

# Appendix D

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## Flame Properties for CH<sub>4</sub>, C<sub>3</sub>H<sub>8</sub>, and H<sub>2</sub>, and CH<sub>4</sub>/H<sub>2</sub> Blends

Tables for various flame properties are given on the following pages.

**Table D.1a** H<sub>2</sub> (298 K) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with a Variable Composition Oxidizer (298 K), Metric Units

O <sub>2</sub>	N <sub>2</sub>	Flame temp. (K)	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Equil. Le
0.21	0.79	2382	0.00179	0.00000	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	2.09E-04	0.124	7.53E-05	2.72	0.383	0.536	1.28
0.30	0.70	2648	0.00933	0.00001	0.04074	0.38912	0.00607	0.51684	0.00321	0.02217	0.01251	0.00E+00	0.104	8.19E-05	4.72	0.851	0.454	1.45
0.40	0.60	2799	0.02092	0.00002	0.06662	0.43867	0.00851	0.39742	0.00770	0.03962	0.02052	4.19E-05	0.091	8.60E-05	7.11	1.420	0.431	1.49
0.50	0.50	2889	0.03269	0.00003	0.08793	0.47585	0.00960	0.29903	0.01253	0.05505	0.02729	4.19E-05	0.082	8.88E-05	9.47	1.962	0.429	1.49
0.60	0.40	2950	0.04357	0.00003	0.10540	0.50534	0.00973	0.21737	0.01717	0.06834	0.03303	8.37E-05	0.075	9.08E-05	11.75	2.459	0.434	1.47
0.70	0.30	2994	0.05333	0.00004	0.11988	0.52948	0.00911	0.14886	0.02148	0.07983	0.03798	1.26E-04	0.070	9.25E-05	13.94	2.913	0.442	1.45
0.80	0.20	3028	0.06203	0.00005	0.13199	0.54964	0.00782	0.09078	0.02545	0.08987	0.04236	1.67E-04	0.066	9.38E-05	16.04	3.328	0.452	1.43
0.90	0.10	3055	0.06980	0.00005	0.14217	0.56673	0.00569	0.04122	0.02915	0.09880	0.04637	0.00E+00	0.062	9.50E-05	18.06	3.709	0.462	1.41
1.00	0.00	3079	0.07695	0.00006	0.15027	0.58120	0.00000	0.00000	0.03302	0.10758	0.05092	0.00E+00	0.059	9.60E-05	20.01	4.0670	0.472	1.40

Pr = Prandtl number, Le = Lewis number.

**Table D.1b** H<sub>2</sub> (77°F) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with a Variable Composition Oxidizer (77°F), English Units

O <sub>2</sub>	N <sub>2</sub>	Flame temp. (°F)	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ ft-hr)	Equil. spec. heat (Btu/ lb-°F)	Equil. therm. cond. (Btu/ ft-hr-°F)	Equil. Pr	Le
0.21	0.79	3827	0.00179	0.00000	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	0	0.00775	5.06E-05	0.650	0.221	0.536	1.28
0.30	0.70	4307	0.00933	0.00001	0.04074	0.38912	0.00607	0.51684	0.00321	0.02217	0.01251	0	0.00649	5.50E-05	1.127	0.492	0.454	1.45
0.40	0.60	4579	0.02092	0.00002	0.06662	0.43867	0.00851	0.39742	0.00770	0.03962	0.02052	0	0.00568	5.78E-05	1.699	0.821	0.431	1.49
0.50	0.50	4741	0.03269	0.00003	0.08793	0.47585	0.00960	0.29903	0.01253	0.05505	0.02729	0	0.00512	5.97E-05	2.262	1.134	0.429	1.49
0.60	0.40	4850	0.04357	0.00003	0.10540	0.50534	0.00973	0.21737	0.01717	0.06834	0.03303	0	0.00470	6.11E-05	2.808	1.421	0.434	1.47
0.70	0.30	4929	0.05333	0.00004	0.11988	0.52948	0.00911	0.14886	0.02148	0.07983	0.03798	0	0.00437	6.22E-05	3.328	1.683	0.442	1.45
0.80	0.20	4990	0.06203	0.00005	0.13199	0.54964	0.00782	0.09078	0.02545	0.08987	0.04236	0	0.00410	6.31E-05	3.830	1.923	0.452	1.43
0.90	0.10	5039	0.06980	0.00005	0.14217	0.56673	0.00569	0.04122	0.02915	0.09880	0.04637	0	0.00387	6.39E-05	4.312	2.143	0.462	1.41
1.00	0.00	5082	0.07695	0.00006	0.15027	0.58120	0.00000	0.00000	0.03302	0.10758	0.05092	0	0.00367	6.45E-05	4.780	2.350	0.472	1.40

**Table D.2a** H<sub>2</sub> (298 K) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.), Metric Units

Air temp. (K)	Flame temp. (K)	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-s)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le
298	2382	0.00179	0.00000	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	2.09E - 04	0.124	7.53E-05	2.72	0.383	0.536	1.28
366	2406	0.00209	0.00000	0.01657	0.32145	0.00287	0.64356	0.00064	0.00768	0.00513	6.69E + 01	0.123	7.58E-05	2.81	0.404	0.527	1.30
478	2444	0.00267	0.00000	0.01882	0.31760	0.00327	0.64207	0.00083	0.00895	0.00579	1.78E + 02	0.121	7.66E-05	2.96	0.442	0.513	1.32
589	2482	0.00335	0.00000	0.02116	0.31350	0.00369	0.64047	0.00106	0.01030	0.00647	2.91E + 02	0.119	7.74E-05	3.11	0.482	0.500	1.35
700	2518	0.00415	0.00000	0.02361	0.30913	0.00413	0.63874	0.00133	0.01174	0.00717	4.06E + 02	0.117	7.82E-05	3.28	0.526	0.488	1.38
811	2553	0.00507	0.00000	0.02615	0.30448	0.00460	0.63687	0.00165	0.01328	0.00790	5.24E + 02	0.115	7.89E-05	3.46	0.573	0.476	1.41
922	2587	0.00613	0.00000	0.02877	0.29958	0.00508	0.63487	0.00202	0.01490	0.00864	6.46E + 02	0.113	7.96E-05	3.64	0.623	0.465	1.43
1033	2620	0.00733	0.00001	0.03145	0.29446	0.00557	0.63274	0.00245	0.01659	0.00939	7.69E + 02	0.111	8.03E-05	3.83	0.677	0.455	1.46
1144	2652	0.00867	0.00001	0.03416	0.28915	0.00608	0.63050	0.00294	0.01833	0.01015	8.95E + 02	0.109	8.09E-05	4.03	0.733	0.445	1.48
1255	2683	0.01015	0.00001	0.03688	0.28369	0.00659	0.62816	0.00348	0.02011	0.01091	1.02E + 03	0.108	8.15E-05	4.24	0.791	0.437	1.50
1366	2712	0.01177	0.00001	0.03960	0.27811	0.00711	0.62573	0.00408	0.02193	0.01166	1.15E + 03	0.106	8.21E-05	4.45	0.852	0.429	1.52

**Table D.2b** H<sub>2</sub> (77°F) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.), English Units

Air temp. (°F)	Flame temp. (°F)	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-F)	Equil. therm. cond. (Btu/ft-hr-F)	Equil. Pr	Le
77	3827	0.00179	0.00000	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	0	0.00775	5.06E-05	0.650	0.221	0.536	1.28
200	3871	0.00209	0.00000	0.01657	0.32145	0.00287	0.64356	0.00064	0.00768	0.00513	29	0.00767	5.10E-05	0.671	0.233	0.527	1.30
400	3940	0.00267	0.00000	0.01882	0.31760	0.00327	0.64207	0.00083	0.00895	0.00579	77	0.00753	5.15E-05	0.706	0.255	0.513	1.32
600	4007	0.00335	0.00000	0.02116	0.31350	0.00369	0.64047	0.00106	0.01030	0.00647	125	0.00740	5.21E-05	0.744	0.279	0.500	1.35
800	4072	0.00415	0.00000	0.02361	0.30913	0.00413	0.63874	0.00133	0.01174	0.00717	175	0.00728	5.26E-05	0.783	0.304	0.488	1.38
1000	4135	0.00507	0.00000	0.02615	0.30448	0.00460	0.63687	0.00165	0.01328	0.00790	225	0.00716	5.31E-05	0.825	0.331	0.476	1.41
1200	4197	0.00613	0.00000	0.02877	0.29958	0.00508	0.63487	0.00202	0.01490	0.00864	278	0.00705	5.35E-05	0.869	0.360	0.465	1.43
1400	4256	0.00733	0.00001	0.03145	0.29446	0.00557	0.63274	0.00245	0.01659	0.00939	331	0.00694	5.40E-05	0.915	0.391	0.455	1.46
1600	4314	0.00867	0.00001	0.03416	0.28915	0.00608	0.63050	0.00294	0.01833	0.01015	385	0.00683	5.44E-05	0.963	0.423	0.445	1.48
1800	4369	0.01015	0.00001	0.03688	0.28369	0.00659	0.62816	0.00348	0.02011	0.01091	439	0.00673	5.48E-05	1.012	0.457	0.437	1.50
2000	4422	0.01177	0.00001	0.03960	0.27811	0.00711	0.62573	0.00408	0.02193	0.01166	495	0.00664	5.52E-05	1.062	0.492	0.429	1.52

**Table D.3a** H<sub>2</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

Fuel temp. (K)	Flame temp. (K)	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Equil. Le
298	2382	0.00179	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	2.09E-04	0.124	7.53E-05	2.72	0.383	0.536	1.28
311	2384	0.00181	0.01537	0.32348	0.00266	0.64434	0.00055	0.00702	0.00478	5.29E+00	0.124	7.53E-05	2.73	0.384	0.535	1.28
366	2392	0.00191	0.01580	0.32275	0.00274	0.64406	0.00058	0.00726	0.00491	2.79E+01	0.124	7.55E-05	2.76	0.391	0.532	1.28
422	2400	0.00202	0.01626	0.32198	0.00282	0.64376	0.00061	0.00751	0.00504	5.10E+01	0.123	7.57E-05	2.79	0.399	0.529	1.29
478	2408	0.00213	0.01672	0.32121	0.00290	0.64347	0.00065	0.00776	0.00517	7.41E+01	0.123	7.59E-05	2.82	0.406	0.526	1.30
533	2416	0.00224	0.01717	0.32043	0.00298	0.64317	0.00069	0.00802	0.00531	9.69E+01	0.122	7.60E-05	2.85	0.414	0.523	1.30
589	2425	0.00236	0.01764	0.31963	0.00306	0.64286	0.00072	0.00828	0.00544	1.20E+02	0.122	7.62E-05	2.88	0.422	0.520	1.31
644	2432	0.00248	0.01810	0.31884	0.00314	0.64256	0.00076	0.00854	0.00558	1.43E+02	0.121	7.64E-05	2.91	0.429	0.517	1.31
700	2440	0.00260	0.01857	0.31802	0.00323	0.64224	0.00081	0.00881	0.00572	1.66E+02	0.121	7.65E-05	2.94	0.437	0.514	1.32
755	2448	0.00273	0.01904	0.31721	0.00331	0.64192	0.00085	0.00907	0.00585	1.89E+02	0.120	7.67E-05	2.97	0.445	0.512	1.33
811	2456	0.00287	0.01953	0.31637	0.00340	0.64160	0.00089	0.00935	0.00599	2.13E+02	0.120	7.69E-05	3.00	0.454	0.509	1.33

**Table D.3b** H<sub>2</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

Fuel temp. (K)	Flame temp. (K)	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-F)	Equil. Pr	Le
77	3827	0.00179	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	0	0.00775	5.06E-05	0.650	0.221	0.536	1.28
100	3831	0.00181	0.01537	0.32348	0.00266	0.64434	0.00055	0.00702	0.00478	2	0.00775	5.07E-05	0.652	0.222	0.535	1.28
200	3846	0.00191	0.01580	0.32275	0.00274	0.64406	0.00058	0.00726	0.00491	12	0.00772	5.08E-05	0.659	0.226	0.532	1.28
300	3861	0.00202	0.01626	0.32198	0.00282	0.64376	0.00061	0.00751	0.00504	22	0.00769	5.09E-05	0.666	0.230	0.529	1.29
400	3875	0.00213	0.01672	0.32121	0.00290	0.64347	0.00065	0.00776	0.00517	32	0.00766	5.10E-05	0.673	0.235	0.526	1.30
500	3890	0.00224	0.01717	0.32043	0.00298	0.64317	0.00069	0.00802	0.00531	42	0.00763	5.11E-05	0.680	0.239	0.523	1.30
600	3904	0.00236	0.01764	0.31963	0.00306	0.64286	0.00072	0.00828	0.00544	52	0.00760	5.13E-05	0.687	0.244	0.520	1.31
700	3919	0.00248	0.01810	0.31884	0.00314	0.64256	0.00076	0.00854	0.00558	61	0.00757	5.14E-05	0.695	0.248	0.517	1.31
800	3933	0.00260	0.01857	0.31802	0.00323	0.64224	0.00081	0.00881	0.00572	71	0.00755	5.15E-05	0.702	0.253	0.514	1.32
900	3947	0.00273	0.01904	0.31721	0.00331	0.64192	0.00085	0.00907	0.00585	81	0.00752	5.16E-05	0.710	0.257	0.512	1.33
1000	3961	0.00287	0.01953	0.31637	0.00340	0.64160	0.00089	0.00935	0.00599	91	0.00749	5.17E-05	0.717	0.262	0.509	1.33

