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APPENDIX F

Physical Properties of Various Organic and Inorganic Substances

General Sources of Data for Tables on the Physical Properties, Heat Capacities, and Thermodynamic Properties in Appendices D, F, and G

1. Kobe, Kenneth A., and Associates. "Thermochemistry of Petrochemicals," reprint from *Petroleum Refiner*, Gulf Publishing, Houston, TX (January, 1949–July, 1958) (enthalpy tables F.2–F.7 and heat capacities of several gases in Table G.1, Appendix G).
2. Lange, N. A. *Handbook of Chemistry*, 12th ed., McGraw-Hill, New York (1979).
3. Maxwell, J. B. *Data Book on Hydrocarbons*, Van Nostrand Reinhold, New York (1950).
4. Perry, J. H., and C. H. Chilton (eds.). *Chemical Engineers' Handbook*, 5th ed., McGraw-Hill, New York (1973).
5. Rossini, Frederick D., et al. "Selected Values of Chemical Thermodynamic Properties," *National Bureau of Standards Circular 500*, U.S. Government Printing Office, Washington, DC (1952).
6. Rossini, Frederick D., et al. "Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds," American Petroleum Institute Research Project 44 (1953 and subsequent years).
7. Weast, Robert C. *Handbook of Chemistry and Physics*, 59th ed., CRC Press, Boca Raton, FL (1979).

Table F.1 Physical Properties of Various Organic and Inorganic Substances* (additional compounds can be found elsewhere on the CD, provided by Professor Carl L. Yaws)

To convert to kcal/g mol, multiply by 0.2390; to Btu/lb mol, multiply by 430.2.

Compound	Formula	Formula Wt.	Sp. Gr.	Melting Temp. (K)	$\Delta\hat{H}$ Fusion (kJ/g mol)	Normal b.p. (K)	$\Delta\hat{H}$Vap. at b.p. (kJ/g mol)	T_c (K)	p_c (atm)	$\hat{V}_c$ (cm^3/g mol)	z_c
Acetaldehyde	C_2H_4O	44.05	$0.783^{18°/4°}$	149.5		293.2		461.0			
Acetic acid	CH_3CHO_2	60.05	1.049	289.9	12.09	390.4	24.4	594.8	57.1	171	0.200
Acetone	C_3H_6O	58.08	0.791	178.2	5.69	329.2	30.2	508.0	47.0	213	0.238
Acetylene	C_2H_2	26.04	0.9061(A)	191.7	3.7	191.7	17.5	309.5	61.6	113	0.274
Air			1.00					132.5	37.2		
Ammonia	NH_3	17.03	$0.817^{-79°}$ 0.597(A)	195.40	5.653	239.73	23.35	405.5	111.3	72.5	0.243
Ammonium carbonate	$(NH_4)_2CO_3{\cdot}H_2O$	114.11			(decomposes at 331 K)						
Ammonium chloride	NH_4CL	53.50	$2.53^{17°}$		(decomposes at 623 K)						
Ammonium nitrate	NH_4NO_3	80.05	$1.725^{25°}$	442.8	5.4		(decomposes at 483.2 K)				
Ammonium sulfate	$(NH_4)_2SO_4$	132.14	1.769	786		(decomposes at 786 K after melting)					
Aniline	C_6H_7N	93.12	1.022	266.9		457.4		699	52.4		
Benzaldehyde	C_6H_5CHO	106.12	1.046	247.16		452.16	38.40				
Benzene	C_6H_6	78.11	0.879	278.693	9.837	353.26	30.76	562.6	48.6	260	0.274
Benzoic acid	$C_7H_6O_2$	122.12	$1.316^{28°/4°}$	395.4		523.0					
Benzyl alcohol	C_7H_8O	108.13	1.045	257.8		478.4					
Boron oxide	B_2O_3	69.64	1.85	723	22.0						
Bromine	Br_2	159.83	$3.119^{20°}$ 5.87(A)	265.8	10.8	331.78	31.0	584	102	144	0.306
1, 2-Butadiene	C_4H_6	54.09	$0.652^{20°}$	136.7		283.3		446			
1, 3-Butadiene	C_4H_6	54.09	0.621	164.1		268.6		425	42.7	221	0.271
Butane	n-C_4H_{10}	58.12	0.579	134.83	4.661	272.66	22.31	425.17	37.47	255	0.374
iso-Butane	iso-C_4H_{10}	58.12	0.557	113.56	4.540	261.43	21.29	408.1	36.0	263	0.283

