0 to 6000 K Ideal Gas

$S°(298.15\ K) = 20.979 \pm 0.013\ (\pm 2.0)\ J{\cdot}K^{-1}{\cdot}mol^{-1}$

$\Delta_f H°(0\ K) = 0\ kJ{\cdot}mol^{-1}$

$\Delta_f H°(298.15\ K) = 0\ kJ{\cdot}mol^{-1}$

Electronic Levels and Quantum Weights	
ϵ_i, cm^{-1}	g_i
0	2

Heat of Formation

Zero by definition.

Heat Capacity and Entropy

As shown by Sommerfeld,[1] the electron gas is a degenerate Fermi–Dirac gas and its properties will differ from the classical (Boltzmann) gas. These deviations will increase as the temperature decreases or as the density increases.[2,3] Due to the low mass of the electron, these departures from classical behavior will persist to higher temperatures and lower densities than for atomic systems. Under conditions of 1 atm pressure, Gordon[3] showed that the deviation of the Fermi–Dirac gas from the Boltzmann gas is negligible above 1250 K. Below this temperature the deviation between classical and quantum statistics will be significant; Mitchell[4] calculates $S°(298.15\ K) = 22.72\ J{\cdot}K^{-1}{\cdot}mol^{-1}$ for the Fermi–Dirac gas compared to the classical value of $20.87\ J{\cdot}K^{-1}{\cdot}mol^{-1}$ for a pressure of 1 atm.

Despite these known deviations we have chosen to present the classical (Boltzmann) values here since the primary purpose of this table is to serve as a reference state for the calculation of tables of thermodynamic properties for atomic and molecular ions. When ionization equilibria are considered, the density (or partial pressure) of the electron gas will be extremely low except at very high temperatures. At an electron partial pressure of 10^{-6} bar, the deviation between classical and quantum statistics will be significant only below 5 K.[3] Deviations from classical statistics are encountered at about this same temperature in some atomic and molecular systems at 1 bar pressure, these are usually ignored since the deviations in the enthalpy and entropy are quite small. Therefore, although this ideal–gas table has the formalism of 1 bar as the standard reference state, it should not be applied to real systems where the electron partial pressure exceeds 10^{-6} bar. An equivalent statement is that the electron gas will behave as an ideal gas only at electron partial pressures less than about 10^{-6} bar, with deviations from ideal gas behavior at higher pressures as a result of the departure from classical statistics.

The thermodynamic functions are calculated here via Boltzmann statistics assuming the electron gas to be an ideal monatomic gas with two equivalent spin states. The relative ionic mass is the electron rest mass as reported in the 1973 CODATA fundamental constants.[5] The first uncertainty in S°(298.15 K) represents the uncertainty in the fundamental constants and electron rest mass (i.e., the uncertainty below 10^{-6} bar where classical statistics is valid) while the value given in parenthesis represents the uncertainty due to the use of classical rather than quantum statistics at 1 atm pressure. Values below 298.15 K are omitted from the table since the classical calculation (at 1 bar pressure) results in negative values of entropy below 109 K.[4] The values of the thermodynamic functions agree with those published by Gurvich *et al.*[6] except for two minor differences. First, the entropy differs by $0.1094\ J{\cdot}K^{-1}{\cdot}mol^{-1}$ because this table uses a standard state pressure of 1 bar, whereas Gurvich *et al.*[6] used 1 atm. Second, smaller entropy differences occur due to the use of slightly different values of *R*.

References

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[5] E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref. Data 2, 663 (1973).
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Enthalpy Reference Temperature = T_r = 298.15 K; Standard State Pressure = $p°$ = 0.1 MPa