**Table D.4a** H<sub>2</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

Flame temp. (K)	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le	Avail. heat (%)
366	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-3.34E+03	0.817	1.78E-05	1.26	0.027	0.825	1.00	82.2
478	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-3.20E+03	0.626	2.23E-05	1.28	0.035	0.808	1.00	78.7
589	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-3.05E+03	0.508	2.65E-05	1.31	0.044	0.795	1.00	75.2
700	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-2.90E+03	0.427	3.06E-05	1.35	0.053	0.785	1.00	71.5
811	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-2.75E+03	0.369	3.44E-05	1.39	0.061	0.777	1.00	67.8
922	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-2.60E+03	0.324	3.80E-05	1.43	0.071	0.769	1.00	63.9
1033	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-2.43E+03	0.290	4.15E-05	1.46	0.080	0.760	1.00	60.0
1144	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-2.27E+03	0.261	4.48E-05	1.50	0.089	0.755	1.00	55.9
1255	0.00000	0.00001	0.34710	0.00000	0.65289	0.00000	0.00000	0.00000	-2.10E+03	0.238	4.80E-05	1.53	0.098	0.750	1.00	51.8
1366	0.00000	0.00003	0.34707	0.00000	0.65288	0.00000	0.00000	0.00001	-1.93E+03	0.219	5.10E-05	1.56	0.107	0.744	1.00	47.5
1478	0.00000	0.00008	0.34700	0.00001	0.65286	0.00000	0.00001	0.00003	-1.75E+03	0.202	5.40E-05	1.59	0.117	0.737	1.00	43.2
1589	0.00000	0.00022	0.34682	0.00004	0.65279	0.00000	0.00004	0.00008	-1.57E+03	0.188	5.69E-05	1.63	0.128	0.728	1.01	38.7
1700	0.00000	0.00051	0.34644	0.00008	0.65266	0.00000	0.00012	0.00018	-1.39E+03	0.176	5.97E-05	1.68	0.140	0.715	1.02	34.2
1811	0.00001	0.00106	0.34568	0.00018	0.65240	0.00000	0.00029	0.00037	-1.20E+03	0.165	6.24E-05	1.74	0.155	0.701	1.03	29.5
1922	0.00004	0.00203	0.34433	0.00034	0.65193	0.00001	0.00062	0.00069	-1.00E+03	0.155	6.50E-05	1.82	0.175	0.678	1.05	24.7
2033	0.00012	0.00361	0.34204	0.00061	0.65114	0.00003	0.00125	0.00120	-7.93E+02	0.147	6.76E-05	1.94	0.201	0.652	1.09	19.5
2144	0.00031	0.00605	0.33841	0.00103	0.64985	0.00008	0.00230	0.00197	-5.68E+02	0.139	7.01E-05	2.12	0.240	0.619	1.13	14.0
2255	0.00074	0.00958	0.33292	0.00164	0.64786	0.00021	0.00399	0.00305	-3.20E+02	0.132	7.26E-05	2.35	0.293	0.581	1.19	7.9
2382	0.00179	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	-2.09E-04	0.124	7.53E-05	2.72	0.383	0.536	1.28	0.0



**Table D.4b** H<sub>2</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

Flame temp. (°F)	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Lc	Avail. heat (%)
200	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1435	0.05102	1.19E-05	0.300	0.016	0.825	1.00	82.2
400	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1374	0.03906	1.50E-05	0.306	0.020	0.808	1.00	78.7
600	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1312	0.03170	1.79E-05	0.313	0.025	0.795	1.00	75.2
800	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1248	0.02668	2.06E-05	0.322	0.030	0.785	1.00	71.5
1000	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1183	0.02302	2.31E-05	0.331	0.036	0.777	1.00	67.8
1200	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1116	0.02025	2.56E-05	0.341	0.041	0.769	1.00	63.9
1400	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-1047	0.01808	2.79E-05	0.350	0.046	0.760	1.00	60.0
1600	0.00000	0.00000	0.34711	0.00000	0.65289	0.00000	0.00000	0.00000	-976	0.01632	3.01E-05	0.358	0.051	0.755	1.00	55.9
1800	0.00000	0.00001	0.34710	0.00000	0.65289	0.00000	0.00000	0.00000	-904	0.01488	3.23E-05	0.366	0.057	0.750	1.00	51.8
2000	0.00000	0.00003	0.34707	0.00000	0.65288	0.00000	0.00000	0.00001	-830	0.01367	3.43E-05	0.373	0.062	0.744	1.00	47.5
2200	0.00000	0.00008	0.34700	0.00001	0.65286	0.00000	0.00001	0.00003	-753	0.01263	3.63E-05	0.381	0.068	0.737	1.00	43.2
2400	0.00000	0.00022	0.34682	0.00004	0.65279	0.00000	0.00004	0.00008	-676	0.01175	3.83E-05	0.390	0.074	0.728	1.01	38.7
2600	0.00000	0.00051	0.34644	0.00008	0.65266	0.00000	0.00012	0.00018	-597	0.01098	4.01E-05	0.401	0.081	0.715	1.02	34.2
2800	0.00001	0.00106	0.34568	0.00018	0.65240	0.00000	0.00029	0.00037	-516	0.01030	4.20E-05	0.415	0.089	0.701	1.03	29.5
3000	0.00004	0.00203	0.34433	0.00034	0.65193	0.00001	0.00062	0.00069	-431	0.00970	4.37E-05	0.436	0.101	0.678	1.05	24.7
3200	0.00012	0.00361	0.34204	0.00061	0.65114	0.00003	0.00125	0.00120	-341	0.00916	4.55E-05	0.464	0.116	0.652	1.09	19.5
3400	0.00031	0.00605	0.33841	0.00103	0.64985	0.00008	0.00230	0.00197	-244	0.00868	4.72E-05	0.506	0.139	0.619	1.13	14.0
3600	0.00074	0.00958	0.33292	0.00164	0.64786	0.00021	0.00399	0.00305	-138	0.00823	4.88E-05	0.561	0.170	0.581	1.19	7.9
3827	0.00179	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	0	0.00775	5.06E-05	0.650	0.221	0.536	1.28	0.0

**Table D.5a** H<sub>2</sub> (298 K) Adiabatically Combusted with Air (298 K) at Various Equivalence Ratios, Metric Units

Equiv. ratio	Flame temp. (K)	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NH <sub>3</sub>	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le
4.00	1559	0.00002	0.51009	0.17004	0.00001	0.00000	0.31983	0.00000	0.00000	0.00000	4.19E-05	0.120	5.27E-05	2.75	0.285	0.509	1.00
2.00	2060	0.00122	0.25696	0.25735	0.00000	0.00001	0.48433	0.00000	0.00014	0.00000	8.37E-05	0.111	6.71E-05	2.23	0.283	0.529	1.09
1.33	2314	0.00332	0.10285	0.30829	0.00000	0.00021	0.58357	0.00004	0.00167	0.00005	2.51E-04	0.117	7.35E-05	2.22	0.312	0.523	1.22
1.00	2382	0.00179	0.01526	0.32366	0.00000	0.00264	0.64440	0.00054	0.00696	0.00475	2.09E-04	0.124	7.53E-05	2.72	0.383	0.536	1.28
0.80	2168	0.00018	0.00144	0.28314	0.00000	0.00454	0.67259	0.00040	0.00471	0.03300	1.67E-04	0.142	7.08E-05	1.92	0.223	0.610	1.15
0.67	1957	0.00002	0.00021	0.24439	0.00000	0.00358	0.69070	0.00012	0.00192	0.05907	0.00E+00	0.161	6.61E-05	1.66	0.158	0.694	1.03
0.57	1782	0.00000	0.00003	0.21370	0.00000	0.00242	0.70405	0.00003	0.00072	0.07903	4.19E-05	0.179	6.22E-05	1.53	0.133	0.718	1.00
0.50	1641	0.00000	0.00001	0.18989	0.00000	0.00158	0.71409	0.00001	0.00028	0.09415	0.00E+00	0.197	5.89E-05	1.46	0.119	0.723	1.00

**Table D.5b** H<sub>2</sub> (77°F) Combusted with air (77°F) at Various Equivalence Ratios, English Units

Equiv. ratio	Flame temp. (°F)	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NH <sub>3</sub>	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Equil. Le
4.00	2347	0.00002	0.51009	0.17004	0.00001	0.00000	0.31983	0.00000	0.00000	0.00000	0	0.00750	3.54E-05	0.657	0.165	0.509	1.00
2.00	3249	0.00122	0.25696	0.25735	0.00000	0.00001	0.48433	0.00000	0.00014	0.00000	0	0.00692	4.51E-05	0.532	0.163	0.529	1.09
1.33	3706	0.00332	0.10285	0.30829	0.00000	0.00021	0.58357	0.00004	0.00167	0.00005	0	0.00728	4.95E-05	0.530	0.180	0.523	1.22
1.00	3827	0.00179	0.01526	0.32366	0.00000	0.00264	0.64440	0.00054	0.00696	0.00475	0	0.00775	5.06E-05	0.650	0.221	0.536	1.28
0.80	3442	0.00018	0.00144	0.28314	0.00000	0.00454	0.67259	0.00040	0.00471	0.03300	0	0.00885	4.76E-05	0.459	0.129	0.610	1.15
0.67	3063	0.00002	0.00021	0.24439	0.00000	0.00358	0.69070	0.00012	0.00192	0.05907	0	0.01002	4.45E-05	0.396	0.091	0.694	1.03
0.57	2748	0.00000	0.00003	0.21370	0.00000	0.00242	0.70405	0.00003	0.00072	0.07903	0	0.01118	4.18E-05	0.366	0.077	0.718	1.00
0.50	2494	0.00000	0.00001	0.18989	0.00000	0.00158	0.71409	0.00001	0.00028	0.09415	0	0.01228	3.96E-05	0.350	0.069	0.723	1.00

**Table D.6a** H<sub>2</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.) with an Exhaust Temp. of 1367 K, Metric Units

Oxid. temp. (K)	H <sub>2</sub>	H <sub>2</sub> O (g)	N <sub>2</sub>	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le	Avail. heat (%)
298	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	47.5
366	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	49.2
478	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	51.9
589	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	54.7
700	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	57.5
811	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	60.4
922	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	63.4
1033	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	66.4
1144	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	69.5
1255	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	72.7
1366	0.00003	0.34707	0.65288	0.00001	-1.93E+03	0.219	5.11E-05	1.56	0.107	0.744	1.00	75.9

**Table D.6b** H<sub>2</sub> (77°F) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.) with an Exhaust Temp. of 2000°F, English Units

Oxid. temp. (°F)	H <sub>2</sub>	H <sub>2</sub> O (g)	N <sub>2</sub>	O <sub>2</sub>	Enthalpy, <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le	Avail. heat (%)
77	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	47.5
200	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	49.2
400	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	51.9
600	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	54.7
800	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	57.5
1000	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	60.4
1200	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	63.4
1400	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	66.4
1600	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	69.5
1800	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	72.7
2000	0.00003	0.34707	0.65288	0.00001	-829	0.01366	3.43E-05	0.373	0.062	0.744	1.00	75.9

**Table D.7a** CH<sub>4</sub> (298 K) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with a Variable Composition Oxidizer (298 K), Metric Units