1-Butene	C_4H_8	56.10	0.60	87.81	3.848	266.91	21.92	419.6	39.7	240	0.277
Butyl phthalate	*see* Dibutyl phthalate										
n-Butyric acid	*n*-$C_4H_8O_2$	88.10	0.958	267		437.1		628	52.0	290	0.293
iso-Butyric acid	iso-$C_4H_8O_2$	88.10	0.949	226		427.7		609			
Calcium arsenate	$Ca_3(AsO_4)_2$	398.06		1723							
Calcium carbide	Ca_2C_2	64.10	$2.22^{18°}$	2573							
Calcium carbonate	$CaCO_3$	100.09	2.93	(decomposes at 1098 K)							
Calcium chloride	$CaCl_2$	110.99	$2.152^{15°}$	1055	28.4						
	$CaCl_2 \cdot H_2O$	129.01									
	$CaCl_2 \cdot 2H_2O$	147.03									
	$CaCl_2 \cdot 6H_2O$	219.09	$1.78^{17°}$	303.4	37.3	(–6H_2O at 473 K)					
Calcium cyanamide	$CaCN_2$	80.11	2.29								
Calcium cyanide	$Ca(CN)_2$	92.12									
Calcium hydroxide	$Ca(OH)_2$	74.10	2.24	(–H_2O at 853 K)							
Calcium oxide	CaO	56.08	2.62	2873	50	3123					
Calcium phosphate	$Ca_3(PO_4)_2$	310.19	3.14	1943							
Calcium silicate	$CaSiO_3$	117.17	2.915	1803	48.62						
Calcium sulfate (gypsum)	$CaSO_4 \cdot 2H_2O$	172.18	2.32	(–1 $\frac{1}{2}$ H_2O at 301° K)							
Carbon	C	12.010	2.26	3873	46.0	4473					
Carbon dioxide	CO_2	44.01	1.53(A) 1.229 satd. liq. at 5162 kPa	$217.0^{5.2atm}$	8.32	(sublimes at 195 K)		304.2	72.9	94	0.275

(Continues)

Table F.1 Physical Properties of Various Organic and Inorganic Substances* *(Continued)*

Compound	Formula	Formula Wt.	Sp. Gr.	Melting Temp. (K)	$\Delta\hat{H}$ Fusion (kJ/g mol)	Normal b.p. (K)	$\Delta\hat{H}$ Vap. at b.p. (kJ/g mol)	T_c (K)	p_c (atm)	$\hat{V}_c$ (cm^3/g mol)	z_c
Carbon disulfide	CS_2	76.14	$1.261^{22°/20°}$ 2.63(A)	161.1	4.39	319.41	26.8	552.0	78.0	170	0.293
Carbon monoxide	CO	28.01	0.968(A)	68.10	0.837	81.66	6.042	133.0	34.5	93	0.294
Carbon tetrachloride	CCl_4	153.84	1.595	250.3	2.5	349.9	30.0	556.4	45.0	276	0.272
Chlorine	Cl_2	70.91	2.49(A)	172.16	6.406	239.10	20.41	417.0	76.1	124	0.276
Chlorobenzene	C_6H_5Cl	112.56	1.107	228		405.26	36.5	632.4	44.6	308	0.265
Chloroform	$CHCl_3$	119.39	$1.489^{20°}$	209.5		334.2		536.0	54.0	240	0.294
Chromium	Cr	52.01	7.1								
Copper	Cu	63.54	8.92	1356.2	13.0	2855	305				
Cumene	C_9H_{12}	120.19	0.862	177.125	7.1	425.56	37.5	636	31.0	440	0.260
Cupric sulfate	$CuSO_4$	159.61	$3.605^{15°}$	(decomposes at 873 K)							
Cyclohexane	C_6H_{12}	84.16	0.779	279.83	2.677	353.90	30.1	553.7	40.4	308	0.274
Cyclopentane	C_5H_{10}	70.13	0.745	179.71	0.6088	322.42	27.30	511.8	44.55	260	0.27
Decane	$C_{10}H_{22}$	142.28	$0.730^{20°}$	243.3		447.0		619.0	20.8	602	0.2476
Dibutyl phthalate	$C_8H_{22}O_4$	278.34	$1.045^{21°}$			613					
Diethyl ether	$(C_2H_5)_2O$	74.12	$0.708^{25°}$	156.86	7.301	307.76	26.05	467	35.6	281	0.261
Ethane	C_2H_6	30.07	1.049(A)	89.89	2.860	184.53	14.72	305.4	48.2	148	0.285
Ethanol	C_2H_6O	46.07	0.789	158.6	5.021	351.7	38.6	516.3	63.0	167	0.248
Ethyl acetate	$C_4H_8O_2$	88.10	0.901	189.4		350.2		523.1	37.8	286	0.252
Ethyl benzene	C_8H_{10}	106.16	0.867	178.185	9.163	409.35	36.0	619.7	37.0	360	0.260
Ethyl bromide	C_2H_5Br	108.98	1.460	154.1		311.4		504	61.5	215	0.320
Ethyl chloride	CH_3CH_2Cl	64.52	$0.903^{10°}$	134.83	4.452	285.43	25	460.4	52.0	199	0.274
3-Ethyl hexane	C_8H_{18}	114.22	0.7169			391.69	34.3	567.0	26.4	466	0.264
Ethylene	C_2H_4	28.05	0.975(A)	103.97	3.351	169.45	13.54	283.1	50.5	124	0.270

