The Complexity of the Solid State.

It is a well-known fact that if we distil off a part of a quantity of pure water, no physical or chemical property is changed by the process; for example, the vapour pressure of the remaining liquid, the vapour tension of the distillate, and the vapour tension of the original quantity of liquid are identical. Precisely the same result is obtained if we distil a quantity of the crystalline aggregation of water, namely, ice. But if we take a mixture of water and alcohol, the result of a partial distillation is quite different; for now the vapour tension of the remaining portion is lower and that of the distillate higher than the vapour tension of the original mixture. This phenomenon is caused by the fact that alcohol is more volatile than water, so that the vapour which is being condensed is richer in alcohol than the evaporating liquid. Consequently the evaporating liquid becomes poorer and the distillate richer in alcohol than the original liquid. Distillation effects, as we see here, a partial separation, and that explains the observed changes in vapour tension. Now there are also crystalline mixtures, which differ from the liquid mixture of the same substances therein only in that the state of aggregation is a crystalline one. Every crystal in this case contains the substances, being mixed, and is named a mixed crystal. If we submit now such a mixed crystal to distillation, the effect is exactly the same as in the case of the mixture of alcohol and water.

On the basis of the above facts, it was of course thought that, taking not a mixture but a pure simple substance, distillation would never effect any changes in vapour tension. Our experiments, however, have shown otherwise. By partial distillation of most carefully purified crystalline violet phosphorus at 360° we got a residue showing a much lower vapour tension than the original quantity, while the distillate had a much higher vapour pressure. While the vapour tension of the original violet phosphorus at 460° was 3 atmospheres, the vapour tension of the residue at the same temperature was only 1 atmosphere, that is, $1/3$ of the original value.

How is this result to be explained? The old considerations of the different states of aggregation are completely powerless to give an explanation. The theory of allotropy, however, offers no difficulty. On the contrary, this result is a valuable confirmation of this theory, because it assumes that every state of aggregation is complex, so that every crystalline state consists of mixed crystals, built up from molecules of different kinds. These different kinds of molecules can change one into the other; the transformation can lead to a chemical equilibrium, and only when this equilibrium (inner equilibrium) is always established, does such a pure substance behave as a real single one. If this equilibrium is established slowly, or if the transformations are stopped, then a pure substance will behave as a mixture.

The velocity with which this inner equilibrium between the different kinds of molecules is established seems to be a very characteristic property of substances, so that there are "rapid" and "slow" substances. Rapid substances can undergo rapid changes without coming out of inner equilibrium, but slow ones can be disturbed. It is clear that in the light of these considerations the results obtained with violet phosphorus can be explained easily. Violet phosphorus is a "slow" substance and therefore evaporation at relatively low temperature will cause the residue to become poorer in the most volatile molecular species, thereby decreasing its vapour tension.

This explanation is borne out by the following fact.

It is to be expected that a substance will become "less slow" or "more rapid" at higher temperatures. In agreement with this it was found that the vapour tension of the distillation residue of violet phosphorus above 470° was no longer constant but slowly rising. Further, it is clear that if the theory is true, a catalyst will bring the violet phosphorus into inner equilibrium and give it the normal vapour pressure. This also was found, for after heating the distillation residue with 0.1 per cent. iodine for five hours at 410° , the vapour tension had become completely normal again.

As is mentioned above, behaviour as a mixture will be complete if all transformations between the different molecular species are stopped, and Baker has showed us how to reach that. The intensive drying seems to be the right method, and that is why, in continuing our experiments, we have applied the drying method of Baker.

The behaviour of sulphur trioxide was studied after drying with freshly distilled fine phosphorus pentoxide. Since sulphur trioxide itself possesses a strong self-drying power, it seemed probable that after a short drying, and perhaps even before that, sulphur trioxide would show distinctly its complexity. During our investigations, there appeared a publication by Leblanc and Rühle entitled "Sulphur Trioxide, a Chemical Chameleon," the title of which shows already the difficulties offered by the behaviour of this substance. Now we found that sulphur trioxide, dried for one month or longer, with the purest very fine phosphorus pentoxide, is so "slow," that it behaves distinctly as a mixture. Since the range of temperature and pressure within which that behaviour reveals itself is much more easily approached than in the case of phosphorus, it could be studied more closely. Thus we could change the vapour pressure of a crystalline state of aggregation continuously by evaporation, so that, for example at 0° , the vapour pressure changed from 208 mm. of mercury to 22 mm. of mercury. Further, it was also possible to get liquids of different vapour pressures, for example at 20° , between 200 and 172 mm. of mercury. Finally we were able to show that the behaviour of sulphur trioxide is that of a mixture, in which one or more compounds are formed.

In connexion with these phenomena, it is interesting to recall that for several years methods have been used which enable us to determine the atomic centres in the space lattice of a crystal, but nothing about an inner equilibrium has been discovered. This would astonish us if it had not turned out that the X-ray analysis of a mixed crystal of different substances gives a diffraction image which does not differ essentially from that of the components. Thus it is not yet possible to conclude from the X-ray diagram, whether or not we have a mixed crystal. It is just because, in the case of a simple substance, the identity of all crystal cells was postulated, that the character of mixed crystals of these substances was never found. Indeed, the identity of the crystal cells excludes a crystal of continuously changeable composition. At present, however, the picture of the complex inner state, supposed by us, is not exact enough to be tested and elaborated by X-ray analysis.

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Atmospheric Electricity and Atmospheric Pollution.

I HAVE read with especial interest the summary, in *NATURE* of April 5, p. 493, of Prof. Nolan's recent work on the relation between the potential gradient and the number of large ions in the atmosphere, because the problem he refers to is at least