O <sub>2</sub>	N <sub>2</sub>	Flame temp. (K)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/ m-sec)	Equil. spec. heat (kJ/ kg-K)	Equil. therm cond. (W/ m-K)	Equil Pr	Equil Le
0.21	0.79	2225	0.00893	0.08539	0.00039	0.00000	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-2.58E+02	0.150	7.12E-05	2.19	0.248	0.630	1.12
0.30	0.70	2525	0.03158	0.09513	0.00312	0.00001	0.01249	0.23302	0.00594	0.58834	0.00204	0.01269	0.01565	-3.56E+02	0.129	7.82E-05	3.63	0.533	0.533	1.29
0.40	0.60	2703	0.05780	0.09934	0.00884	0.00001	0.02389	0.27268	0.00949	0.46666	0.00616	0.02653	0.02859	-4.57E+02	0.116	8.27E-05	5.27	0.909	0.479	1.39
0.50	0.50	2813	0.08072	0.10220	0.01587	0.00002	0.03474	0.30299	0.01155	0.36006	0.01138	0.04032	0.04013	-5.51E+02	0.108	8.57E-05	6.82	1.286	0.454	1.44
0.60	0.40	2889	0.10031	0.10472	0.02321	0.00003	0.04449	0.32738	0.01231	0.26721	0.01697	0.05312	0.05025	-6.38E+02	0.102	8.80E-05	8.28	1.646	0.443	1.46
0.70	0.30	2944	0.11712	0.10704	0.03039	0.00004	0.05311	0.34761	0.01197	0.18615	0.02255	0.06479	0.05922	-7.20E+02	0.097	8.99E-05	9.65	1.983	0.437	1.46
0.80	0.20	2988	0.13168	0.10920	0.03721	0.00005	0.06070	0.36473	0.01059	0.11514	0.02798	0.07540	0.06732	-7.97E+02	0.092	9.14E-05	10.95	2.297	0.436	1.45
0.90	0.10	3023	0.14438	0.11120	0.04363	0.00006	0.06736	0.37937	0.00789	0.05285	0.03325	0.08515	0.07487	-8.69E+02	0.089	9.27E-05	12.18	2.589	0.436	1.44
1.00	0.00	3054	0.15534	0.11310	0.04983	0.00007	0.07296	0.39154	0.00000	0.00000	0.03893	0.09486	0.08338	-9.36E+02	0.086	9.39E-05	13.35	2.868	0.437	1.44

**Table D.7b** CH<sub>4</sub> (77°F) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with a Variable Composition Oxidizer (77°F), English Units

O <sub>2</sub>	N <sub>2</sub>	Flame temp. (°F)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm cond. (Btu/ft-hr-°F)	Equil Pr	Equil Le
0.21	0.79	3545	0.00893	0.08539	0.00039	0.00000	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-111	0.00938	4.79E-05	0.524	0.143	0.536	1.28
0.30	0.70	4086	0.03158	0.09513	0.00312	0.00001	0.01249	0.23302	0.00594	0.58834	0.00204	0.01269	0.01565	-153	0.00805	5.26E-05	0.867	0.308	0.454	1.45
0.40	0.60	4406	0.05780	0.09934	0.00884	0.00001	0.02389	0.27268	0.00949	0.46666	0.00616	0.02653	0.02859	-196	0.00726	5.56E-05	1.258	0.525	0.431	1.49
0.50	0.50	4604	0.08072	0.10220	0.01587	0.00002	0.03474	0.30299	0.01155	0.36006	0.01138	0.04032	0.04013	-237	0.00673	5.76E-05	1.628	0.743	0.429	1.49
0.60	0.40	4740	0.10031	0.10472	0.02321	0.00003	0.04449	0.32738	0.01231	0.26721	0.01697	0.05312	0.05025	-274	0.00634	5.92E-05	1.977	0.951	0.434	1.47
0.70	0.30	4840	0.11712	0.10704	0.03039	0.00004	0.05311	0.34761	0.01197	0.18615	0.02255	0.06479	0.05922	-310	0.00603	6.04E-05	2.305	1.146	0.442	1.45
0.80	0.20	4918	0.13168	0.10920	0.03721	0.00005	0.06070	0.36473	0.01059	0.11514	0.02798	0.07540	0.06732	-343	0.00577	6.15E-05	2.615	1.327	0.452	1.43
0.90	0.10	4981	0.14438	0.11120	0.04363	0.00006	0.06736	0.37937	0.00789	0.05285	0.03325	0.08515	0.07487	-373	0.00555	6.24E-05	2.908	1.496	0.462	1.41
1.00	0.00	5037	0.15534	0.11310	0.04983	0.00007	0.07296	0.39154	0.00000	0.00000	0.03893	0.09486	0.08338	-403	0.00535	6.32E-05	3.189	1.657	0.472	1.40

**Table D.8a** CH<sub>4</sub> (298 K) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.), Metric Units

Air temp. (K)	Flame temp. (K)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Equil. Le
298	2225	0.00893	0.08539	0.00039	0.00000	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-2.58E+02	0.150	7.12E-05	2.19	0.248	0.630	1.12
366	2254	0.01008	0.08415	0.00048	0.00000	0.00404	0.18249	0.00222	0.70782	0.00027	0.00335	0.00510	-1.93E+02	0.148	7.19E-05	2.27	0.262	0.622	1.14
478	2301	0.01212	0.08193	0.00067	0.00000	0.00482	0.18088	0.00266	0.70631	0.00039	0.00415	0.00607	-8.43E+01	0.145	7.28E-05	2.39	0.286	0.608	1.16
589	2345	0.01431	0.07955	0.00091	0.00000	0.00566	0.17908	0.00315	0.70464	0.00054	0.00505	0.00711	2.52E+01	0.142	7.38E-05	2.52	0.313	0.595	1.18
700	2389	0.01665	0.07700	0.00121	0.00000	0.00659	0.17709	0.00367	0.70279	0.00073	0.00605	0.00821	1.37E+02	0.139	7.47E-05	2.66	0.342	0.580	1.21
811	2431	0.01913	0.07429	0.00159	0.00000	0.00759	0.17488	0.00424	0.70078	0.00098	0.00715	0.00936	2.52E+02	0.136	7.56E-05	2.80	0.374	0.566	1.23
922	2471	0.02172	0.07146	0.00205	0.00000	0.00867	0.17248	0.00484	0.69860	0.00128	0.00836	0.01055	3.70E+02	0.134	7.64E-05	2.95	0.408	0.552	1.26
1033	2511	0.02437	0.06853	0.00260	0.00000	0.00981	0.16987	0.00547	0.69627	0.00165	0.00966	0.01177	4.90E+02	0.131	7.72E-05	3.10	0.445	0.538	1.29
1144	2550	0.02706	0.06556	0.00325	0.00000	0.01102	0.16708	0.00612	0.69380	0.00208	0.01103	0.01299	6.12E+02	0.129	7.80E-05	3.26	0.484	0.524	1.32
1255	2587	0.02975	0.06257	0.00400	0.00000	0.01228	0.16411	0.00679	0.69120	0.00259	0.01248	0.01420	7.36E+02	0.126	7.87E-05	3.41	0.526	0.511	1.34
1366	2623	0.03242	0.05958	0.00487	0.00001	0.01360	0.16098	0.00747	0.68849	0.00318	0.01399	0.01540	8.62E+02	0.124	7.95E-05	3.57	0.569	0.498	1.37



**Table D.8b** CH<sub>4</sub> (77°F) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.), English Units

Air temp. (°F)	Flame temp. (°F)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le
77	3545	0.00893	0.08539	0.00039	0.00000	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-111	0.00938	4.79E-05	0.524	0.143	0.630	1.12
200	3598	0.01008	0.08415	0.00048	0.00000	0.00404	0.18249	0.00222	0.70782	0.00027	0.00335	0.00510	-83	0.00925	4.83E-05	0.541	0.151	0.622	1.14
400	3682	0.01212	0.08193	0.00067	0.00000	0.00482	0.18088	0.00266	0.70631	0.00039	0.00415	0.00607	-36	0.00904	4.90E-05	0.571	0.165	0.608	1.16
600	3762	0.01431	0.07955	0.00091	0.00000	0.00566	0.17908	0.00315	0.70464	0.00054	0.00505	0.00711	11	0.00886	4.96E-05	0.603	0.181	0.595	1.18
800	3840	0.01665	0.07700	0.00121	0.00000	0.00659	0.17709	0.00367	0.70279	0.00073	0.00605	0.00821	59	0.00868	5.02E-05	0.636	0.198	0.580	1.21
1000	3915	0.01913	0.07429	0.00159	0.00000	0.00759	0.17488	0.00424	0.70078	0.00098	0.00715	0.00936	108	0.00850	5.08E-05	0.670	0.216	0.566	1.23
1200	3989	0.02172	0.07146	0.00205	0.00000	0.00867	0.17248	0.00484	0.69860	0.00128	0.00836	0.01055	159	0.00834	5.14E-05	0.705	0.236	0.552	1.26
1400	4060	0.02437	0.06853	0.00260	0.00000	0.00981	0.16987	0.00547	0.69627	0.00165	0.00966	0.01177	211	0.00819	5.19E-05	0.741	0.257	0.538	1.29
1600	4129	0.02706	0.06556	0.00325	0.00000	0.01102	0.16708	0.00612	0.69380	0.00208	0.01103	0.01299	263	0.00804	5.25E-05	0.778	0.280	0.524	1.32
1800	4196	0.02975	0.06257	0.00400	0.00000	0.01228	0.16411	0.00679	0.69120	0.00259	0.01248	0.01420	317	0.00790	5.30E-05	0.815	0.304	0.511	1.34
2000	4261	0.03242	0.05958	0.00487	0.00001	0.01360	0.16098	0.00747	0.68849	0.00318	0.01399	0.01540	371	0.00776	5.34E-05	0.852	0.329	0.498	1.37

**Table D.9a** CH<sub>4</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

Fuel temp. (K)	Flame temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/ kg-K)	Equil. therm. cond. (W/ m-K)	Equil. Pr	Le
298	2225	0.00893	0.08539	0.00039	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-2.58E+02	0.150	7.12E-05	2.19	0.248	0.630	1.12
311	2226	0.00896	0.08536	0.00039	0.00362	0.18336	0.00197	0.70864	0.00021	0.00292	0.00456	-2.56E+02	0.150	7.13E-05	2.19	0.248	0.630	1.12
366	2229	0.00908	0.08523	0.00040	0.00366	0.18327	0.00200	0.70856	0.00022	0.00297	0.00462	-2.49E+02	0.150	7.13E-05	2.20	0.250	0.629	1.13
422	2233	0.00922	0.08508	0.00041	0.00371	0.18316	0.00203	0.70846	0.00023	0.00302	0.00468	-2.41E+02	0.150	7.14E-05	2.21	0.251	0.628	1.13
478	2236	0.00936	0.08492	0.00042	0.00377	0.18305	0.00206	0.70835	0.00023	0.00308	0.00476	-2.33E+02	0.149	7.15E-05	2.22	0.253	0.627	1.13
533	2240	0.00952	0.08475	0.00043	0.00383	0.18293	0.00209	0.70823	0.00024	0.00313	0.00483	-2.24E+02	0.149	7.16E-05	2.23	0.255	0.626	1.13
589	2245	0.00969	0.08457	0.00045	0.00389	0.18280	0.00213	0.70811	0.00025	0.00320	0.00491	-2.14E+02	0.149	7.17E-05	2.24	0.257	0.625	1.13
644	2249	0.00987	0.08437	0.00046	0.00396	0.18266	0.00217	0.70798	0.00026	0.00327	0.00500	-2.04E+02	0.149	7.18E-05	2.25	0.259	0.624	1.13
700	2254	0.01007	0.08416	0.00048	0.00404	0.18250	0.00221	0.70783	0.00027	0.00334	0.00509	-1.93E+02	0.148	7.19E-05	2.26	0.262	0.622	1.14
755	2259	0.01027	0.08394	0.00050	0.00412	0.18234	0.00226	0.70768	0.00028	0.00342	0.00519	-1.82E+02	0.148	7.20E-05	2.28	0.264	0.621	1.14
811	2264	0.01050	0.08369	0.00052	0.00420	0.18217	0.00231	0.70752	0.00029	0.00351	0.00530	-1.70E+02	0.147	7.21E-05	2.29	0.267	0.619	1.14

