THERMODYNAMIC PROPERTIES OF NITRIC OXIDE AT 200 TO 2000° K AND PRESSURES TO 1000 BAR

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So far, no experimental data on the caloric properties of nitric oxide in these temperature and pressure ranges have been published. Using their equation of state, Opfell, Schlinger, and Sage [1] calculated the enthalpy and entropy in the temperature range of 210-377° K and at pressures to 207 bar. The tables in [1] can only be used in calculations that do not require high accuracy, since their equation of state, owing to insufficiently accurate and inconsistent P, V, and T measurements, does not, as was shown in [2], give the real thermodynamic surface of nitric oxide.

We calculated the enthalpy and entropy from the equation of state in [2], which was formulated after special analysis of the P, V, and T data and which gives all of the characteristics of the thermodynamic behavior of the pure material. Our calculations for round temperature and pressure values are given in the table, which also shows the molar concentration γ.

The caloric values for the ideal-gas state were calculated by the equations given below, which, with sufficient accuracy describe the data in [3] and [4]:

$$I_0 = 255 + 3551\theta - 221.02\,\theta^2 + 38.994\theta^3 - $$
$$- 3.22728\,\theta^4 + 0.147248\,\theta^5 - $$
$$- 0.003559\,\theta^6 + 0.000035624\,\theta^7 \text{ J/mol},$$

$$s_0 = 180.7909 + 81.764 \lg \theta -$$
$$- 44.204\left(\frac{\theta}{10}\right) + 58.4902\left(\frac{\theta}{10}\right)^2 - 43.0303\left(\frac{\theta}{10}\right)^3 +$$
$$+ 18.4060\left(\frac{\theta}{10}\right)^4 - 4.2708\left(\frac{\theta}{10}\right)^5 +$$
$$+ 0.4156\left(\frac{\theta}{10}\right)^6 \text{ J/mole} \cdot \text{degree K},$$

where $\theta = T/100$.

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Thermodynamic Properties of Nitric Oxide (γ, kmole/m^3; I, kJ/mole; s, kJ/mole • degree)

P, bar	200 °K			300 °K		
	γ	I	s	γ	I	s
1	0.0601	6.22	198.6	0.0401	9.23	210.8
5	0.306	6.14	184.9	0.201	9.19	197.3
10	0.623	6.05	178.8	0.404	9.14	191.4
15	0.954	5.95	175.1	0.608	9.10	188.0
20	1.29	5.86	172.4	0.815	9.05	185.4
30	2.03	5.64	168.3	1.23	8.96	181.8
40	2.84	5.41	165.0	1.65	8.87	179.2
50	3.75	5.15	162.2	2.07	8.79	177.1
75	6.68	4.37	155.8	3.18	8.54	173.1
100	11.6	3.17	148.3	4.29	8.32	170.1
150	19.5	1.65	139.2	6.55	7.89	165.5
200				8.77	7.50	162.0
250				10.9	7.15	159.2
300				12.8	6.88	156.8
400				15.9	6.52	153.3
500				18.3	6.32	150.7
750						
1000						

(cont'd)

P, bar	400 °K			500 °K		
	γ	I	s	γ	I	s
1	0.0301	12.22	219.4	0.0241	15.23	226.1
5	0.150	12.20	206.0	0.120	15.22	212.7
10	0.301	12.17	200 1	0.241	15.21	206.9
15	0.453	12.15	196.6	0,360	15.20	203.5
20	0.601	12.13	194.3	0.480	15.18	201.1
30	0.904	12.08	190.8	0.719	15.15	197.6
40	1.20	12.03	188.3	0.956	15.13	195.2
50	1.51	11.97	186.3	1.19	15.10	193.3
75	2.26	11.86	182.6	1.79	15.04	189.7
100	3.01	11.75	180.0	2.36	14.97	187.2
150	4.48	11.55	176.1	3.50	14.86	183.5
200	5.91	11.37	173.2	4.59	14.77	180.8
250	7.27	11.22	170.9	5.64	14.69	178.7
300	8.56	11.08	169 0	6.64	14.61	176.9
400	10.9	10.88	165.9	8.52	14.53	174.1
500	13.0	10.73	163.4	10.2	14.49	171.9
750	17.0	10.64	159.1	13.7	14.52	167.7
1000	19.8	10.82	156.1	16.4	14.71	164.8

P, bar	600 °K			700 °K		
	γ	I	s	γ	I	s
1	0.0200	18.32	231.7	0.0172	21.48	236.6
5	0.100	18.32	218.3	0.0857	21.48	223.2
10	0.200	18.31	212.5	0.171	21.48	217.4
15	0.300	18.30	209.1	0.257	21.48	214.0
20	0.399	18,29	206.7	0.342	21.47	211.6
30	0,597	18.27	203.3	0.511	21.46	208.2
40	0.794	18.26	200.9	0.679	21.46	205.8
50	0.990	18.24	199.0	0.847	21.45	203.9
75	1.48	18.19	195.5	1.26	21.43	200.5
100	1.95	18,16	193.0	1.67	21.42	198.0
150	2.89	18.11	189.4	2.47	21.40	194.5
200	3.79	18.07	186.8	3.24	21.39	191.9
250	4.66	18.04	184.8	3.98	21.39	190.0
300	5.49	18.02	183.1	4.73	21.39	188.3
400	7.06	18.00	180.4	6.06	21.43	185.7
500	8.49	18.01	178.3	7.32	21.48	183.7
750	11.6	18.13	174.3	10,1	21.68	179.9
1000	14.1	18.37	171.5	12.4	21.99	177.2