Ethylene glycol	$C_2H_6O_2$	62.07	$1.113^{19°}$	260	11.23	470.4	56.9				
Ferric oxide	Fe_2O_3	159.70	5.12	1833		(decomposes at 1833 K)					
Ferric sulfide	Fe_2S_3	207.90	4.3	(decomposes)							
Ferrous sulfide	FeS	87.92	4.84	1466		(decomposes)					
Formaldehyde	H_2CO	30.03	$0.815^{-20°}$	154.9		253.9	24.5				
Formic acid	CH_2O_2	46.03	1.220	281.46	12.7	373.7	22.3				
Glycerol	$C_3H_8O_3$	92.09	$1.260^{50°}$	291.36	18.30	563.2					
Helium	He	4.00	0.1368(A)	3.5	0.02	4.216	0.084	5.26	2.26	58	0.304
Heptane	C_7H_{16}	100.20	0.684	182.57	14.03	371.59	31.69	540.2	27.0	426	0.260
Hexane	C_6H_{14}	86.17	0.659	177.84	13.03	341.90	28.85	507.9	29.9	368	0.264
Hydrogen	H_2	2.016	0.06948(A)	13.96	0.12	20.39	0.904	33.3	12.8	65	0.304
Hydrogen chloride	HCl	36.47	1.268(A)	158.94	1.99	188.11	16.15	324.6	81.5	87	0.266
Hydrogen fluoride	HF	20.01	1.15	238		293		503.2			
Hydrogen sulfide	H_2S	34.08	1.1895(A)	187.63	2.38	212.82	18.67	373.6	88.9	98	0.284
Iodine	I_2	253.8	$4.93^{20°}$	386.5		457.4		826.0			
Iron	Fe	55.85	7.7	1808	15	3073	353				
Iron oxide	Fe_3O_4	231.55	5.2	1867	138	(decomposes at 1867 K after melting)					
Lead	Pb	207.21	$11.337^{20°}$	600.6	5.10	2023	180				
Lead oxide	PbO	223.21	9.5	1159	11.7	1745	213				
Magnesium	Mg	24.32	1.74	923	9.2	1393	132				
Magnesium chloride	$MgCl_2$	95.23	$2.325^{25°}$	987	43.1	1691	137				
Magnesium hydroxide	$Mg(OH)_2$	58.34	2.4	(decomposes at 623 K)							
Magnesium oxide	MgO	40.32	3.65	3173	77.4	3873					
Mercury	Hg	200.61	$13.546^{20°}$								
Methane	CH_4	16.04	0.554(A)	90.68	0.941	111.67	8.180	190.7	45.8	99	0.290
Methanol	CH_3OH	32.04	0.792	175.26	3.17	337.9	35.3	513.2	78.5	118	0.222
Methyl acetate	$C_3H_6O_2$	74.08	0.933	174.3		330.3		506.7	46.3	228	0.254