**Table D.9b** CH<sub>4</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

Fuel temp. (°F)	Flame temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le
77	2225	0.00893	0.08539	0.00039	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-111	0.00938	4.79E-05	0.524	0.143	0.630	1.12
100	2226	0.00896	0.08536	0.00039	0.00362	0.18336	0.00197	0.70864	0.00021	0.00292	0.00456	-110	0.00938	4.79E-05	0.524	0.143	0.630	1.12
200	2229	0.00908	0.08523	0.00040	0.00366	0.18327	0.00200	0.70856	0.00022	0.00297	0.00462	-107	0.00936	4.80E-05	0.526	0.144	0.629	1.13
300	2233	0.00922	0.08508	0.00041	0.00371	0.18316	0.00203	0.70846	0.00023	0.00302	0.00468	-104	0.00935	4.80E-05	0.528	0.145	0.628	1.13
400	2236	0.00936	0.08492	0.00042	0.00377	0.18305	0.00206	0.70835	0.00023	0.00308	0.00476	-100	0.00933	4.81E-05	0.530	0.146	0.627	1.13
500	2240	0.00952	0.08475	0.00043	0.00383	0.18293	0.00209	0.70823	0.00024	0.00313	0.00483	-96	0.00931	4.81E-05	0.533	0.147	0.626	1.13
600	2245	0.00969	0.08457	0.00045	0.00389	0.18280	0.00213	0.70811	0.00025	0.00320	0.00491	-92	0.00929	4.82E-05	0.535	0.149	0.625	1.13
700	2249	0.00987	0.08437	0.00046	0.00396	0.18266	0.00217	0.70798	0.00026	0.00327	0.00500	-88	0.00927	4.83E-05	0.538	0.150	0.624	1.13
800	2254	0.01007	0.08416	0.00048	0.00404	0.18250	0.00221	0.70783	0.00027	0.00334	0.00509	-83	0.00925	4.83E-05	0.541	0.151	0.622	1.14
900	2259	0.01027	0.08394	0.00050	0.00412	0.18234	0.00226	0.70768	0.00028	0.00342	0.00519	-78	0.00923	4.84E-05	0.544	0.153	0.621	1.14
1000	2264	0.01050	0.08369	0.00052	0.00420	0.18217	0.00231	0.70752	0.00029	0.00351	0.00530	-73	0.00920	4.85E-05	0.547	0.154	0.619	1.14

**Table D.10a** CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

Gas temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le	Avail. heat (%)
366	0.00000	0.09502	0.00000	0.00000	0.19004	0.00000	0.71493	0.00000	0.00000	0.00000	-2.94E+03	0.920	1.89E-05	1.13	0.027	0.782	1.00	87.6
478	0.00000	0.09502	0.00000	0.00000	0.19004	0.00000	0.71493	0.00000	0.00000	0.00000	-2.81E+03	0.705	2.35E-05	1.15	0.035	0.772	1.00	83.5
589	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-2.68E+03	0.572	2.77E-05	1.19	0.043	0.766	1.00	79.2
700	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-2.55E+03	0.481	3.16E-05	1.22	0.051	0.761	1.00	74.8
811	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-2.41E+03	0.415	3.53E-05	1.26	0.059	0.756	1.00	70.3
922	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-2.27E+03	0.365	3.87E-05	1.29	0.067	0.751	1.00	65.7
1033	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-2.13E+03	0.326	4.21E-05	1.33	0.075	0.747	1.00	61.0
1144	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-1.98E+03	0.294	4.52E-05	1.35	0.082	0.744	1.00	56.1
1255	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-1.82E+03	0.268	4.83E-05	1.38	0.090	0.741	1.00	51.1
1366	0.00001	0.09501	0.00000	0.00001	0.19003	0.00000	0.71492	0.00000	0.00000	0.00001	-1.67E+03	0.247	5.12E-05	1.40	0.097	0.738	1.00	46.1
1478	0.00005	0.09496	0.00000	0.00004	0.18999	0.00002	0.71489	0.00000	0.00001	0.00004	-1.51E+03	0.228	5.40E-05	1.43	0.106	0.732	1.00	40.9
1589	0.00016	0.09485	0.00000	0.00011	0.18989	0.00004	0.71481	0.00000	0.00003	0.00010	-1.35E+03	0.212	5.68E-05	1.46	0.114	0.728	1.00	35.7
1700	0.00041	0.09458	0.00000	0.00024	0.18969	0.00010	0.71463	0.00000	0.00010	0.00025	-1.19E+03	0.198	5.94E-05	1.51	0.125	0.719	1.01	30.3
1811	0.00092	0.09403	0.00001	0.00048	0.18929	0.00022	0.71427	0.00000	0.00023	0.00054	-1.01E+03	0.186	6.20E-05	1.58	0.138	0.710	1.02	24.7
1922	0.00190	0.09298	0.00003	0.00090	0.18858	0.00044	0.71360	0.00001	0.00051	0.00105	-8.34E+02	0.175	6.46E-05	1.67	0.155	0.698	1.03	18.8
2033	0.00357	0.09118	0.00008	0.00157	0.18736	0.00081	0.71245	0.00004	0.00103	0.00191	-6.40E+02	0.165	6.71E-05	1.82	0.181	0.675	1.06	12.5
2144	0.00622	0.08832	0.00021	0.00259	0.18542	0.00138	0.71060	0.00011	0.00193	0.00323	-4.28E+02	0.156	6.95E-05	2.01	0.215	0.651	1.09	5.6
2255	0.00893	0.08539	0.00039	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-2.58E+02	0.150	7.12E-05	2.19	0.248	0.630	1.12	0.0

**Table D.10b** CH<sub>4</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

Flame temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le	Avail. heat (%)
200	0.00000	0.09502	0.00000	0.00000	0.19004	0.00000	0.71493	0.00000	0.00000	0.00000	-1265	0.05744	1.27E-05	0.269	0.016	0.782	1.00	87.6
400	0.00000	0.09502	0.00000	0.00000	0.19004	0.00000	0.71493	0.00000	0.00000	0.00000	-1210	0.04398	1.58E-05	0.276	0.020	0.772	1.00	83.5
600	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-1154	0.03569	1.86E-05	0.284	0.025	0.766	1.00	79.2
800	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-1096	0.03003	2.12E-05	0.292	0.029	0.761	1.00	74.8
1000	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-1037	0.02592	2.37E-05	0.301	0.034	0.756	1.00	70.3
1200	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-976	0.02280	2.61E-05	0.309	0.039	0.751	1.00	65.7
1400	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-914	0.02035	2.83E-05	0.317	0.043	0.747	1.00	61.0
1600	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-850	0.01838	3.04E-05	0.323	0.048	0.744	1.00	56.1
1800	0.00000	0.09502	0.00000	0.00000	0.19005	0.00000	0.71493	0.00000	0.00000	0.00000	-784	0.01675	3.25E-05	0.329	0.052	0.741	1.00	51.1
2000	0.00001	0.09501	0.00000	0.00001	0.19003	0.00000	0.71492	0.00000	0.00000	0.00001	-718	0.01539	3.44E-05	0.335	0.056	0.738	1.00	46.1
2200	0.00005	0.09496	0.00000	0.00004	0.18999	0.00002	0.71489	0.00000	0.00001	0.00004	-650	0.01422	3.63E-05	0.342	0.061	0.732	1.00	40.9
2400	0.00016	0.09485	0.00000	0.00011	0.18989	0.00004	0.71481	0.00000	0.00003	0.00010	-580	0.01323	3.82E-05	0.349	0.066	0.728	1.00	35.7
2600	0.00041	0.09458	0.00000	0.00024	0.18969	0.00010	0.71463	0.00000	0.00010	0.00025	-510	0.01236	4.00E-05	0.361	0.072	0.719	1.01	30.3
2800	0.00092	0.09403	0.00001	0.00048	0.18929	0.00022	0.71427	0.00000	0.00023	0.00054	-436	0.01160	4.17E-05	0.376	0.080	0.710	1.02	24.7
3000	0.00190	0.09298	0.00003	0.00090	0.18858	0.00044	0.71360	0.00001	0.00051	0.00105	-358	0.01092	4.34E-05	0.399	0.089	0.698	1.03	18.8
3200	0.00357	0.09118	0.00008	0.00157	0.18736	0.00081	0.71245	0.00004	0.00103	0.00191	-275	0.01031	4.51E-05	0.434	0.104	0.675	1.06	12.5
3400	0.00622	0.08832	0.00021	0.00259	0.18542	0.00138	0.71060	0.00011	0.00193	0.00323	-184	0.00976	4.67E-05	0.481	0.124	0.651	1.09	5.6
3600	0.00893	0.08539	0.00039	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-111	0.00938	4.79E-05	0.524	0.143	0.630	1.12	0.0

**Table D.11a** CH<sub>4</sub> (298 K) Adiabatically Combusted with Air (298 K) at Various Equivalence Ratios, Metric Units

Equiv. ratio	Flame temp. (K)	C(gr)	CH <sub>4</sub>	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NH <sub>3</sub>	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil.	
																				Pr	Le
4.00	944	0.0483	0.02281	0.11559	0.02752	0.00000	0.33907	0.04363	0.00012	0.00000	0.40293	0.00000	0.00000	0.00000	-8.84E+02	0.246	3.85E-05	6.71	0.401	0.644	0.80
2.00	1563	0.0000	0.00000	0.11939	0.02850	0.00002	0.17637	0.11939	0.00000	0.00000	0.55633	0.00000	0.00000	0.00000	-4.88E+02	0.177	5.55E-05	1.66	0.152	0.603	0.99
1.33	2030	0.0000	0.00000	0.06524	0.05041	0.00044	0.05021	0.18077	0.00000	0.00002	0.65273	0.00000	0.00017	0.00000	-3.37E+02	0.154	6.68E-05	1.61	0.168	0.640	1.06
1.00	2225	0.0000	0.00000	0.00893	0.08539	0.00039	0.00361	0.18338	0.00000	0.00197	0.70866	0.00021	0.00291	0.00455	-2.58E+02	0.150	7.12E-05	2.19	0.248	0.630	1.12
0.80	1995	0.0000	0.00000	0.00050	0.07692	0.00002	0.00022	0.15380	0.00000	0.00323	0.72654	0.00012	0.00164	0.03699	-2.08E+02	0.170	6.65E-05	1.59	0.151	0.698	1.03
0.67	1781	0.0000	0.00000	0.00004	0.06540	0.00000	0.00002	0.13059	0.00000	0.00223	0.73705	0.00003	0.00053	0.06411	-1.75E+02	0.192	6.18E-05	1.44	0.123	0.723	1.00
0.57	1612	0.0000	0.00000	0.00000	0.05656	0.00000	0.00000	0.11304	0.00000	0.00135	0.74460	0.00000	0.00017	0.08427	-1.51E+02	0.213	5.79E-05	1.38	0.110	0.726	1.00
0.50	1478	0.0000	0.00000	0.00000	0.04988	0.00000	0.00000	0.09973	0.00000	0.00080	0.75018	0.00000	0.00005	0.09934	-1.33E+02	0.233	5.48E-05	1.33	0.100	0.729	1.00

**Table D.11b** CH<sub>4</sub> (77°F) Combusted with Air (77°F) at Various Equivalence Ratios, English Units

Equiv. ratio	Flame temp. (°F)	C(gr)	CH <sub>4</sub>	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NH <sub>3</sub>	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Equil. Le
4.00	1240	0.0483	0.02281	0.11559	0.02752	0.00000	0.33907	0.04363	0.00012	0.00000	0.40293	0.00000	0.00000	0.00000	-380	0.01537	2.59E-05	1.602	0.232	0.644	0.80
2.00	2353	0.0000	0.00000	0.11939	0.02850	0.00002	0.17637	0.11939	0.00000	0.00000	0.55633	0.00000	0.00000	0.00000	-210	0.01105	3.73E-05	0.395	0.088	0.603	0.99
1.33	3195	0.0000	0.00000	0.06524	0.05041	0.00044	0.05021	0.18077	0.00000	0.00002	0.65273	0.00000	0.00017	0.00000	-145	0.00963	4.49E-05	0.385	0.097	0.640	1.06
1.00	3545	0.0000	0.00000	0.00893	0.08539	0.00039	0.00361	0.18338	0.00000	0.00197	0.70866	0.00021	0.00291	0.00455	-111	0.00938	4.79E-05	0.524	0.143	0.630	1.12
0.80	3132	0.0000	0.00000	0.00050	0.07692	0.00002	0.00022	0.15380	0.00000	0.00323	0.72654	0.00012	0.00164	0.03699	-90	0.01061	4.47E-05	0.379	0.087	0.698	1.03
0.67	2747	0.0000	0.00000	0.00004	0.06540	0.00000	0.00002	0.13059	0.00000	0.00223	0.73705	0.00003	0.00053	0.06411	-75	0.01196	4.16E-05	0.344	0.071	0.723	1.00
0.57	2441	0.0000	0.00000	0.00000	0.05656	0.00000	0.00000	0.11304	0.00000	0.00135	0.74460	0.00000	0.00017	0.08427	-65	0.01328	3.90E-05	0.330	0.064	0.726	1.00
0.50	2201	0.0000	0.00000	0.00000	0.04988	0.00000	0.00000	0.09973	0.00000	0.00080	0.75018	0.00000	0.00005	0.09934	-57	0.01452	3.68E-05	0.319	0.058	0.729	1.00

