activity produced by sunlight as in the photographic plate, by electricity as in the fixation of nitrogen, and by shock as in the explosion of nitroglycerin, may as readily be explained by the ionic condition as the atomic.

The inference is:

- (1) That the atomic condition is an imaginary condition used to better explain various chemical actions, or
- (2) That the atomic and the ionic conditions are identical.