(Continues)

Table F.1 Physical Properties of Various Organic and Inorganic Substances* *(Continued)*

Compound	Formula	Formula Wt.	Sp. Gr.	Melting Temp. (K)	$\Delta\hat{H}$ Fusion (kJ/g mol)	Normal b.p. (K)	$\Delta\hat{H}$ Vap. at b.p. (kJ/g mol)	T_c (K)	p_c (atm)	$\hat{V}_c$ (cm^3/g mol)	z_c
Methyl amine	CH_5N	31.06	$0.699^{-11°}$	180.5		266.3^{758mm}		429.9	73.6		
Methyl chloride	CH_3Cl	50.49	1.785(A)	175.3		249		416.1	65.8	143	0.276
Methyl ethyl ketone	C_4H_8O	72.10	0.805	186.1		352.6					
Methyl cyclohexane	C_7H_{14}	98.18	0.769	146.58	6.751	374.10	31.7	572.2	34.32	344	0.251
Molybdenum	Mo	95.95	10.2								
Napthalene	$C_{10}H_8$	128.16	1.145	353.2		491.0					
Nickel	Ni	58.69	$8.90^{20°}$	1725		3173					
Nitric acid	HNO_3	63.02	1.502	231.56	10.47	359	30.30				
Nitrobenzene	$C_6H_5O_2N$	123.11	1.203	278.7		483.9					
Nitrogen	N_2	28.02	12.5(D)	63.15	0.720	77.34	5.577	126.2	33.5	90	0.291
Nitrogen dioxide	NO_2	46.01	1.448	263.86	7.334	294.46	14.73	431.0	100.0	82	0.232
Nitrogen (nitric) oxide	NO	30.01	1.0367(A)	109.51	2.301	121.39	13.78	180	64.0	58	0.251
Nitrogen pentoxide	N_2O_5	108.02	$1.63^{18°}$	303		320					
Nitrogen tetraoxide	N_2O_4	92	$1.448^{20°}$	263.7		294.3		431.0	99.0		
Nitrogen trioxide	N_2O_3	76.02	$1.447^{2°}$	171		276.5					
Nitrous oxide	N_2O	44.02	$1.226^{-89°}$ 1.530(A)	182.1		184.4		309.5	71.7	96.3	0.272
n-Nonane	C_9H_{20}	128.25	0.718	219.4		423.8		595	23		
n-Octane	C_8H_{18}	114.22	0.703	216.2		398.7		595.0	22.5	543	0.250
Oxalic acid	$C_2H_2O_4$	90.04	1.90	(decomposes at 459 K)							
Oxygen	O_2	32.00	1.1053(A)	54.40	0.443	90.19	6.820	154.4	49.7	74	0.290