**Table D.12a** CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.) with an Exhaust Temp. of 1367 K, Metric Units

Oxid. temp. (K)	CO	CO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	N <sub>2</sub>	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le	Avail. heat (%)
298	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	46.1
366	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	48.2
478	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	51.7
589	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	55.3
700	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	59.0
811	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	62.7
922	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	66.6
1033	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	70.5
1144	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	74.5
1255	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	78.5
1366	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-1.67E+03	0.246	5.12E-05	1.40	0.097	0.737	1.00	82.6



**Table D.12b** CH<sub>4</sub> (77°F) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.) with an Exhaust Temp. of 2000°F, English Units

Oxid. temp. (°F)	CO	CO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	N <sub>2</sub>	O <sub>2</sub>	Enthalpy, <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le	Avail. heat (%)
77	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	46.1
200	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	48.2
400	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	51.7
600	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	55.3
800	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	59.0
1000	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	62.7
1200	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	66.6
1400	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	70.5
1600	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	74.5
1800	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	78.5
2000	0.00001	0.09501	0.00001	0.19003	0.71492	0.00001	-718	0.01538	3.44E-05	0.335	0.056	0.737	1.00	82.6

**Table D.13a** C<sub>3</sub>H<sub>8</sub> (298 K) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with a Variable Composition Oxidizer (298 K), Metric Units

O <sub>2</sub>	N <sub>2</sub>	Flame temp. (K)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/ kg-K)	Equil. therm cond. (W/ m-K)	Equil. Pr	Le
0.21	0.79	2266	0.01248	0.10269	0.00046	0.00000	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-1.42E+02	0.151	7.20E-05	2.27	0.259	0.631	1.13
0.30	0.70	2562	0.04149	0.11386	0.00340	0.00001	0.01089	0.18788	0.00700	0.60063	0.00266	0.01332	0.01887	-1.96E+02	0.131	7.87E-05	3.76	0.550	0.538	1.29
0.40	0.60	2739	0.07453	0.11889	0.00932	0.00002	0.02044	0.21919	0.01097	0.47806	0.00773	0.02718	0.03366	-2.51E+02	0.119	8.31E-05	5.37	0.920	0.484	1.39
0.50	0.50	2849	0.10359	0.12235	0.01654	0.00003	0.02954	0.24298	0.01326	0.36994	0.01409	0.04090	0.04677	-3.02E+02	0.111	8.61E-05	6.86	1.288	0.458	1.44
0.60	0.40	2925	0.12862	0.12538	0.02410	0.00004	0.03774	0.26203	0.01410	0.27517	0.02089	0.05366	0.05827	-3.49E+02	0.105	8.83E-05	8.25	1.637	0.445	1.45
0.70	0.30	2982	0.15027	0.12816	0.03152	0.00005	0.04501	0.27779	0.01370	0.19203	0.02770	0.06531	0.06846	-3.93E+02	0.100	9.01E-05	9.56	1.962	0.439	1.46
0.80	0.20	3027	0.16913	0.13074	0.03860	0.00006	0.05144	0.29108	0.01211	0.11888	0.03435	0.07594	0.07768	-4.35E+02	0.096	9.17E-05	10.78	2.265	0.436	1.45
0.90	0.10	3063	0.18565	0.13312	0.04529	0.00006	0.05709	0.30240	0.00901	0.05452	0.04083	0.08571	0.08629	-4.73E+02	0.093	9.30E-05	11.94	2.548	0.436	1.44
1.00	0.00	3095	0.19999	0.13537	0.05178	0.00007	0.06184	0.31164	0.00000	0.00000	0.04783	0.09546	0.09602	-5.09E+02	0.090	9.42E-05	13.05	2.818	0.436	1.43

**Table D.13b** C<sub>3</sub>H<sub>8</sub> (77°F) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with a Variable Composition Oxidizer (77°F), English Units

O <sub>2</sub>	N <sub>2</sub>	Flame temp. (°F)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ ft-hr)	Equil. spec. heat (Btu/ lb-°F)	Equil. therm cond. (Btu/ft-hr -°F)	Equil Pr	Le
0.21	0.79	3620	0.01248	0.10269	0.00046	0.00000	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-61	0.00942	4.84E-05	0.543	0.150	0.631	1.13
0.30	0.70	4151	0.04149	0.11386	0.00340	0.00001	0.01089	0.18788	0.00700	0.60063	0.00266	0.01332	0.01887	-84	0.00817	5.29E-05	0.897	0.318	0.538	1.29
0.40	0.60	4470	0.07453	0.11889	0.00932	0.00002	0.02044	0.21919	0.01097	0.47806	0.00773	0.02718	0.03366	-108	0.00742	5.59E-05	1.281	0.532	0.484	1.39
0.50	0.50	4668	0.10359	0.12235	0.01654	0.00003	0.02954	0.24298	0.01326	0.36994	0.01409	0.04090	0.04677	-130	0.00692	5.79E-05	1.639	0.744	0.458	1.44
0.60	0.40	4806	0.12862	0.12538	0.02410	0.00004	0.03774	0.26203	0.01410	0.27517	0.02089	0.05366	0.05827	-150	0.00655	5.94E-05	1.971	0.946	0.445	1.45
0.70	0.30	4908	0.15027	0.12816	0.03152	0.00005	0.04501	0.27779	0.01370	0.19203	0.02770	0.06531	0.06846	-169	0.00625	6.06E-05	2.283	1.134	0.439	1.46
0.80	0.20	4988	0.16913	0.13074	0.03860	0.00006	0.05144	0.29108	0.01211	0.11888	0.03435	0.07594	0.07768	-187	0.00601	6.17E-05	2.575	1.309	0.436	1.45
0.90	0.10	5053	0.18565	0.13312	0.04529	0.00006	0.05709	0.30240	0.00901	0.05452	0.04083	0.08571	0.08629	-203	0.00580	6.26E-05	2.852	1.472	0.436	1.44
1.00	0.00	5111	0.19999	0.13537	0.05178	0.00007	0.06184	0.31164	0.00000	0.00000	0.04783	0.09546	0.09602	-219	0.00561	6.34E-05	3.116	1.628	0.436	1.43

**Table D.14a** C<sub>3</sub>H<sub>8</sub> (298 K) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.), Metric Units

Air temp. (K)	Flame temp. (K)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le
298	2266	0.01248	0.10269	0.00046	0.00000	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-1.42E+02	0.151	7.20E-05	2.27	0.259	0.631	1.13
366	2294	0.01394	0.10110	0.00057	0.00000	0.00368	0.14756	0.00274	0.71987	0.00038	0.00372	0.00646	-7.75E+01	0.149	7.25E-05	2.35	0.273	0.624	1.14
478	2339	0.01649	0.09831	0.00077	0.00000	0.00432	0.14609	0.00324	0.71814	0.00054	0.00453	0.00758	3.03E+01	0.146	7.35E-05	2.48	0.298	0.611	1.16
589	2382	0.01920	0.09534	0.00103	0.00000	0.00502	0.14447	0.00378	0.71625	0.00073	0.00542	0.00875	1.39E+02	0.143	7.44E-05	2.61	0.325	0.598	1.18
700	2423	0.02207	0.09219	0.00134	0.00000	0.00578	0.14269	0.00436	0.71420	0.00097	0.00641	0.00998	2.51E+02	0.140	7.52E-05	2.75	0.354	0.585	1.20
811	2464	0.02508	0.08888	0.00173	0.00000	0.00659	0.14074	0.00498	0.71198	0.00128	0.00749	0.01126	3.65E+02	0.137	7.61E-05	2.89	0.385	0.572	1.23
922	2503	0.02820	0.08543	0.00219	0.00000	0.00746	0.13862	0.00563	0.70960	0.00164	0.00865	0.01257	4.82E+02	0.135	7.69E-05	3.04	0.418	0.558	1.25
1033	2542	0.03139	0.08189	0.00274	0.00000	0.00838	0.13634	0.00631	0.70708	0.00208	0.00990	0.01390	6.02E+02	0.132	7.76E-05	3.18	0.453	0.545	1.28
1144	2579	0.03462	0.07829	0.00338	0.00000	0.00935	0.13390	0.00701	0.70442	0.00259	0.01121	0.01522	7.23E+02	0.130	7.84E-05	3.33	0.491	0.532	1.31
1255	2615	0.03784	0.07468	0.00413	0.00001	0.01036	0.13132	0.00772	0.70165	0.00318	0.01259	0.01652	8.46E+02	0.128	7.91E-05	3.48	0.530	0.519	1.33
1366	2650	0.04104	0.07109	0.00498	0.00001	0.01140	0.12860	0.00845	0.69877	0.00386	0.01401	0.01780	9.71E+02	0.126	7.98E-05	3.62	0.571	0.507	1.36

**Table D.14b** C<sub>3</sub>H<sub>8</sub> (77°F) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.), English Units

Air temp. (°F)	Flame temp. (°F)	CO	CO <sub>2</sub>	H	HO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-F)	Equil. therm. cond. (Btu/ft-hr-F)	Equil. Pr	Le
77	3620	0.01248	0.10269	0.00046	0.00000	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-61	0.00942	4.84E-05	0.543	0.150	0.631	1.13
200	3670	0.01394	0.10110	0.00057	0.00000	0.00368	0.14756	0.00274	0.71987	0.00038	0.00372	0.00646	-33	0.00930	4.88E-05	0.561	0.158	0.624	1.14
400	3750	0.01649	0.09831	0.00077	0.00000	0.00432	0.14609	0.00324	0.71814	0.00054	0.00453	0.00758	13	0.00910	4.94E-05	0.592	0.172	0.611	1.16
600	3827	0.01920	0.09534	0.00103	0.00000	0.00502	0.14447	0.00378	0.71625	0.00073	0.00542	0.00875	60	0.00892	5.00E-05	0.624	0.188	0.598	1.18
800	3902	0.02207	0.09219	0.00134	0.00000	0.00578	0.14269	0.00436	0.71420	0.00097	0.00641	0.00998	108	0.00874	5.06E-05	0.657	0.204	0.585	1.20
1000	3975	0.02508	0.08888	0.00173	0.00000	0.00659	0.14074	0.00498	0.71198	0.00128	0.00749	0.01126	157	0.00857	5.12E-05	0.691	0.222	0.572	1.23
1200	4046	0.02820	0.08543	0.00219	0.00000	0.00746	0.13862	0.00563	0.70960	0.00164	0.00865	0.01257	207	0.00841	5.17E-05	0.725	0.242	0.558	1.25
1400	4115	0.03139	0.08189	0.00274	0.00000	0.00838	0.13634	0.00631	0.70708	0.00208	0.00990	0.01390	259	0.00826	5.22E-05	0.760	0.262	0.545	1.28
1600	4182	0.03462	0.07829	0.00338	0.00000	0.00935	0.13390	0.00701	0.70442	0.00259	0.01121	0.01522	311	0.00812	5.27E-05	0.795	0.284	0.532	1.31
1800	4248	0.03784	0.07468	0.00413	0.00001	0.01036	0.13132	0.00772	0.70165	0.00318	0.01259	0.01652	364	0.00798	5.32E-05	0.830	0.306	0.519	1.33
2000	4311	0.04104	0.07109	0.00498	0.00001	0.01140	0.12860	0.00845	0.69877	0.00386	0.01401	0.01780	418	0.00784	5.37E-05	0.865	0.330	0.507	1.36

**Table D.15a** C<sub>3</sub>H<sub>8</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

Fuel temp. (K)	Flame temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/ kg-K)	Equil. therm. cond. (W/ m-K)	Equil. Pr	Equil. Le
298	2266	0.01248	0.10269	0.00046	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-1.42E+02	0.151	7.20E-05	2.27	0.259	0.631	1.13
311	2267	0.01251	0.10266	0.00047	0.00332	0.14836	0.00246	0.72082	0.00031	0.00328	0.00582	-1.41E+02	0.151	7.20E-05	2.27	0.259	0.631	1.13
366	2270	0.01264	0.10251	0.00047	0.00335	0.14829	0.00248	0.72073	0.00032	0.00332	0.00588	-1.35E+02	0.151	7.20E-05	2.28	0.261	0.631	1.13
422	2273	0.01280	0.10233	0.00049	0.00339	0.14820	0.00251	0.72063	0.00032	0.00337	0.00596	-1.28E+02	0.150	7.21E-05	2.29	0.262	0.630	1.13
478	2276	0.01298	0.10214	0.00050	0.00344	0.14810	0.00255	0.72051	0.00033	0.00342	0.00603	-1.20E+02	0.150	7.22E-05	2.30	0.264	0.629	1.13
533	2280	0.01317	0.10193	0.00051	0.00348	0.14799	0.00259	0.72038	0.00034	0.00348	0.00612	-1.11E+02	0.150	7.22E-05	2.31	0.266	0.628	1.13
589	2284	0.01338	0.10170	0.00053	0.00354	0.14787	0.00263	0.72024	0.00035	0.00355	0.00621	-1.02E+02	0.150	7.23E-05	2.32	0.268	0.627	1.13
644	2288	0.01361	0.10146	0.00054	0.00359	0.14774	0.00267	0.72009	0.00037	0.00362	0.00631	-9.18E+01	0.149	7.24E-05	2.33	0.270	0.626	1.13
700	2293	0.01385	0.10119	0.00056	0.00365	0.14761	0.00272	0.71993	0.00038	0.00369	0.00642	-8.12E+01	0.149	7.25E-05	2.35	0.272	0.624	1.14
755	2297	0.01410	0.10091	0.00058	0.00372	0.14746	0.00277	0.71976	0.00039	0.00377	0.00653	-7.02E+01	0.149	7.26E-05	2.36	0.275	0.623	1.14
811	2302	0.01438	0.10062	0.00060	0.00379	0.14731	0.00282	0.71957	0.00041	0.00385	0.00665	-5.84E+01	0.148	7.27E-05	2.37	0.278	0.622	1.14

