Table of Ion Critical Densities with e-

Table 18.1 Critical Electron Density $n_{crit}(e^-)$ (cm^{-3}) for Selected np^2 and np^4 Ions

Configuration	Ion	$n_{crit}(e)$ at $T = 10^4$ K $^3P_0$	$^3P_1$	$^3P_2$	$^1D_2$	$^1S_0$
$1s^2 2s^2 2p^2$	C I	–	7.37×10^0	1.21×10^1		
	N II	–	1.67×10^2	2.96×10^2	7.68×10^4	1.23×10^7
	O III	–	1.74×10^3	3.79×10^3	6.40×10^5	2.78×10^7
	Ne V	–	3.19×10^5	3.48×10^5	1.44×10^8	9.58×10^8
$1s^2 2s^2 2p^4$	O I	3.11×10^3	2.87×10^4	–	1.62×10^6	4.04×10^8
	Ne III	3.02×10^4	2.76×10^6	–	9.47×10^6	1.37×10^8
	Mg V	4.36×10^6	4.75×10^7	–	1.07×10^9	8.07×10^9
$1s^2 2s^2 2p^6 3s^2 3p^2$	Si I	–	7.72×10^2	1.92×10^3		
	S III	–	4.22×10^3	1.31×10^4	7.33×10^5	1.52×10^7
	Ar V	–	1.09×10^7	1.16×10^7	3.65×10^8	2.49×10^8
$1s^2 2s^2 2p^2 3s^2 3p^4$	S I	1.04×10^5	1.55×10^5	–	4.12×10^7	1.38×10^9
	Ar III	2.49×10^5	2.67×10^6	–	1.26×10^7	4.54×10^8

Table 18.2 Critical Electron Density $n_{crit}(e^-)$ (cm^{-3}) for Selected np^3 Ions, for $T = 10^4$ K

Configuration	Ion	$n_{crit}(e)$ at $T = 10^4$ K $^2D^o_{3/2}$	$^2D^o_{5/2}$	$^2P^o_{1/2}$	$^2P^o_{3/2}$
$1s^2 2s^2 2p^3$	N I	2.18×10^4	1.19×10^4	7.11×10^7	3.15×10^7
	O II	4.49×10^3	3.31×10^3	5.30×10^6	1.03×10^7
	Ne IV	1.40×10^6	4.66×10^5	4.17×10^8	2.79×10^8
$1s^2 2s^2 2p^6 3s^2 3p^3$	S II	1.49×10^4	1.57×10^3	1.49×10^6	1.91×10^6
	Ar IV	1.35×10^6	1.55×10^4	1.06×10^7	1.81×10^7

Critical Densities for Molecules

Optically thin critical density for collisions with H_2 (Shirley 2015)