n-Pentane	C_5H_{12}	72.15	$0.630^{18°}$	143.49	8.393	309.23	25.77	469.8	33.3	311	0.269
iso-Pentane	iso-C_5H_{12}	72.15	$0.621^{19°}$	113.1		300.9		461.0	32.9	308	0.268
l-Pentane	C_5H_{10}	70.13	0.641	107.96	4.937	303.13		474	39.9		
Phenol	C_6H_5OH	94.11	$1.071^{25°}$	315.66	11.43	454.56		692.1	60.5		
Phenyl hydrazine	$C_6H_8N_2$	108.14	$1.097^{23°}$	292.76	16.43	51.66					
Phosphoric acid	H_3PO_4	98.00	$1.834^{18°}$	315.51	10.5	$(-\frac{1}{2}\ H_2O$ at 486 K)					
Phosphorus (red)	P_4	123.90	2.20	863	81.17	863	41.84				
Phosphorus (white)	P_4	123.90	1.82	317.4	2.5	553	49.71				
Phosphorus pentoxide	P_2O_5	141.95	2.387	(sublimes at 523 K)							
Propane	C_3H_8	44.09	1.562(A)	85.47	3.524	231.09	18.77	369.9	42.0	200	0.277
Propene	C_3H_6	42.08	1.498(A)	87.91	3.002	255.46	18.42	365.1	45.4	181	0.274
Propionic acid	$C_3H_6O_2$	74.08	0.993	252.2		414.4		612.5	53.0		
n-Propyl alcohol	C_3H_8O	60.09	0.804	146		370.2		536.7	49.95	220	0.251
iso-Propyl alcohol	C_3H_8O	60.09	0.785	183.5		355.4		508.8	53.0	219	0.278
n-Propyl benzene	C_9H_{12}	120.19	0.862	173.660	8.54	432.38	38.2	638.7	31.3	429	0.257
Silicon dioxide	SiO_2	60.09	2.25	1883	8.54	2503					
Sodium bisulfate	$NaHSO_4$	120.07	2.742	455							
Sodium carbonate (sal soda)	$Na_2CO_3{\cdot}10H_2O$	286.15	1.46	306.5		($-H_2O$ at 306.5 K)					
Sodium carbonate (soda ash)	Na_2CO_3	105.99	2.533	1127	33.4	(decomposes)					
Sodium chloride	NaCl	58.45	2.163	1081	28.5	1738	171				
Sodium cyanide	NaCN	49.01		835	16.7	1770	155				
Sodium hydroxide	NaOH	40.00	2.130	592	8.4	1663					
Sodium nitrate	$NaNO_3$	85.00	2.257	583	15.9	(decomposes at 653 K)					
Sodium nitrite	$NaNO_2$	69.00	$2.168^{0°}$	544		(decomposes at 593 K)					
Sodium sulfate	Na_2SO_4	142.05	2.698	1163	24.3						
Sodium sulfide	Na_2S	78.05	1.856	1223	6.7						
Sodium sulfite	Na_2SO_3	126.05	$2.633^{15°}$	(decomposes)							

(Continues)

Table F.1 Physical Properties of Various Organic and Inorganic Substances* *(Continued)*

Compound	Formula	Formula Wt.	Sp. Gr.	Melting Temp. (K)	$\Delta\hat{H}$ Fusion (kJ/g mol)	Normal b.p. (K)	$\Delta\hat{H}$ Vap. at b.p. (kJ/g mol)	T_c (K)	p_c (atm)	$\hat{V}_c$ (cm^3/g mol)	z_c
Sodium thiosulfate	$Na_2S_2O_3$ 158.11	1.667									
Sulfur (rhombic)	S_8	256.53	2.07	386	10.0	717.76	84				
Sulfur (monoclinic)	S_8	256.53	1.96	392	14.17	717.76	84				
Sulfur cholride (mono)	S_2CL_2	135.05	1.687	193.0		411.2	36.0				
Sulfur dioxide	SO_2	64.07	2.264(A)	197.68	7.402	263.14	24.92	430.7	77.8	122	0.269
Sulfur trioxide	SO_3	80.07	2.75(A)	290.0	24.5	316.5	41.8	491.4	83.8	126	0.262
Sulfuric acid	H_2SO_4	98.08	$1.834^{18°}$	283.51	9.87			(decomposes at 613 K)			
Toluene	$C_6H_5CH_3$	92.13	0.866	178.169	6.619	383.78	33.5	593.9	40.3	318	0.263
Water	H_2O	18.016	$1.00^{4°}$	273.16	6.009	373.16	40.65	647.4	218.3	56	0.230
m-Xylene	C_8H_{10}	106.16	0.864	225.288	11.57	412.26	34.4	619	34.6	390	0.27
o-Xylene	C_8H_{10}	106.16	0.880	247.978	13.60	417.58	36.8	631.5	35.7	380	0.26
p-Xylene	C_8H_{10}	106.16	0.861	286.423	17.11	411.51	36.1	618	33.9	370	0.25
Zinc	Zn	65.38	7.140	692.7	6.673	1180	114.8				
Zinc sulfate	$ZnSO_4$	161.44	$3.74^{15°}$	(decomposes at 1013 K)							

*Sources of data are listed at the beginning of Appendix F.
Sp. gr. = 20°C/4°C unless specified. Sp. gr. for gas referred to air (A).

Table F.2 Enthalpies of Paraffinic Hydrocarbon Vapors, C_1–C_6 (J/g mol) (at 1 atm)
To convert to Btu/lb mol, multiply by 0.4306.