**Table D.15b** C<sub>3</sub>H<sub>8</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

Fuel temp. (°F)	Flame temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le
77	3620	0.01248	0.10269	0.00046	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-61	0.00942	4.84E-05	0.543	0.150	0.631	1.13
100	3621	0.01251	0.10266	0.00047	0.00332	0.14836	0.00246	0.72082	0.00031	0.00328	0.00582	-61	0.00942	4.84E-05	0.543	0.150	0.631	1.13
200	3626	0.01264	0.10251	0.00047	0.00335	0.14829	0.00248	0.72073	0.00032	0.00332	0.00588	-58	0.00941	4.84E-05	0.545	0.151	0.631	1.13
300	3631	0.01280	0.10233	0.00049	0.00339	0.14820	0.00251	0.72063	0.00032	0.00337	0.00596	-55	0.00939	4.85E-05	0.547	0.152	0.630	1.13
400	3637	0.01298	0.10214	0.00050	0.00344	0.14810	0.00255	0.72051	0.00033	0.00342	0.00603	-51	0.00938	4.85E-05	0.549	0.152	0.629	1.13
500	3644	0.01317	0.10193	0.00051	0.00348	0.14799	0.00259	0.72038	0.00034	0.00348	0.00612	-48	0.00936	4.86E-05	0.552	0.154	0.628	1.13
600	3652	0.01338	0.10170	0.00053	0.00354	0.14787	0.00263	0.72024	0.00035	0.00355	0.00621	-44	0.00934	4.86E-05	0.554	0.155	0.627	1.13
700	3659	0.01361	0.10146	0.00054	0.00359	0.14774	0.00267	0.72009	0.00037	0.00362	0.00631	-39	0.00932	4.87E-05	0.557	0.156	0.626	1.13
800	3667	0.01385	0.10119	0.00056	0.00365	0.14761	0.00272	0.71993	0.00038	0.00369	0.00642	-35	0.00930	4.88E-05	0.560	0.157	0.624	1.14
900	3676	0.01410	0.10091	0.00058	0.00372	0.14746	0.00277	0.71976	0.00039	0.00377	0.00653	-30	0.00928	4.88E-05	0.563	0.159	0.623	1.14
1000	3685	0.01438	0.10062	0.00060	0.00379	0.14731	0.00282	0.71957	0.00041	0.00385	0.00665	-25	0.00926	4.89E-05	0.567	0.160	0.622	1.14

**Table D.16a** C<sub>3</sub>H<sub>8</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

Flame temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le	Avail. heat (%)
366	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.87E+03	0.943	1.92E-05	1.10	0.027	0.772	1.00	89.6
478	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.74E+03	0.722	2.38E-05	1.13	0.035	0.764	1.00	85.5
589	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.61E+03	0.586	2.79E-05	1.16	0.043	0.760	1.00	81.3
700	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.48E+03	0.493	3.18E-05	1.20	0.051	0.756	1.00	76.9
811	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.35E+03	0.426	3.54E-05	1.24	0.058	0.752	1.00	72.5
922	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.21E+03	0.374	3.89E-05	1.27	0.066	0.748	1.00	67.9
1033	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-2.07E+03	0.334	4.22E-05	1.30	0.074	0.744	1.00	63.2
1144	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1.92E+03	0.302	4.53E-05	1.32	0.081	0.742	1.00	58.4
1255	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1.77E+03	0.275	4.83E-05	1.35	0.088	0.739	1.00	53.6
1366	0.00002	0.11622	0.00000	0.00001	0.15497	0.00000	0.72877	0.00000	0.00000	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	48.6
1478	0.00006	0.11617	0.00000	0.00003	0.15493	0.00002	0.72874	0.00000	0.00001	0.00004	-1.46E+03	0.234	5.40E-05	1.39	0.102	0.734	1.00	43.5
1589	0.00019	0.11603	0.00000	0.00009	0.15486	0.00004	0.72865	0.00000	0.00003	0.00011	-1.31E+03	0.217	5.67E-05	1.43	0.111	0.729	1.00	38.3
1700	0.00048	0.11571	0.00000	0.00019	0.15469	0.00011	0.72847	0.00000	0.00009	0.00026	-1.15E+03	0.203	5.94E-05	1.48	0.122	0.722	1.01	33.0
1811	0.00110	0.11505	0.00001	0.00038	0.15436	0.00023	0.72808	0.00000	0.00021	0.00057	-9.78E+02	0.190	6.20E-05	1.54	0.134	0.713	1.02	27.5
1922	0.00224	0.11381	0.00002	0.00071	0.15377	0.00046	0.72737	0.00001	0.00047	0.00113	-8.01E+02	0.179	6.45E-05	1.64	0.150	0.704	1.03	21.7
2033	0.00421	0.11167	0.00007	0.00123	0.15277	0.00084	0.72615	0.00004	0.00095	0.00206	-6.11E+02	0.169	6.69E-05	1.79	0.175	0.682	1.05	15.4
2144	0.00733	0.10829	0.00018	0.00203	0.15115	0.00145	0.72418	0.00011	0.00178	0.00350	-4.02E+02	0.160	6.93E-05	1.99	0.208	0.661	1.08	8.5
2266	0.01248	0.10269	0.00046	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-1.42E+02	0.151	7.20E-05	2.27	0.259	0.631	1.13	0.0



**Table D.16b** C<sub>3</sub>H<sub>8</sub> (Variable Temp.) Adiabatically and Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

Flame temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le	Avail. heat (%)
200	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1232	0.05888	1.29E-05	0.263	0.016	0.772	1.00	89.6
400	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1178	0.04508	1.60E-05	0.270	0.020	0.764	1.00	85.5
600	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1124	0.03659	1.88E-05	0.278	0.025	0.760	1.00	81.3
800	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1067	0.03078	2.14E-05	0.287	0.029	0.756	1.00	76.9
1000	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-1009	0.02657	2.38E-05	0.295	0.034	0.752	1.00	72.5
1200	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-949	0.02337	2.61E-05	0.303	0.038	0.748	1.00	67.9
1400	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-888	0.02086	2.83E-05	0.310	0.042	0.744	1.00	63.2
1600	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-825	0.01884	3.05E-05	0.316	0.047	0.742	1.00	58.4
1800	0.00000	0.11624	0.00000	0.00000	0.15498	0.00000	0.72878	0.00000	0.00000	0.00000	-761	0.01717	3.25E-05	0.322	0.051	0.739	1.00	53.6
2000	0.00002	0.11622	0.00000	0.00001	0.15497	0.00000	0.72877	0.00000	0.00000	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	48.6
2200	0.00006	0.11617	0.00000	0.00003	0.15493	0.00002	0.72874	0.00000	0.00001	0.00004	-630	0.01458	3.63E-05	0.332	0.059	0.734	1.00	43.5
2400	0.00019	0.11603	0.00000	0.00009	0.15486	0.00004	0.72865	0.00000	0.00003	0.00011	-562	0.01356	3.82E-05	0.341	0.064	0.729	1.00	38.3
2600	0.00048	0.11571	0.00000	0.00019	0.15469	0.00011	0.72847	0.00000	0.00009	0.00026	-493	0.01267	3.99E-05	0.353	0.070	0.722	1.01	33.0
2800	0.00110	0.11505	0.00001	0.00038	0.15436	0.00023	0.72808	0.00000	0.00021	0.00057	-420	0.01189	4.17E-05	0.369	0.077	0.713	1.02	27.5
3000	0.00224	0.11381	0.00002	0.00071	0.15377	0.00046	0.72737	0.00001	0.00047	0.00113	-345	0.01119	4.34E-05	0.392	0.087	0.704	1.03	21.7
3200	0.00421	0.11167	0.00007	0.00123	0.15277	0.00084	0.72615	0.00004	0.00095	0.00206	-263	0.01057	4.50E-05	0.427	0.101	0.682	1.05	15.4
3400	0.00733	0.10829	0.00018	0.00203	0.15115	0.00145	0.72418	0.00011	0.00178	0.00350	-173	0.01000	4.66E-05	0.474	0.120	0.661	1.08	8.5
3620	0.01248	0.10269	0.00046	0.00331	0.14838	0.00245	0.72084	0.00031	0.00327	0.00581	-61	0.00942	4.84E-05	0.543	0.150	0.631	1.13	0.0

**Table D.17a** C<sub>3</sub>H<sub>8</sub> (298 K) Adiabatically Combusted with Air (298 K) at Various Equivalence Ratios, Metric Units

Equiv. ratio	Flame temp. (K)	C(gr)	CH <sub>4</sub>	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NH <sub>3</sub>	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Equil. Le
4.00	1004	0.0701	0.00975	0.16583	0.01569	0.00000	0.30829	0.02061	0.00007	0.00000	0.40966	0.00000	0.00000	0.00000	-4.82E+02	0.245	4.06E-05	4.18	0.269	0.631	0.82
2.00	1633	0.0000	0.00000	0.15310	0.02977	0.00003	0.15167	0.09215	0.00000	0.00000	0.57329	0.00000	0.00000	0.00000	-2.68E+02	0.176	5.72E-05	1.59	0.148	0.613	1.00
1.33	2098	0.0000	0.00000	0.07936	0.06268	0.00060	0.03881	0.15013	0.00000	0.00005	0.66807	0.00000	0.00028	0.00001	-1.86E+02	0.154	6.81E-05	1.58	0.169	0.635	1.08
1.00	2266	0.0000	0.00000	0.01248	0.10269	0.00046	0.00331	0.14838	0.00000	0.00245	0.72084	0.00031	0.00327	0.00581	-1.42E+02	0.151	7.20E-05	2.27	0.259	0.631	1.13
0.80	2042	0.0000	0.00000	0.00089	0.09346	0.00003	0.00025	0.12460	0.00000	0.00371	0.73755	0.00018	0.00185	0.03748	-1.15E+02	0.169	6.74E-05	1.60	0.154	0.697	1.03
0.67	1821	0.0000	0.00000	0.00008	0.07949	0.00000	0.00003	0.10575	0.00000	0.00258	0.74663	0.00004	0.00061	0.06479	-9.68E+01	0.191	6.26E-05	1.44	0.125	0.720	1.01
0.57	1646	0.0000	0.00000	0.00001	0.06864	0.00000	0.00000	0.09143	0.00000	0.00157	0.75302	0.00001	0.00019	0.08513	-8.33E+01	0.211	5.87E-05	1.37	0.110	0.727	1.00
0.50	1508	0.0000	0.00000	0.00000	0.06046	0.00000	0.00000	0.08058	0.00000	0.00093	0.75768	0.00000	0.00006	0.10028	-7.33E+01	0.231	5.55E-05	1.32	0.101	0.729	1.00

