gave 3 grams of a dark red oil with a decided isonitrile odor. This odor was noticed to a slight extent in all the reductions of nitrobenzene.

Paranitrotoluene in Concentrated Solution.—Ten grams of *p*-nitrotoluene dissolved in 250 cc. of 95 per cent. alcohol and reduced in the manner just described, with 53 grams of 10 per cent. amalgam gave 4 grams *p*-azotoluene, melting-point 144°, equal to 52.2 per cent. of the theory, and 3.5 grams of *p*-azoxytoluene, melting-point 54°, or 42.5 per cent. of the theoretical.

It is probable that the reason for the more marked reducing action of the amalgam in the concentrated hot solution is that the magnesium ethylate is, in part, oxidized as it forms, while if the reduction be carried out in the cold the ethylate precipitates and is not affected by the subsequent boiling.

NOTE.

Note on the Amount of Moisture Remaining in a Gas after Drying with Phosphorus Pentoxide.—My earlier[1] paper on this subject stated that the amount of moisture left in a gas by this drying agent is something like a milligram in 40,000 liters. It is now possible to make the approximation somewhat closer. In order to explain the advance in precision it will be convenient to refer to the parallel case of sulphuric acid.

If air is passed through sulphuric acid it retains some water and takes up some vapor of sulphur trioxide. It is easy to determine the sum of these two quantities, and easy to determine the quantity of sulphur trioxide. The difference of these quantities gives the amount of aqueous vapor left unabsorbed. The quantities concerned are so large, in the case of sulphuric acid, that volumes of a few hundred liters of gas are sufficient to give a tolerable accuracy to the determinations.

Phosphorus pentoxide leaves so little water vapor that an experiment, lasting four months and dealing with 4,300 liters, only gave a quantity 0.1 mg. for the sum of water and of phosphorus pentoxide vapor. This result was published in the hope that it night be found useful, although the amount of pentoxide vapor

[1] *Am. J. Sci.*, **34**, 199 (1887); Fresenius: *Ztschr. anal. Chem.*, **27**, 1.

was undetermined, so that the actual amount of water vapor might be decidedly less than the value stated.

The amount of pentoxide vapor contained in this sum has now been determined. A set of voltameters was arranged to deliver a liter of oxygen an hour and a little less than twice as much hydrogen. The gases finally passed through a large volume of phosphorus pentoxide. Here it was hoped that the two gases would be saturated with the vapor of the drying agent, but the quantity taken up is so small that no direct proof of saturation was obtained. The two gases were then led into a combustion chamber, such as was used in my syntheses of water,[1] except that no auxiliary drying tubes were needed, and that a globe was fused on in which should be collected the 0.5 liter of water about to be produced. The combustion was maintained for a fortnight. Three liters were entering the chamber each hour, but only a few bubbles were escaping in the same time; vapors of phosphorus pentoxide entering would, therefore, have to remain so long in contact with water and steam that their absorption may be assumed complete.

When nearly 900 liters of the gases had been consumed the water was mixed with a few milligrams of sodium carbonate and evaporated to the volume of 5 cc. This residue was mixed with nitric acid and molybdate solution, and sealed in a glass tube. Similar tubes containing known amounts of phosphorus pentoxide were treated in the same way. All the tubes were heated to 40° for a suitable time. A careful comparison of the precipitate showed that the first tube contained 0.02 mg. of phosphorus pentoxide. This being the amount in 900 liters, the 4,300 liter of the earlier experiment would have given 0.1 mg. of pentoxide. But this is the amount of pentoxide and water, taken together, which is contained in 4,300 liters, according to the experiment of 1887. If the difference of two so uncertain numbers could be trusted, the inference would be made that phosphorus pentoxide leaves no moisture in a gas. It may be added that the 4,300 liters of 1887 were probably not quite saturated with the vapor of the pentoxide.

No one, perhaps, is more fully aware than the writer what large *percentage* errors are contained in the values. No such experi

[1] Smithsonian Contributions, No. 980, p. 100, Fig. 36.

ments as these, nor many like them, could establish, with precision, the physical constants of phosphorus pentoxide. But they show conclusively, unless gross error be suspected, that no gravimetric experiments which the scientific world has in hand at present would need to take account of the moisture which phosphorus pentoxide leaves in a gas. A current passing at the rate of 2 liters an hour through 25 cc. of the pentoxide properly filled into a drying tube, contains much less than 1 mg. of water vapor in 40,000 liters; whether a half or a tenth of this quantity, no one can now say.

Many, speaking hastily, use expressions which imply that it is difficult to dry a gas completely in refined experiments. It is easy to dry a gas completely, but it is difficult to keep it dry when it is passed into a vessel with a well-wet surface, such as the surface of ordinary so-called dry glass. According to Talleyrand, one important office of language is to conceal thought; and, in refined experiments the use of the word *dry*, as applied to any exposed surface of glass below the point of fusion, is to be regarded as a charming example of such concealment. If a man, preparing absolute alcohol, collects his product in bottles not drained after washing, he may, doubtless, be permitted to conceal his thought by saying that it is excessively difficult to prepare absolute alcohol.

My own requirements as to dryness of glass surfaces have not been extreme, nor my means of detecting residual moisture so fine as is the case with experiments on the rate of chemical change in the absence of water. The inner surface of a glass apparatus containing phosphorus pentoxide and kept exhausted to a hundred-millionth of an atmosphere has seemed dry after five days at ordinary temperatures, or after one day at 100°. But if the apparatus is filled with a gas, dry when introduced, the glass surface loses its moisture to that gas, and the diffusion of the moisture from the glass to the pentoxide is but a slow process. The time needed to dry the glass will, therefore, be much longer than if a vacuum were maintained. This is not because the drying of a gas is difficult or slow, but because it is a slow process to dry a gas and moisten it alternately for perhaps a score of times.

EDWARD W. MORLEY.

WESTERN RESERVE UNIVERSITY,
CLEVELAND, OHIO.