K	C_1	C_2	C_3	*n*-C_4	*i*-C_4	*n*-C_5	*n*-C_6
273	0						
291	630	912	1264	1709	1658	2125	2545
298	879	1277	1771	2394	2328	2976	3563
300	950	1383	1919	2592	2522	3222	3858
400	4740	7305	10,292	13,773	13,623	17,108	20,463
500	9100	14,476	20,685	27,442	27,325	34,020	40,622
600	14,054	22,869	32,777	43,362	43,312	53,638	64,011
700	19,585	32,342	46,417	61,186	61,220	75,604	90,123
800	25,652	42,718	61,337	80,600	80,767	99,495	118,532
900	32,204	53,931	77,404	101,378	101,754	125,101	148,866
1000	39,204	65,814	94,432	123,428	123,971	152,213	181,041
1100	46,567	78,408	112,340	146,607	147,234	180,665	214,764
1200	54,308	91,504	131,042	170,707	171,418	210,246	249,868
1300	62,383	105,143	150,331	195,727	196,480	240,872	286,143
1400	70,709	119,202	170,205	221,375	222,212	272,378	323,465
1500	79,244	133,678	190,581	247,650	248,571	304,595	361,539
1600	88,031						
1800	106,064						
2000	124,725						
2200	143,804						
2500	173,050						

Table F.3 Enthalpies of Other Hydrocarbon Vapors (J/g mol) (at 1 atm)
To convert to Btu/lb mol, multiply by 0.4306.

K	Ethylene	Propylene	l-Butene	iso-Butene	Acety-lene	Benzene
273	0	0	0	0	0	0
291	753	1104	1536	1538	769	1381
298	1054	1548	2154	2154	1075	1945
300	1125	1665	2313	2322	1163	2109
400	6008	8882	12,455	12,367	5899	11,878
500	11,890	17,572	24,765	24,468	11,125	24,372
600	18,648	27,719	38,911	38,425	16,711	39,150
700	26,158	39,049	54,643	53,889	22,556	55,840
800	34,329	51,379	71,755	70,793	28,686	74,015
900	43,053	64,642	89,997	88,826	35,074	93,471
1000	52,258	78,742	109,286	107,947	41,635	113,972
1100	61,923	93,470	129,494	123,846	48,388	135,394
1200	71,964	108,825	150,456	148,866	55,271	157,611
1300	82,341	124,683	172,087	170,414	62,342	180,456
1400	92,968	141,000	194,304	188,363	69,622	203,844
1500	103,888	157,736	217,065	215,183	76,944	227,777

Table F.4 Enthalpies of Nitrogen and Some of its Oxides (J/g mol) (at 1 atm)
To convert to Btu/lb mol, multiply by 0.4306.

K	N_2	NO	N_2O	NO_2	N_2O_4
273	0	0	0	0	0
291	524	537	686	658	1384
298	728	746	957	917	1937
300	786	686	1034	985	2083
400	3695	3785	5121	4865	10,543
500	6644	6811	9582	9070	19,915
600	9627	9895	14,386	13,564	30,124
700	12,652	13,054	19,513	18,305	
800	15,756	16,292	24,950	23,242	
900	18,961	19,597	30,693	28,334	
1000	22,171	22,970	36,748	33,551	
1100	25,472	26,392	43,129	38,869	
1200	28,819	29,861	49,862	44,266	
1300	32,216	33,371		49,731	
1400	35,639	36,915		55,258	
1500	39,145	40,488		60,826	
1750	47,940	49,505			
2000	56,902	58,634			
2250	65,981	67,856			
2500	75,060	77,127			

Table F.5 Enthalpies of Sulfur Compound Vapors (J/g mol) (at 1 atm)
To convert to Btu/lb mol, multiply by 0.4306.

K	$S_2(g)$	SO_2	SO_3	H_2S	CS_2
273	0	0	0	0	0
291	579	706	899	607	807
298	805	984	1255	845	1125
300	869	1064	1338	909	1217
400	4196	5234	6861	4372	5995
500	7652	9744	13,033	7978	11,108
600	11,192	14,514	19,832	11,752	16,455
700	14,790	19,501	27,154	15,706	21,974
800	18,426	24,647	34,748	19,840	27,631
900	22,087	29,915	42,676	24,145	33,388
1000	25,769	35,275	50,835	28,610	39,220
1100	29,463	40,706	59,203	33,216	45,103
1200	33,174	46,191	67,738	37,953	51,044
1300	36,898	51,714	76,399	42,802	57,027
1400	40,630	57,320		47,739	63,052
1500	44,371	62,927		52,802	69,119
1600	48,116	68,533		57,906	75,186
1700	51,881	74,182		63,094	81,295
1800	55,605	79,872		68,324	87,361
1900	59,370	85,520			
2000	63,136	91,253			
2500	82,006	119,871			
3000	100,959	148,657			