**Table D.17b** C<sub>3</sub>H<sub>8</sub> (77°F) Combusted with Air (77°F) at Various Equivalence Ratios, English Units

Equiv. ratio	Flame temp. (°F)	C(gr)	CH <sub>4</sub>	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NH <sub>3</sub>	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond.		
																			Pr	Le	
4.00	1348	0.0701	0.00975	0.16583	0.01569	0.00000	0.30829	0.02061	0.00007	0.00000	0.40966	0.00000	0.00000	0.00000	-207	0.01532	2.73E-05	0.997	0.155	0.631	0.82
2.00	2479	0.0000	0.00000	0.15310	0.02977	0.00003	0.15167	0.09215	0.00000	0.00000	0.57329	0.00000	0.00000	0.00000	-115	0.01101	3.84E-05	0.379	0.086	0.613	1.00
1.33	3317	0.0000	0.00000	0.07936	0.06268	0.00060	0.03881	0.15013	0.00000	0.00005	0.66807	0.00000	0.00028	0.00001	-80	0.00960	4.58E-05	0.377	0.098	0.635	1.08
1.00	3620	0.0000	0.00000	0.01248	0.10269	0.00046	0.00331	0.14838	0.00000	0.00245	0.72084	0.00031	0.00327	0.00581	-61	0.00942	4.84E-05	0.543	0.150	0.631	1.13
0.80	3215	0.0000	0.00000	0.00089	0.09346	0.00003	0.00025	0.12460	0.00000	0.00371	0.73755	0.00018	0.00185	0.03748	-49	0.01058	4.53E-05	0.382	0.089	0.697	1.03
0.67	2818	0.0000	0.00000	0.00008	0.07949	0.00000	0.00003	0.10575	0.00000	0.00258	0.74663	0.00004	0.00061	0.06479	-42	0.01190	4.21E-05	0.343	0.072	0.720	1.01
0.57	2502	0.0000	0.00000	0.00001	0.06864	0.00000	0.00000	0.09143	0.00000	0.00157	0.75302	0.00001	0.00019	0.08513	-36	0.01319	3.95E-05	0.327	0.064	0.727	1.00
0.50	2254	0.0000	0.00000	0.00000	0.06046	0.00000	0.00000	0.08058	0.00000	0.00093	0.75768	0.00000	0.00006	0.10028	-32	0.01442	3.73E-05	0.316	0.058	0.729	1.00

**Table D.18a** C<sub>3</sub>H<sub>8</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.) with an Exhaust Temp. of 1367 K, Metric Units

Oxid. temp. (K)	CO	CO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	N <sub>2</sub>	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le	Avail. heat (%)
298	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	48.6
366	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	50.7
478	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	54.2
589	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	57.8
700	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	61.5
811	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	65.2
922	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	69.1
1033	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	73.0
1144	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	77.0
1255	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	81.1
1366	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-1.62E+03	0.253	5.12E-05	1.37	0.095	0.737	1.00	85.2

**Table D.18b** C<sub>3</sub>H<sub>8</sub> (77°F) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (Variable Temp.) with an Exhaust Temp. of 2000°F, English Units

Oxid. temp. (°F)	CO	CO <sub>2</sub>	H <sub>2</sub>	H <sub>2</sub> O (g)	N <sub>2</sub>	O <sub>2</sub>	Enthalpy, <i>H</i> (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le	Avail. heat (%)
77	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	48.6
200	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	50.7
400	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	54.2
600	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	57.8
800	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	61.5
1000	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	65.2
1200	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	69.1
1400	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	73.0
1600	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	77.0
1800	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	81.1
2000	0.00002	0.11622	0.00001	0.15497	0.72877	0.00001	-696	0.01577	3.44E-05	0.327	0.055	0.737	1.00	85.2

**Table D.19a**  $\text{H}_2 + \text{CH}_4$  (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (298 K), Metric Units

$\text{H}_2$	$\text{CH}_4$	Exhaust temp. (K)	CO	$\text{CO}_2$	H	$\text{H}_2$	$\text{H}_2\text{O}$ (g)	NO	$\text{N}_2$	O	OH	$\text{O}_2$	Enthalpy, $H$ (kJ/kg)	Density ( $\text{kg}/\text{m}^3$ )	Viscosity ( $\text{kg}/\text{m}\cdot\text{sec}$ )	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le
0.0	1.0	2225	0.00893	0.08539	0.00039	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-2.58E+02	0.150	7.12E-05	2.19	0.248	0.630	1.12
0.1	0.9	2230	0.00888	0.08265	0.00041	0.00378	0.18773	0.00199	0.70676	0.00022	0.00300	0.00458	-2.51E+02	0.149	7.14E-05	2.21	0.251	0.627	1.13
0.2	0.8	2235	0.00881	0.07945	0.00043	0.00400	0.19281	0.00202	0.70453	0.00023	0.00311	0.00461	-2.43E+02	0.148	7.15E-05	2.22	0.255	0.624	1.13
0.3	0.7	2241	0.00872	0.07567	0.00046	0.00427	0.19881	0.00205	0.70189	0.00024	0.00325	0.00465	-2.33E+02	0.147	7.17E-05	2.24	0.259	0.620	1.14
0.4	0.6	2249	0.00858	0.07114	0.00050	0.00461	0.20602	0.00209	0.69871	0.00025	0.00341	0.00469	-2.22E+02	0.146	7.19E-05	2.27	0.265	0.616	1.14
0.5	0.5	2258	0.00837	0.06562	0.00055	0.00505	0.21483	0.00214	0.69480	0.00027	0.00362	0.00474	-2.07E+02	0.144	7.21E-05	2.30	0.272	0.610	1.15
0.6	0.4	2270	0.00805	0.05875	0.00062	0.00567	0.22585	0.00219	0.68990	0.00029	0.00390	0.00479	-1.89E+02	0.142	7.24E-05	2.34	0.281	0.603	1.16
0.7	0.3	2285	0.00751	0.04997	0.00072	0.00655	0.24001	0.00227	0.68354	0.00032	0.00427	0.00485	-1.64E+02	0.140	7.28E-05	2.39	0.293	0.593	1.18
0.8	0.2	2306	0.00654	0.03839	0.00088	0.00792	0.25886	0.00236	0.67500	0.00036	0.00479	0.00489	-1.31E+02	0.136	7.33E-05	2.45	0.310	0.580	1.20
0.9	0.1	2336	0.00461	0.02255	0.00117	0.01030	0.28507	0.00249	0.66289	0.00042	0.00560	0.00489	-8.08E+01	0.131	7.41E-05	2.55	0.337	0.562	1.23
1.0	0.0	2382	0.00000	0.00000	0.00179	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	2.09E-04	0.124	7.53E-05	2.72	0.383	0.536	1.28

**Table D.19b** H<sub>2</sub> + CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (77°F), English Units

H <sub>2</sub>	CH <sub>4</sub>	Product temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le
0.0	1.0	3545	0.00893	0.08539	0.00039	0.00361	0.18338	0.00197	0.70866	0.00021	0.00291	0.00455	-111	0.00938	4.79E-05	0.524	0.143	0.630	1.12
0.1	0.9	3554	0.00888	0.08265	0.00041	0.00378	0.18773	0.00199	0.70676	0.00022	0.00300	0.00458	-108	0.00933	4.80E-05	0.527	0.145	0.627	1.13
0.2	0.8	3563	0.00881	0.07945	0.00043	0.00400	0.19281	0.00202	0.70453	0.00023	0.00311	0.00461	-104	0.00927	4.81E-05	0.531	0.147	0.624	1.13
0.3	0.7	3574	0.00872	0.07567	0.00046	0.00427	0.19881	0.00205	0.70189	0.00024	0.00325	0.00465	-100	0.00920	4.82E-05	0.536	0.150	0.620	1.14
0.4	0.6	3588	0.00858	0.07114	0.00050	0.00461	0.20602	0.00209	0.69871	0.00025	0.00341	0.00469	-95	0.00911	4.83E-05	0.542	0.153	0.616	1.14
0.5	0.5	3605	0.00837	0.06562	0.00055	0.00505	0.21483	0.00214	0.69480	0.00027	0.00362	0.00474	-89	0.00901	4.85E-05	0.549	0.157	0.610	1.15
0.6	0.4	3626	0.00805	0.05875	0.00062	0.00567	0.22585	0.00219	0.68990	0.00029	0.00390	0.00479	-81	0.00888	4.87E-05	0.558	0.162	0.603	1.16
0.7	0.3	3654	0.00751	0.04997	0.00072	0.00655	0.24001	0.00227	0.68354	0.00032	0.00427	0.00485	-71	0.00872	4.90E-05	0.570	0.169	0.593	1.18
0.8	0.2	3691	0.00654	0.03839	0.00088	0.00792	0.25886	0.00236	0.67500	0.00036	0.00479	0.00489	-56	0.00850	4.93E-05	0.586	0.179	0.580	1.20
0.9	0.1	3744	0.00461	0.02255	0.00117	0.01030	0.28507	0.00249	0.66289	0.00042	0.00560	0.00489	-35	0.00820	4.98E-05	0.610	0.195	0.562	1.23
1.0	0.0	3827	0.00000	0.00000	0.00179	0.01526	0.32366	0.00264	0.64440	0.00054	0.00696	0.00475	0	0.00775	5.06E-05	0.650	0.221	0.536	1.28

**Table D.20a** H<sub>2</sub> + CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (533 K), Metric Units

H <sub>2</sub>	CH <sub>4</sub>	Exhaust temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, <i>H</i> (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Equil. Le
0.0	1.0	2323	0.01319	0.08077	0.00078	0.00523	0.18001	0.00290	0.70550	0.00046	0.00458	0.00658	-3.02E+01	0.143	7.33E-05	2.46	0.299	0.601	1.17
0.1	0.9	2327	0.01306	0.07812	0.00082	0.00547	0.18425	0.00292	0.70359	0.00047	0.00471	0.00659	-2.32E+01	0.143	7.34E-05	2.47	0.303	0.599	1.17
0.2	0.8	2332	0.01289	0.07503	0.00086	0.00576	0.18921	0.00295	0.70136	0.00048	0.00485	0.00661	-1.50E+01	0.142	7.35E-05	2.49	0.308	0.595	1.18
0.3	0.7	2337	0.01268	0.07138	0.00091	0.00612	0.19506	0.00298	0.69872	0.00050	0.00503	0.00663	-5.26E+00	0.141	7.37E-05	2.51	0.313	0.591	1.19
0.4	0.6	2344	0.01238	0.06703	0.00098	0.00657	0.20208	0.00302	0.69554	0.00052	0.00525	0.00664	6.66E+00	0.140	7.39E-05	2.54	0.320	0.586	1.19
0.5	0.5	2352	0.01198	0.06172	0.00106	0.00716	0.21066	0.00306	0.69164	0.00054	0.00552	0.00665	2.15E+01	0.138	7.41E-05	2.57	0.328	0.580	1.20
0.6	0.4	2363	0.01139	0.05514	0.00118	0.00797	0.22137	0.00311	0.68673	0.00057	0.00587	0.00666	4.04E+01	0.136	7.44E-05	2.61	0.339	0.572	1.22
0.7	0.3	2377	0.01048	0.04677	0.00135	0.00912	0.23511	0.00318	0.68039	0.00062	0.00634	0.00665	6.54E+01	0.134	7.47E-05	2.66	0.354	0.562	1.23
0.8	0.2	2395	0.00897	0.03579	0.00161	0.01088	0.25335	0.00326	0.67185	0.00068	0.00700	0.00660	1.00E+02	0.131	7.52E-05	2.73	0.375	0.549	1.26
0.9	0.1	2422	0.00616	0.02089	0.00206	0.01389	0.27863	0.00336	0.65976	0.00078	0.00799	0.00647	1.51E+02	0.126	7.59E-05	2.84	0.406	0.531	1.29
1.0	0.0	2463	0.00000	0.00000	0.00299	0.01997	0.31560	0.00348	0.64130	0.00094	0.00960	0.00612	2.34E+02	0.120	7.70E-05	3.03	0.461	0.507	1.34



**Table D.20b** H<sub>2</sub> + CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (500°F), English Units

H <sub>2</sub>	CH <sub>4</sub>	Exhaust temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le
0.0	1.0	3722	0.01319	0.08077	0.00078	0.00523	0.18001	0.00290	0.70550	0.00046	0.00458	0.00658	-13	0.00895	4.93E-05	0.587	0.173	0.601	1.17
0.1	0.9	3729	0.01306	0.07812	0.00082	0.00547	0.18425	0.00292	0.70359	0.00047	0.00471	0.00659	-10	0.00890	4.94E-05	0.590	0.175	0.599	1.17
0.2	0.8	3737	0.01289	0.07503	0.00086	0.00576	0.18921	0.00295	0.70136	0.00048	0.00485	0.00661	-6	0.00885	4.95E-05	0.594	0.178	0.595	1.18
0.3	0.7	3747	0.01268	0.07138	0.00091	0.00612	0.19506	0.00298	0.69872	0.00050	0.00503	0.00663	-2	0.00879	4.96E-05	0.599	0.181	0.591	1.19
0.4	0.6	3760	0.01238	0.06703	0.00098	0.00657	0.20208	0.00302	0.69554	0.00052	0.00525	0.00664	3	0.00871	4.97E-05	0.605	0.185	0.586	1.19
0.5	0.5	3774	0.01198	0.06172	0.00106	0.00716	0.21066	0.00306	0.69164	0.00054	0.00552	0.00665	9	0.00862	4.98E-05	0.613	0.190	0.580	1.20
0.6	0.4	3793	0.01139	0.05514	0.00118	0.00797	0.22137	0.00311	0.68673	0.00057	0.00587	0.00666	17	0.00850	5.00E-05	0.623	0.196	0.572	1.22
0.7	0.3	3818	0.01048	0.04677	0.00135	0.00912	0.23511	0.00318	0.68039	0.00062	0.00634	0.00665	28	0.00835	5.03E-05	0.635	0.204	0.562	1.23
0.8	0.2	3851	0.00897	0.03579	0.00161	0.01088	0.25335	0.00326	0.67185	0.00068	0.00700	0.00660	43	0.00816	5.06E-05	0.653	0.216	0.549	1.26
0.9	0.1	3899	0.00616	0.02089	0.00206	0.01389	0.27863	0.00336	0.65976	0.00078	0.00799	0.00647	65	0.00788	5.11E-05	0.679	0.235	0.531	1.29
1.0	0.0	3974	0.00000	0.00000	0.00299	0.01997	0.31560	0.00348	0.64130	0.00094	0.00960	0.00612	101	0.00747	5.18E-05	0.724	0.267	0.507	1.34

