

XXII.—*On the Synthetical Production of Ammonia by the Combination of Hydrogen and Nitrogen in presence of Heated Spongy Platinum (Preliminary Notice).*

By GEORGE STILLINGFLEET JOHNSON, King's College, London.

IN the course of my experiments on the "Occlusion of Hydrogen by Copper," the results of which were published in this Journal in May, 1879, being anxious to ascertain whether hydrogenised copper is capable of retaining its occluded hydrogen when heated in a gas which has no chemical action upon it, I investigated the action of *nitrogen* gas at a red heat upon freshly hydrogenised copper, and found the occluded hydrogen was entirely lost by the metal under those conditions. Subsequently, advantage was taken of this fact in order to determine how far the water collected on heating recently hydrogenised copper in dry air was due to aqueous vapour or *moisture* retained by the reduced metal, and how far to the oxidation of occluded hydrogen gas. For this purpose, I passed a stream of dry pure nitrogen gas through a series of tubes, the first of which was a combustion-tube containing metallic copper recently reduced in hydrogen gas, the second being a counterpoised tube containing sulphuric acid, the third a hard glass tube containing oxide of copper, and the fourth a second counterpoised tube containing sulphuric acid. The oxide of copper-tube was heated to redness first, and the nitrogen passed till the second  $\text{H}_2\text{SO}_4$ -tube had a constant weight.

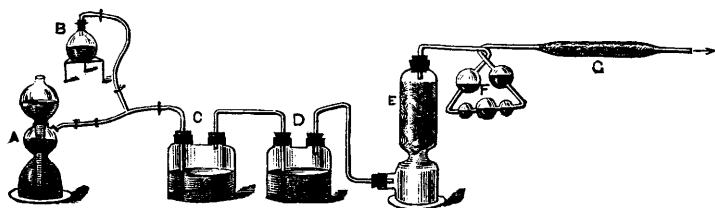
The hydrogenised copper was then heated in a stream of nitrogen, the  $\text{CuO}$ -tube being still kept at a red heat. In all cases the second  $\text{H}_2\text{SO}_4$ -tube gained weight due to water produced by oxidation in the  $\text{CuO}$ -tube of occluded hydrogen evolved by the copper at a red heat

in an atmosphere of nitrogen; but it was also noticed that a small quantity of white saline matter collected in front of the first  $\text{H}_2\text{SO}_4$ -tube, and this suggested the possibility of the formation of traces of ammonia by combination of nitrogen with a portion of the hydrogen evolved from the heated copper.

Acting upon this hypothesis, I passed a mixture of hydrogen and nitrogen gases, carefully purified, over spongy copper and over asbestos at a red heat, and obtained in both cases minute traces of ammonia; so small a quantity, in fact, that the results were not deemed worthy of publication at that time, though sufficiently suggestive to make it well worth while to attempt the synthesis of ammonia by such metals as *spongy platinum*, spongy palladium, &c.\*

The opportunity long delayed, arrived a few days since, and I determined to investigate the action of spongy platinum upon a mixture of pure hydrogen and nitrogen gases at a low red heat. With this purpose in view, I fitted up the following apparatus:—

APPARATUS FOR THE PRODUCTION OF AMMONIA BY SYNTHESIS FROM NITROGEN AND HYDROGEN.



A contains zinc and sulphuric acid, from which hydrogen gas is evolved, and enters the Woulffe's bottle C, which contains a solution of nitrate of silver, next passes through D, which contains oil of vitriol, then through E, which contains fragments of pumice-stone moistened with oil of vitriol, then through the bulbs F, which contain "Nessler reagent," then through the tube G, which contains the spongy platinum. The spongy platinum having been heated to redness in pure hydrogen, and the absence of ammonia therein being proved by a negative result with the Nessler test, the solution of nitrite of ammonium in the flask B was heated until nitrogen gas was evolved, and, mixing with the hydrogen, passed through the drying and purifying apparatus, and came in contact with the heated spongy platinum.

\* I was the more anxious to investigate this matter, as the only experiments I could find recorded bearing upon the subject were those of Professor Donkin, who succeeded in obtaining traces of ammonia by the action of induced electricity upon a mixture of nitrogen and hydrogen, but did not obtain quantities sufficient for gravimetric analysis.

As soon as the mixed nitrogen and hydrogen gases reached the hot spongy platinum *ammonia* was produced, as shown by the brown colour assumed by the Nessler reagent, by the odour of the gas as it issued from the tube, by the restoration of the blue colour to reddened litmus exposed to its action, by the fumes which it produced with vapour of hydrochloric acid, &c.

The experiment was repeated *ab initio* several times with the same platinum, and always with precisely similar results.

In two experiments pure nitrogen was passed over the heated platinum first, and, after all ammonia had been expelled, hydrogen was allowed to mix with the nitrogen, when the ammonia was at once reproduced as before.

Having thus proved *qualitatively* that ammonia is produced synthetically when a mixture of pure hydrogen and nitrogen gases is passed over heated spongy platinum, I made a *quantitative* experiment by collecting the ammonia produced in bulbs containing a known volume of standard sulphuric acid. 8.5 c.c. of decinormal sulphuric acid were neutralised by the ammonia evolved during two hours and a half. Hence 0.0144 gram of ammonia had been produced, which corresponds with a formation of 0.0059 gram of  $\text{NH}_3$  per hour.

I hope to complete this research by investigating the influence of temperature, proportion of N to H, quantity of spongy metal present, rapidity of current of gas passing through the apparatus, and especially the action of *spongy palladium* and other substances, with a view to ascertain the most favourable conditions for the *maximum production of ammonia by synthesis*.

---