Molecule	$j \rightarrow k$	ν_{jk} (GHz)	E_j/k (K)	A_{jk} (s^{-1})	$n_{ph}(T_{cmb})$	$n_{crit}^{thin,no\ bg}(T_k)$ cm^{-3} 10K	20K	50K	100K
HCO^+	1 – 0	89.189	4.28	4.3E-5	0.264	6.8E+4	4.5E+4	2.9E+4	2.3E+4
	2 – 1	178.375	12.84	4.1E-4	0.046	5.6E+5	4.2E+5	2.8E+5	2.2E+5
	3 – 2	267.558	25.68	1.5E-3	0.009	1.6E+6	1.4E+6	1.0E+6	8.1E+5
	4 – 3	356.734	42.80	3.6E-3	0.002	3.6E+6	3.2E+6	2.5E+6	2.0E+6
$H^{13}CO^+$	1 – 0	86.754	4.16	3.9E-5	0.279	6.2E+4	4.1E+4	2.7E+4	2.0E+4
	2 – 1	173.507	12.49	3.7E-4	0.050	5.1E+5	3.8E+5	2.6E+0	2.0E+5
	3 – 2	260.255	24.98	1.3E-3	0.011	1.5E+6	1.3E+6	9.5E+5	7.3E+5
	4 – 3	346.998	41.63	3.3E-3	0.002	3.4E+6	2.9E+6	2.3E+6	1.8E+6
N_2H^+	1 – 0	93.174	4.47	3.6E-5	0.242	6.1E+4	4.1E+4	2.6E+4	2.0E+4
	2 – 1	186.345	13.41	3.5E-4	0.040	5.0E+5	3.7E+5	2.6E+5	1.9E+5
	3 – 2	279.512	26.83	1.3E-3	0.007	1.4E+6	1.2E+6	9.2E+5	7.1E+5
	4 – 3	372.673	44.71	3.1E-3	0.001	3.2E+6	2.8E+6	2.2E+6	1.7E+6
HCN	1 – 0	88.632	4.25	2.4E-5	0.268	4.7E+5	3.0E+5	1.7E+5	1.1E+5
	2 – 1	177.261	12.76	2.3E-4	0.047	4.1E+6	2.8E+6	1.6E+6	1.1E+6
	3 – 2	265.886	25.52	8.4E-4	0.010	1.4E+7	1.0E+7	5.7E+6	3.8E+6
	4 – 3	354.505	42.53	2.1E-3	0.002	3.0E+7	2.3E+7	1.4E+7	9.1E+6
$H^{13}CN$	1 – 0	86.340	4.14	2.2E-5	0.282	5.3E+5	2.5E+5	1.3E+5	9.7E+4
	2 – 1	172.678	12.43	2.1E-4	0.051	3.4E+6	2.2E+6	1.2E+6	9.1E+5
	3 – 2	259.012	24.86	7.7E-4	0.011	8.8E+6	6.6E+6	4.1E+6	3.3E+6
	4 – 3	345.340	41.43	1.9E-3	0.002	1.9E+7	1.5E+7	9.7E+6	7.7E+6
HNC	1 – 0	90.664	4.35	2.7E-5	0.256	1.4E+5	1.1E+5	8.4E+4	7.0E+4
	2 – 1	181.325	13.05	2.6E-4	0.043	1.3E+6	1.0E+6	8.2E+5	6.8E+5
	3 – 2	271.981	26.11	9.3E-4	0.009	5.1E+6	4.0E+6	3.1E+6	2.5E+6
	4 – 3	362.630	43.51	2.3E-3	0.002	1.3E+7	1.0E+7	7.8E+6	6.2E+6
CN	$1_{3/2} - 0_{1/2}$	113.495	5.45	1.2E-5	0.158	4.1E+5	2.4E+5	1.1E+5	6.4E+4
	$2_{5/2} - 1_{3/2}$	226.876	16.34	1.1E-4	0.019	3.2E+6	2.2E+6	1.1E+6	6.4E+5
	$3_{7/2} - 2_{5/2}$	340.249	32.66	4.1E-4	0.003	8.3E+6	6.5E+6	3.5E+6	2.1E+6
CS	1 – 0	48.991	2.40	1.7E-6	0.734	1.5E+4	1.1E+4	7.8E+3	5.7E+3
	2 – 1	97.981	7.10	1.7E-5	0.218	1.3E+5	1.0E+5	7.4E+4	5.5E+4
	3 – 2	146.969	14.10	6.1E-5	0.082	4.4E+5	3.6E+5	2.6E+5	2.0E+5
	4 – 3	195.954	23.50	1.5E-4	0.033	1.0E+6	8.6E+5	6.4E+5	4.8E+5
	5 – 4	244.936	35.30	3.0E-4	0.014	2.0E+6	1.7E+6	1.3E+6	9.5E+5
	6 – 5	293.912	49.40	5.2E-4	0.006	3.4E+6	2.9E+6	2.2E+6	1.6E+6
	7 – 6	342.883	65.80	8.4E-4	0.002	5.0E+6	4.4E+6	3.4E+6	2.6E+6
p-NH_3[c]	(1, 1)	23.694	1.14	1.7E-7	1.940	2.0E+3	1.8E+3	1.2E+3	8.7E+2
	(2, 2)	23.723	42.32	2.3E-7	1.937	1.6E+3	1.5E+3	1.4E+3	1.1E+3
	$2^+_1 - 1^-_1$	1168.452	57.21	1.2E-2	0.000	1.2E+8	1.1E+8	9.0E+7	6.7E+7
	$2^-_1 - 1^+_1$	1215.245	58.32	1.4E-2	0.000	1.4E+8	1.2E+8	1.0E+8	7.5E+7
o-NH_3[c]	(3, 3)	23.870	123.54	2.6E-7	1.923	1.5E+3	1.5E+3	1.4E+3	1.2E+3
	$1_0 - 0_0$	572.498	27.48	1.6E-3	0.000	4.0E+7	3.1E+7	1.7E+7	9.9E+6