**Table D.21a** H<sub>2</sub> + CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (811 K), Metric Units

H <sub>2</sub>	CH <sub>4</sub>	Exhaust temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le
0.0	1.0	2431	0.01913	0.07429	0.00159	0.00759	0.17489	0.00424	0.70078	0.00098	0.00715	0.00936	2.52E+02	0.136	7.56E-05	2.80	0.374	0.566	1.23
0.1	0.9	2434	0.01887	0.07179	0.00165	0.00791	0.17898	0.00426	0.69888	0.00100	0.00731	0.00934	2.59E+02	0.136	7.57E-05	2.82	0.379	0.563	1.24
0.2	0.8	2438	0.01854	0.06888	0.00172	0.00830	0.18376	0.00428	0.69666	0.00102	0.00751	0.00932	2.68E+02	0.135	7.58E-05	2.84	0.384	0.559	1.24
0.3	0.7	2443	0.01812	0.06545	0.00181	0.00878	0.18941	0.00430	0.69403	0.00104	0.00774	0.00930	2.78E+02	0.134	7.59E-05	2.86	0.391	0.555	1.25
0.4	0.6	2449	0.01759	0.06137	0.00192	0.00939	0.19618	0.00433	0.69087	0.00107	0.00802	0.00926	2.90E+02	0.133	7.61E-05	2.89	0.399	0.550	1.26
0.5	0.5	2456	0.01687	0.05641	0.00207	0.01018	0.20443	0.00436	0.68698	0.00111	0.00837	0.00921	3.06E+02	0.131	7.63E-05	2.92	0.410	0.544	1.27
0.6	0.4	2465	0.01587	0.05028	0.00227	0.01124	0.21473	0.00440	0.68210	0.00116	0.00882	0.00914	3.25E+02	0.130	7.65E-05	2.96	0.423	0.536	1.29
0.7	0.3	2477	0.01441	0.04251	0.00255	0.01274	0.22792	0.00444	0.67579	0.00122	0.00941	0.00902	3.51E+02	0.128	7.68E-05	3.02	0.441	0.526	1.30
0.8	0.2	2493	0.01210	0.03239	0.00297	0.01501	0.24537	0.00450	0.66729	0.00131	0.01022	0.00883	3.86E+02	0.125	7.73E-05	3.10	0.467	0.513	1.33
0.9	0.1	2517	0.00809	0.01880	0.00368	0.01879	0.26946	0.00455	0.65526	0.00144	0.01141	0.00851	4.39E+02	0.121	7.79E-05	3.23	0.506	0.497	1.36
1.0	0.0	2553	0.00000	0.00000	0.00507	0.02615	0.30448	0.00460	0.63687	0.00165	0.01328	0.00790	5.24E+02	0.115	7.89E-05	3.45	0.573	0.476	1.41

**Table D.21b** H<sub>2</sub> + CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (1000°F), English Units

H <sub>2</sub>	CH <sub>4</sub>	Exhaust temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Le
0.0	1.0	3915	0.01913	0.07429	0.00159	0.00759	0.17489	0.00424	0.70078	0.00098	0.00715	0.00936	108	0.00850	5.08E-05	0.670	0.216	0.566	1.23
0.1	0.9	3922	0.01887	0.07179	0.00165	0.00791	0.17898	0.00426	0.69888	0.00100	0.00731	0.00934	112	0.00846	5.09E-05	0.674	0.219	0.563	1.24
0.2	0.8	3929	0.01854	0.06888	0.00172	0.00830	0.18376	0.00428	0.69666	0.00102	0.00751	0.00932	115	0.00841	5.10E-05	0.678	0.222	0.559	1.24
0.3	0.7	3938	0.01812	0.06545	0.00181	0.00878	0.18941	0.00430	0.69403	0.00104	0.00774	0.00930	120	0.00836	5.10E-05	0.683	0.226	0.555	1.25
0.4	0.6	3948	0.01759	0.06137	0.00192	0.00939	0.19618	0.00433	0.69087	0.00107	0.00802	0.00926	125	0.00829	5.11E-05	0.690	0.231	0.550	1.26
0.5	0.5	3961	0.01687	0.05641	0.00207	0.01018	0.20443	0.00436	0.68698	0.00111	0.00837	0.00921	131	0.00821	5.13E-05	0.698	0.237	0.544	1.27
0.6	0.4	3978	0.01587	0.05028	0.00227	0.01124	0.21473	0.00440	0.68210	0.00116	0.00882	0.00914	140	0.00810	5.15E-05	0.708	0.245	0.536	1.29
0.7	0.3	3999	0.01441	0.04251	0.00255	0.01274	0.22792	0.00444	0.67579	0.00122	0.00941	0.00902	151	0.00797	5.17E-05	0.722	0.255	0.526	1.30
0.8	0.2	4028	0.01210	0.03239	0.00297	0.01501	0.24537	0.00450	0.66729	0.00131	0.01022	0.00883	166	0.00779	5.20E-05	0.741	0.270	0.513	1.33
0.9	0.1	4070	0.00809	0.01880	0.00368	0.01879	0.26946	0.00455	0.65526	0.00144	0.01141	0.00851	189	0.00754	5.24E-05	0.771	0.293	0.497	1.36
1.0	0.0	4135	0.00000	0.00000	0.00507	0.02615	0.30448	0.00460	0.63687	0.00165	0.01328	0.00790	225	0.00716	5.30E-05	0.825	0.331	0.476	1.41

**Table D.22a**  $H_2 + CH_4$  (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (1089 K), Metric Units

$H_2$	$CH_4$	Exhaust temp. (K)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, $H$ (kJ/kg)	Density (kg/m <sup>3</sup> )	Viscosity (kg/m-sec)	Equil. spec. heat (kJ/kg-K)	Equil. therm. cond. (W/m-K)	Equil. Pr	Le
0.0	1.0	2531	0.02572	0.06705	0.00291	0.01041	0.16849	0.00579	0.69505	0.00186	0.01034	0.01238	5.51E+02	0.130	7.76E-05	3.18	0.465	0.531	1.30
0.1	0.9	2534	0.02528	0.06474	0.00301	0.01083	0.17242	0.00580	0.69317	0.00188	0.01054	0.01233	5.59E+02	0.129	7.77E-05	3.20	0.470	0.528	1.31
0.2	0.8	2537	0.02474	0.06206	0.00312	0.01134	0.17701	0.00581	0.69097	0.00191	0.01078	0.01226	5.67E+02	0.129	7.78E-05	3.22	0.477	0.524	1.31
0.3	0.7	2541	0.02408	0.05891	0.00327	0.01196	0.18241	0.00582	0.68836	0.00194	0.01107	0.01218	5.78E+02	0.128	7.79E-05	3.24	0.486	0.520	1.32
0.4	0.6	2546	0.02323	0.05516	0.00344	0.01273	0.18889	0.00583	0.68522	0.00198	0.01141	0.01208	5.90E+02	0.127	7.81E-05	3.27	0.496	0.515	1.33
0.5	0.5	2553	0.02213	0.05063	0.00367	0.01373	0.19679	0.00585	0.68137	0.00203	0.01184	0.01195	6.06E+02	0.126	7.82E-05	3.31	0.509	0.509	1.34
0.6	0.4	2561	0.02065	0.04503	0.00398	0.01507	0.20663	0.00586	0.67653	0.00209	0.01237	0.01178	6.26E+02	0.124	7.85E-05	3.36	0.525	0.501	1.36
0.7	0.3	2571	0.01853	0.03798	0.00441	0.01694	0.21920	0.00587	0.67027	0.00217	0.01308	0.01154	6.53E+02	0.122	7.88E-05	3.42	0.547	0.492	1.38
0.8	0.2	2585	0.01533	0.02885	0.00504	0.01973	0.23581	0.00588	0.66185	0.00228	0.01403	0.01119	6.90E+02	0.119	7.92E-05	3.52	0.579	0.481	1.40
0.9	0.1	2605	0.01002	0.01668	0.00607	0.02429	0.25866	0.00588	0.64990	0.00245	0.01538	0.01066	7.44E+02	0.116	7.97E-05	3.66	0.626	0.467	1.43
1.0	0.0	2636	0.00000	0.00000	0.00799	0.03281	0.29182	0.00583	0.63163	0.00269	0.01746	0.00977	8.32E+02	0.110	8.06E-05	3.93	0.704	0.450	1.47

**Table D.22b** H<sub>2</sub> + CH<sub>4</sub> (298 K) Stoichiometrically ( $\phi = 1.00$ ) Combusted with Air (1500°F), English Units

H <sub>2</sub>	CH <sub>4</sub>	Exhaust temp. (°F)	CO	CO <sub>2</sub>	H	H <sub>2</sub>	H <sub>2</sub> O (g)	NO	N <sub>2</sub>	O	OH	O <sub>2</sub>	Enthalpy, H (Btu/lb)	Density (lb/ft <sup>3</sup> )	Viscosity (lbm/ft-hr)	Equil. spec. heat (Btu/lb-°F)	Equil. therm. cond. (Btu/ft-hr-°F)	Equil. Pr	Equil. Le
0.0	1.0	4095	0.02572	0.06705	0.00291	0.01041	0.16849	0.00579	0.69505	0.00186	0.01034	0.01238	237	0.00811	5.22E-05	0.759	0.268	0.531	1.30
0.1	0.9	4101	0.02528	0.06474	0.00301	0.01083	0.17242	0.00580	0.69317	0.00188	0.01054	0.01233	240	0.00807	5.23E-05	0.763	0.272	0.528	1.31
0.2	0.8	4107	0.02474	0.06206	0.00312	0.01134	0.17701	0.00581	0.69097	0.00191	0.01078	0.01226	244	0.00803	5.23E-05	0.768	0.276	0.524	1.31
0.3	0.7	4114	0.02408	0.05891	0.00327	0.01196	0.18241	0.00582	0.68836	0.00194	0.01107	0.01218	248	0.00798	5.24E-05	0.774	0.281	0.520	1.32
0.4	0.6	4124	0.02323	0.05516	0.00344	0.01273	0.18889	0.00583	0.68522	0.00198	0.01141	0.01208	254	0.00792	5.25E-05	0.781	0.286	0.515	1.33
0.5	0.5	4135	0.02213	0.05063	0.00367	0.01373	0.19679	0.00585	0.68137	0.00203	0.01184	0.01195	261	0.00784	5.26E-05	0.790	0.294	0.509	1.34
0.6	0.4	4149	0.02065	0.04503	0.00398	0.01507	0.20663	0.00586	0.67653	0.00209	0.01237	0.01178	269	0.00775	5.28E-05	0.802	0.303	0.501	1.36
0.7	0.3	4168	0.01853	0.03798	0.00441	0.01694	0.21920	0.00587	0.67027	0.00217	0.01308	0.01154	281	0.00762	5.30E-05	0.817	0.316	0.492	1.38
0.8	0.2	4193	0.01533	0.02885	0.00504	0.01973	0.23581	0.00588	0.66185	0.00228	0.01403	0.01119	296	0.00746	5.32E-05	0.840	0.334	0.481	1.40
0.9	0.1	4230	0.01002	0.01668	0.00607	0.02429	0.25866	0.00588	0.64990	0.00245	0.01538	0.01066	320	0.00723	5.36E-05	0.875	0.362	0.467	1.43
1.0	0.0	4285	0.00000	0.00000	0.00799	0.03281	0.29182	0.00583	0.63163	0.00269	0.01746	0.00977	358	0.00688	5.42E-05	0.939	0.407	0.450	1.47