COMMENT ON "ANOTHER POINT OF VIEW."

BY ALEXANDER SMITH.

While I am indebted to the editor for his courtesy in giving me the opportunity to comment on Mr. Peters' article, there is much that might be said, yet little that must be said. "He sees things from one viewpoint, and I from another."

In one or two places, however, I question whether we are seeing the same things at all. Thus, I feel that something more than a difference in viewpoint is involved when we read, "the truth of Boyle's and Charles' laws depends largely upon the molecular theory of matter."

Again he says, "But to allow the atomic theory to explain the fact of chemical combination, or any other theory to explain any observed phenomenon is entirely out of the question." Yet, further down, in connection with ozone and oxygen, we read "Will he [the student] not demand an explanation? Is it a very long step to say that the oxygen molecule consists of two atoms and the ozone of three?" This looks to me like, not one, but two other points of view. Can any meaning be attached either to the word theory, or to the word explanation which will reconcile these statements?

I tried to show that the atomic theory explains the quantitative laws, but fails to throw light on the qualitative facts which usually precede them. Mr. Peters, however, would introduce the theory at the earlier stage. His first reason, that the molecular theory has been previously studied in physics, would justify the discussion of photography and batteries before constant proportions because light and electricity are parts of physics. His second reason, that he "sees no objection to reviewing briefly very early in the course in chemistry the molecular theory" seems, from my viewpoint, unsafe. One may so easily overlook or fail fully to appreciate objections, that positive and thoroughly sound reasons for every decision of this sort should be demanded by one's pedagogical conscience before the decision is made.

The conception that the meaning of a symbol or equation can be stated only in terms of the atomic theory, as a consequence of which equations have to be postponed until after the atomic theory has been explained, does not appear to me to be consistent with facts, or, for example, with a common use of equations, namely in working simple arithmetical problems.

In the matter of H_2 , there seems to be some confusion. I did not discuss the question of purely theoretical *vs.* purely abstract terms for expressing facts to beginners. That would be as fruitless a subject as discussing whether a neat menu-card or a photograph of a breakfast would best satisfy the appetite of a hungry pupil. I suppose we all agree that the third possibility, the experimental, gives the best results. I was not writing a paragraph for a text-book, but trying in the course of a highly condensed address, delivered, not to pupils, but to teachers of chemistry, briefly to characterize two views. It was the two possible viewpoints of the teacher, not the mode of presentation from either viewpoint, that I was discussing, for the latter would have been outside of the limits set by my title and enforced by the briefness of the time.

But, aside from the misapprehension of my purpose, Mr. Peters does make clear, in this connection, the point at which our views diverge. He thinks it involves the more abstract viewpoint if we reason: (1) that there are equal numbers of molecules in equal volumes of gaseous substances (at the same temperature and pressure); (2) that our formulae, being molecular, represent relative weights of equal volumes of gaseous substances (without this, neither Mr. Peters nor anyone else has any cause to use the formula H_2 , rather than H at all); and (3) that, since 1 liter of hydrogen contains .09 g. of the element, while 1 liter of hydrogen chloride contains by measurement only .045 g., if the latter quantity be represented by H , the former must be represented by H_2 . There are various ways of expressing this third step, of which this appears to be the most literal. Now I think the statement that one molecule of hydrogen contains two atoms, and that the formula of the gas is therefore H_2 , is vastly more abstract. I assume, of course, that all necessary illustrations and every pedagogical art will be used in presentation, whichever point of view is in the teacher's mind. Suppose Mr. Peters to use the second point of view and his pupil to ask, "How do we know that there are two atoms in the molecule?" is Mr. Peters not then compelled to go into the explanation from the other viewpoint after all? If, therefore, the statement in terms of atoms, contains, implicitly, the longer statement, is it not *ipso facto*, the more abstract of the two? There still remains the question of whether the subject is an appropriate one for treatment in a high school course at all, and whether it is not rather of interest

only to those who are in college and are going on to more advanced work in chemistry. I took up the subject because it actually is handled in secondary schools, and I was not discussing the ideal content, but only the viewpoint in certain items of the commonly accepted content.

As to the nascent state, iron, zinc and other metals reduce ferric chloride without the presence of hydrochloric acid, so that no hydrogen need be evolved at all. The view which I presented is one now held by many chemists, including so eminent an authority in electro-chemistry as Prof. Haber of Karlsruhe, and is therefore entitled to more consideration than Mr. Peters accords it. If we accept the catalytic theory, perhaps we may not know a great deal more than we did before, but we do know this, that a single explanation, if it is ever found, will probably cover both catalytic and nascent action, whereas from Mr. Peters' viewpoint, two explanations are required. Simplification is one of the principles of the scientific method.

In regard to valence, my statements certainly would seem hopelessly abstract to beginners, but then they were addressed to teachers. Again, if our pupils can determine experimentally that 12 grams of magnesium displace 1 gram of hydrogen, but cannot utilize the result even with the assistance of the teacher, I fail to see how they can understand the more abstract way of stating the same result when the teacher informs them that one atom of magnesium displaces two atoms of hydrogen. Does Mr. Peters mean that they have to learn the latter form of the statement off by heart? What good can it then do them, when so learned? His remarks, if they represent the experience of many teachers, seem to show that we should not try to teach valence in any form in the secondary school. Its case seems to be somewhat like that of H_2 . Finally, the quotations from my *Introduction to General Inorganic Chemistry* cannot be judged without careful examination of the context. But Mr. Peters seems to criticise me for venturing to introduce the atomic theory on p. 51 after I have completed the discussion of the quantitative laws (which I indicated in the Point of View to be the place where it should go), although in the opening part of his paper he contends that it ought to be put in much earlier. He is difficult to please. More space is taken up with the atomic and molecular theories in the work referred to than in any other with which I am acquainted! But my viewpoint is such that I cannot accept as conclusive the reasons, photographic or otherwise, which favor the use of these theories in chemistry before the quantitative laws are discussed.