	J·K⁻¹mol⁻¹			kJ·mol⁻¹			
T/K	$C_p°$	S°	$-[G°-H°(T_r)]/T$	$H°-H°(T_r)$	$\Delta_f H°$	$\Delta_f G°$	log K_f
0				−6.197			
100							
200							
250							
298.15	20.786	20.979	20.979	0.	0.	0.	0.
300	20.786	21.107	20.979	0.038	0.	0.	0.
350	20.786	24.311	21.232	1.078	0.	0.	0.
400	20.786	27.087	21.794	2.117	0.	0.	0.
450	20.786	29.535	22.521	3.156	0.	0.	0.
500	20.786	31.725	23.334	4.196	0.	0.	0.
600	20.786	35.515	25.058	6.274	0.	0.	0.
700	20.786	38.719	26.786	8.353	0.	0.	0.
800	20.786	41.495	28.455	10.431	0.	0.	0.
900	20.786	43.943	30.043	12.510	0.	0.	0.
1000	20.786	46.133	31.544	14.589	0.	0.	0.
1100	20.786	48.114	32.962	16.667	0.	0.	0.
1200	20.786	49.923	34.301	18.746	0.	0.	0
1300	20.786	51.587	35.568	20.824	0.	0.	0
1400	20.786	53.127	36.768	22.903	0.	0	0
1500	20.786	54.561	37.907	24.982	0.	0.	0.
1600	20.786	55.903	38.990	27.060	0.	0.	0.
1700	20.786	57.163	40.022	29.139	0.	0.	0.
1800	20.786	58.351	41.008	31.217	0.	0	0.
1900	20.786	59.475	41.950	33.296	0.	0.	0.
2000	20.786	60.541	42.853	35.375	0.	0.	0
2100	20.786	61.555	43.720	37.453	0.	0.	0
2200	20.786	62.522	44.553	39.532	0.	0.	0
2300	20.786	63.446	45.354	41.610	0.	0.	0
2400	20.786	64.331	46.127	43.689	0.	0.	0.
2500	20.786	65.179	46.872	45.768	0.	0.	0
2600	20.786	65.994	47.592	47.846	0.	0.	0
2700	20.786	66.779	48.288	49.925	0.	0.	0.
2800	20.786	67.535	48.962	52.004	0.	0.	0.
2900	20.786	68.264	49.615	54.082	0.	0.	0.
3000	20.786	68.969	50.249	56.161	0.	0.	0.
3100	20.786	69.650	50.863	58.239	0.	0.	0.
3200	20.786	70.310	51.461	60.318	0.	0.	0.
3300	20.786	70.950	52.042	62.397	0.	0.	0.
3400	20.786	71.570	52.607	64.475	0.	0.	0.
3500	20.786	72.173	53.158	66.554	0.	0.	0.
3600	20.786	72.759	53.694	68.632	0.	0.	0.
3700	20.786	73.328	54.217	70.711	0.	0.	0.
3800	20.786	73.882	54.727	72.790	0.	0.	0.
3900	20.786	74.422	55.225	74.868	0.	0.	0.
4000	20.786	74.949	55.712	76.947	0.	0.	0.
4100	20.786	75.462	56.187	79.025	0.	0.	0.
4200	20.786	75.963	56.652	81.104	0.	0.	0.
4300	20.786	76.452	57.107	83.183	0.	0.	0.
4400	20.786	76.930	57.552	85.261	0.	0.	0.
4500	20.786	77.397	57.988	87.340	0.	0.	0.
4600	20.786	77.854	58.415	89.418	0.	0.	0.
4700	20.786	78.301	58.833	91.497	0.	0.	0.
4800	20.786	78.738	59.243	93.576	0.	0.	0.
4900	20.786	79.167	59.646	95.654	0.	0.	0.
5000	20.786	79.587	60.040	97.733	0.	0.	0.
5100	20.786	79.998	60.428	99.811	0.	0.	0.
5200	20.786	80.402	60.808	101.890	0.	0.	0.
5300	20.786	80.798	61.181	103.969	0.	0.	0.
5400	20.786	81.187	61.548	106.047	0.	0.	0.
5500	20.786	81.568	61.909	108.126	0.	0.	0.
5600	20.786	81.942	62.263	110.204	0.	0.	0.
5700	20.786	82.310	62.612	112.283	0.	0.	0.
5800	20.786	82.672	62.954	114.362	0.	0.	0.
5900	20.786	83.027	63.292	116.440	0.	0.	0.
6000	20.786	83.377	63.623	118.519	0.	0.	0.

PREVIOUS: March 1977 (1 atm) CURRENT: March 1982 (1 bar)