P, bar	800 °K			900 °K		
	γ	I	s	γ	I	s
1	0.0150	24.72	240.9	0.0134	28.03	244.8
5	0.0750	24.71	227.5	0.0667	28.02	231.4
10	0.150	24.71	221.8	0.133	28.02	225.7
15	0.225	24.72	218.4	0.200	28.03	222.3
20	0.298	24.72	216.0	0.266	28.03	219.9
30	0.447	24.72	212.6	0.398	28.03	216.5
40	0,596	24.72	210.1	0.529	28.04	214.1
50	0.741	24,72	208.3	0.659	28.04	212.2
75	1.10	24,72	204.9	0.982	28.06	208,8
100	1.46	24.72	202.4	1.30	28.07	206,4
150	2.16	24.73	198.9	1.92	28.11	202.9
200	2.84	24.74	196.4	2.53	28.15	200.4
250	3.49	24.76	194.5	3.11	28.20	198.5
300	4.13	24.79	192.8	3.68	28.25	196.9
400	5.34	24,86	190.3	4,76	28.36	194,4
500	6,46	24.96	188,3	5,80	28.48	192,4
750	8.96	25.25	184.6	8.08	28.81	188,8
1000	11.1	25.59	181.9	10.1	29.17	186.1

(cont'd)

P, bar	1000 °K			1200 °K		
	γ	I	s	γ	I	s
1	0.0120	31.40	248.4	0.0100	38.28	254.6
5	0.0600	31.39	235.0	0.0500	38.28	241,3
10	0.120	31.40	229.2	0.100	38.29	235.5
15	0.180	31.40	225.8	0.150	38.30	232.1
20	0.240	31.41	223.4	0.200	38.31	229.7
30	0.357	31.42	220.1	0.299	38,32	226,3
40	0.476	31 43	217.6	0.397	38.34	223.9
50	0.593	31.44	215.8	0.495	38.35	222,1
75	0.884	31.46	212.4	0.738	38.39	218.7
100	1.17	31 48	210.0	0.978	38.42	216.3
150	1.73	31,53	206.5	1.45	38.50	212.9
200	2.28	31 59	204.0	1.91	38.57	210.4
250	2.81	31.65	202.1	2.36	38.66	208.5
300	3.33	31.71	200.6	2.80	38,74	207,0
400	4.32	31.84	198.1	3.64	38.93	204.5
500	5.25	31.99	196.1	4.44	39.13	202.6
750	7.37	32.40	192.5	6.28	39.63	199.1
1000	9.21	32.85	190.0	7.91	40.16	196.6

P, bar	1400 °K			1600 °K		
	γ	I	s	γ	I	s
1	0.00859	45.31	260.0	0.00752	52.45	264.8
5	0.0429	45.31	246.7	0.0375	52.45	251.4
10	0.0857	45.32	240.9	0.0750	52.46	245.6
15	0.128	45.33	237.6	0.112	52.47	242.3
20	0,171	45.34	235.1	0.150	52.48	239.9
30	0.256	45.36	231.8	0.225	52.50	236 5
40	0.341	45.38	229.4	0,298	52.52	234.2
50	0.425	45.40	227.5	0.372	52.54	232.3
75	0.635	45.44	224.1	0.555	52,59	228.9
100	0.841	45.49	221.7	0.738	52,64	226.5
150	1.25	45.58	218.3	1.10	52.74	223.1
200	1.64	45.68	215.9	1.45	52.85	220.7
250	2.03	45.79	214.0	1.79	52.97	218.8
300	2.42	45.89	212.5	2.13	53,09	217.3
400	3.15	46.11	210.1	2.78	53.33	214.9
500	3.85	46.33	208.2	3.41	53.57	213.0
750	5.49	46 89	204.7	4.89	54.18	209.6
1000	6.96	47.47	202.3	6.22	54.82	207.2

P, bar	1800 °K			2000 °K		
	γ	I	s	γ	I	s
1	0.00668	59.67	269.0	0.00601	66.96	272.9
5	0.0334	59.67	255.7	0.0301	66.96	259.5
10	0.0667	59,68	249.9	0.0601	66.98	253.8
15	0.100	59.70	246.6	0.0900	66.99	250.4
20	0.133	59.72	244.2	0.120	67.01	248.0
30	0.199	59.74	240.8	0.179	67.03	244.7
40	0.266	59.76	238.4	0.239	67.06	242.2
50	0.332	59.79	236.5	0.298	67.09	240.4
75	0.495	59.85	233.2	0.445	67.15	237.0
100	0.656	59.91	230.8	0.591	67.21	234.6
150	0.976	60.03	227.4	0.879	67.34	231.2
200	1.29	60.15	225.0	1.16	67.46	228.9
250	1.60	60.27	223.1	1.44	67.59	227.0
300	1.90	60.40	221.6	1.72	67.71	225.5
400	2.49	60.65	219.2	2.26	67.95	223.0
500	3.06	60.89	217.3	2.78	68.22	221.2
750	4.39	61.48	213.9	4.01	68.90	217.8
1000	5.64	62.06	211.4	5.15	69.57	215.4