Table F.6 Enthalpies of Combustion Gases* (J/g mol)†

K	N_2	O_2	Air	H_2	CO	CO_2	H_2O
273	0	0	0	0	0	0	0
291	524	527	523	516	525	655	603
298	728	732	726	718	728	912	837
300	786	790	784	763	786	986	905
400	3695	3752	3696	3655	3699	4903	4284
500	6644	6811	6660	6589	6652	9204	7752
600	9627	9970	9673	9518	9665	13,807	11,326
700	12,652	13,225	12,736	12,459	12,748	18,656	15,016
800	15,756	16,564	15,878	15,413	15,899	23,710	18,823
900	18,961	19,970	19,116	18,384	19,125	28,936	22,760
1000	22,171	23,434	22,367	21,388	22,413	34,308	26,823
1100	25,472	26,940	25,698	24,426	25,760	39,802	31,011
1200	28,819	30,492	29,078	27,509	29,154	45,404	35,312
1300	32,216	34,078	32,501	30,626	32,593	51,090	39,722
1400	35,639	37,693	35,953	33,789	36,070	56,860	44,237
1500	39,145	41,337	39,463	36,994	39,576	62,676	48,848
1750	47,940	50,555	48,325	45,275	48,459	77,445	60,751
2000	56,902	59,914	57,320	53,680	57,488	92,466	73,136
2250	65,981	69,454	66,441	62,341	66,567	107,738	85,855
2500	75,060	79,119	75,646	71,211	75,772	123,176	98,867
2750	84,265	88,910	84,935	80,290	85,018	138,699	112,089
3000	93,512	98,826	94,265	89,453	94,265	154,347	125,520
3500	112,131	119,034	113,135	108,030	112,968	185,895	152,799
4000	130,875	141,410	132,172	127,528	131,796	217,777	180,414

*Pressure = 1 atm.

†To convert to cal/g mol, multiply by 0.2390.

SOURCE: Kobe et al., *Thermochemistry of Petrochemicals,* p. 30.

Table F.7 Enthalpies of Combustion Gases* (Btu/lb mol)

°R	N_2	O_2	Air	H_2	CO	CO_2	H_2O
492	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	55.67	55.93	55.57	57.74	55.68	68.95	64.02
520	194.9	195.9	194.6	191.9	194.9	243.1	224.2
537	313.2	315.1	312.7	308.9	313.3	392.2	360.5
600	751.9	758.8	751.2	744.4	752.4	963	867.5
700	1450	1471	1450	1433	1451	1914	1679
800	2150	2194	2153	2122	2154	2915	2501
900	2852	2931	2861	2825	2863	3961	3336
1000	3565	3680	3579	3511	3580	5046	4184
1100	4285	4443	4306	4210	4304	6167	5047
1200	5005	5219	5035	4917	5038	7320	5925
1300	5741	6007	5780	5630	5783	8502	6819
1400	6495	6804	6540	6369	6536	9710	7730
1500	7231	7612	7289	7069	7299	10,942	8657
1600	8004	8427	8068	7789	8072	12,200	9602
1700	8774	9251	8847	8499	8853	13,470	10,562
1800	9539	10,081	9623	9219	9643	14,760	11,540
1900	10,335	10,918	10,425	9942	10,440	16,070	12,530
2000	11,127	11,760	11,224	10,689	11,243	17,390	13,550
2100	11,927	12,610	12,030	11,615	12,050	18,730	14,570
2200	12,730	13,460	12,840	12,160	12,870	20,070	15,610
2300	13,540	14,320	13,660	12,890	13,690	21,430	16,660
2400	14,350	15,180	14,480	13,650	14,520	22,800	17,730
2500	15,170	16,040	15,300	14,400	15,350	24,180	18,810

*Pressure = 1 atm.

SOURCE: K. Kobe et al., *Thermochemistry of Petrochemicals*, p. 30.