

[CONTRIBUTION FROM FERTILIZER INVESTIGATIONS, BUREAU OF CHEMISTRY AND SOILS, UNITED STATES DEPARTMENT OF AGRICULTURE]

The Solubility of a Mixture of Hydrogen and Nitrogen in Water at 25° in the Pressure Range 50 to 1000 Atmospheres

By R. WIEBE AND V. L. GADDY

Continuing the work on the solubilities of gases in water¹ it was thought of particular interest to determine how far the solubility of a mixture would deviate from values calculated from the pure constituents over a wide range of pressure.

nitrogen mixture was prepared by burning hydrogen in air. The amount of argon introduces an uncertainty of about 0.2%. The composition of the gas in the two phases was analyzed by means of a modified form of thermal conductivity appa-

TABLE I

THE SOLUBILITY OF A HYDROGEN-NITROGEN MIXTURE IN WATER AT 25° (CC. OF GAS AT S. P. T. PER G. OF WATER)

Pressure in atm.	Solubilities					Av. for set of runs	Percentage of H ₂ in the gas present in		Final av.
							Liquid phase	Gas phase	
50	0.8324	0.8373	0.8376	0.8324	0.8310				
	.8351	.8349				0.8344	80.27	76.57	
		.8361	.8335	.8364	.8376	.8359	80.08	76.41	0.8349 ± 0.0005
100	1.635	1.637	1.640	1.642	1.638	1.638	80.73	76.40	
	1.637	1.638	1.644	1.649	1.649	1.643	80.96	76.54	
	1.646	1.647	1.644	1.649	1.639	1.645		76.51	
	1.645	1.639	1.648	1.642	1.648				
	1.645					1.645	80.88	76.60	1.643 ± .001
200	3.223	3.191	3.224	3.214	3.223	3.215	82.22		
	3.189	3.201	3.211	3.202	3.216				
	3.208					3.205	83.13		3.209 ± .003
400			6.062	6.062	6.066	6.063	84.20	76.31	
		6.080	6.065	6.060	6.084	6.072	84.46	76.32	6.068 ± .002
600	8.783	8.822	8.811	8.824	8.785	8.805	85.05	76.36	
		8.795	8.807	8.834	8.817	8.813	84.80		8.809 ± .004
800		11.331	11.310	11.289	11.318	11.312	85.60	76.39	
		11.318	11.347	11.337	11.367	11.342	85.04	76.41	11.327 ± .006
1000		13.698	13.780	13.809	13.703	13.748	85.96	76.28	
		13.693	13.742	13.616	13.754	13.701	85.66		13.724 ± .014
						Average	76.42% H ₂		

TABLE II

Pressure in atm.	Solubilities				Calcd. values for 76.42% H ₂ mixture	Experimental values	% Deviation from experimental values
	Of hydrogen	Of hydrogen multiplied by 0.7642	Of nitrogen	Of nitrogen multiplied by 0.2358			
25	0.463	0.333	0.348	0.082	0.415		
50	.867	.663	.674	.159	.822	0.8349	1.6
100	1.728	1.321	1.264	.298	1.619	1.643	1.5
200	3.39	2.591	2.257	.532	3.123	3.209	2.7
300	5.00	3.821	3.061	.722	4.543		
400	6.57	5.021	3.785	.893	5.914	6.068	2.5
500	8.09	6.182	4.441	1.047	7.229		
600	9.58	7.321	5.037	1.188	8.509	8.809	3.4
700	11.04	8.437	5.600	1.320	9.757		
800	12.46	9.522	6.134	1.446	10.968	11.327	3.2
900	13.85	10.584	6.646	1.567	12.151		
1000	15.20	11.616	7.15	1.686	13.302	13.724	3.1

The same method and procedure were used as in previous work. An approximately 3:1 hydrogen-

ratus² containing glass instead of the more usual metal cells. This particular apparatus had pre-

(1) THIS JOURNAL, 55, 947 (1933); 56, 76 (1934); 57, 847 (1935).

(2) Palmer and Weaver, Tech. Papers Bureau of Standards No. 249, 1924.

viously been used by Dr. P. H. Emmett and Mr. J. F. Shultz who kindly put it at our disposal for this work. Three analyses were made, one of the dissolved gas, one of the incoming gas and one of the gas above the saturated solution, the latter two, of course, gave identical results.

On the basis of this work it should be possible to calculate the solubility of any mixture of hydrogen and nitrogen in water at 25° and very likely up to 100° within a few per cent. and with considerably greater accuracy in the low pressure range. Neither constituent gives any sign of ab-

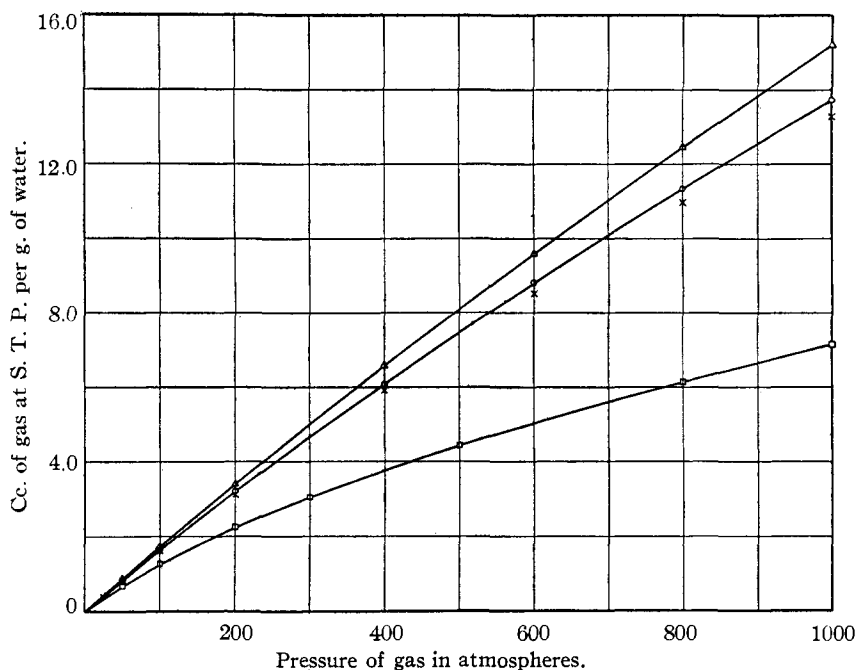


Fig. 1.— Δ , Solubility of pure hydrogen; \circ , solubility of a 76.4:23.6 hydrogen-nitrogen mixture; \times , calculated values for the mixture from the values of the pure constituents; \square , solubility of pure nitrogen.

The experimental data are shown in Table I. Pressures are given in international atmospheres. The average composition of the gas was 76.42% hydrogen and 23.58% nitrogen.

In Table II we have calculated the solubility of such a mixture from the values of the pure constituents. The percentage deviations from the experimental values show a maximum similar to those given by Bartlett and co-workers for the percentage deviations from the rule of additive volumes of 3:1 hydrogen-nitrogen mixtures.³

(3) Bartlett, Cupples and Tremearne, *THIS JOURNAL*, **50**, 1275 (1928).

normality over the temperature range up to 100°. No further work on the solubility of mixtures of gases in water is contemplated for the present.

Summary

The solubility in water of an approximately 3:1 hydrogen-nitrogen mixture was determined at 25° and from 50 to 1000 atmospheres.

It was found that the solubility of the mixture could be calculated within a few per cent. from the values of the pure constituents.

WASHINGTON, D. C.

RECEIVED JUNE 17, 1935