Appendix

Nomenclature

a	Velocity of sound (m/s)
A	Interfacial area, or bed cross-sectional area, m^2 (ft^2)
A_p, A_E, A_W, A_N, A_S	Coefficients in finite difference formulations
b	Body force (N)
b'	Coefficients resulting from velocity profile
c	Particle local velocity vector (m/s)
C	Velocity fluctuation vector (m/s)
C_F	Flotsam concentration (-)
C'_f	Skin friction coefficient
C_i	Bagnold's constant for grain inertia
C_J	Jetsam concentration (-)
C_o	Normalized bed surface velocity (-)
C_p	Specific heat capacity at constant pressure, (kJ/kg)
C_{sp}	Characteristic particle spacing (1/m)
C_v	Specific heat of water vapor (kJ/kg)
C'	Apparent viscosity defined
C_1, C_2	Constants in Plank's equation
CFD	Computational fluid dynamics
CRZ	Central recirculation zone
d_p	Particle diameter (m)
D	Kiln diameter, m (ft) or Diffusion coefficient (m^2/s)
D_I, D_{II}	Damkohler Number
DPM	Dry particle mass burnout rate (kg/s)
e	Emissivity, also void fraction where appropriate

e_p	Coefficient of restitution of particles (-)
E	Emissive power (W/m^2)
$\bar{E}$	Mean void diameter ratio (-)
E_h	Thermal energy, sensible heat (W)
E_k	Kinetic energy associated with local average velocity
E_m	Void diameter ratio that results in spontaneous percolation
E_{PT}	Pseudo-thermal energy associated with velocity fluctuations
Eu	Euler Number (-)
ERZ	External recirculation zone
F	Feed rate (kg-dry/hr or lb-dry/hr), also view factor
f_c, % fill	Percent fill
f_p	Frequency of precession
Fr	Rotational Froude number, $\omega^2 R/g$ (-)
g	Acceleration due to gravity (m/s^2)
g_o	Pair distribution function in collisional theory
$g_1(\nu)$, $g_2(\nu)$, …	Terms defined in granular flow constitutive equations
G	Mass flow rate of gas (kg/s) or freeboard gas velocity ($lb/h/ft^2$), Irradiation, (W/m^2), Conductance, Gibbs free energy, and also turbulence
$\dot{G}_o$	Linear momentum
h	Heat transfer coefficient (W/m^2) or specific enthalpy (kJ/kg)
H	Bed depth (m) or Molar enthalpy (kJ/mol)
HHV	High heating value (kJ/kg)
ΔH_o	Molar enthalpy of reaction ($H_{prod} - H_{react}$)
H_i, H_j	Species enthalpy (kJ/kg)
J	Radiosity, (W/m^2)
k	Thermal conductivity (W/mK)
K	Dissociation constant (atm-units), also a factor in Craya-Curtet number determination
$\bar{k}$	Segregation flux (m^2s^2)
k_{av}	Ratio of mean voids projected area and mean projected total area
K_c, K_v, k_s	Rate constant
L, L_c	Distance from apex of bed cross-section to mid-chord, chord length

Le'	Lewis Number (-)
LHV	Low heating value (kJ/kg)
$\dot{L}_o$	Angular momentum
$\dot{m}$	Mass flow rate (kg/s)
m_f	Mass fraction component
M	Craya-Curtet Number (-), also Molar mass (kJ/kmol)
Ma	Mach Number (-)
M/N	Ratio of number of voids to number of particles in a layer
n	Number of revolutions (l/s)
$\dot{n}$	Species fraction
N_c	Number of cascades per kiln revolution
Nu	Nusselt Number (-)
P	Total stress tensor
p	Absolute pressure, (bar)
Pe	Peclet number (-)
Pr	Prandtl number, $c_p\mu/k$ (-)
q	Energy flux (W/m^2), or Bed's axial volumetric flow rate, m^3/s (ft^3/hr)
q''	Heat flux, (W/m^2)
$\dot{q}$	Heat source term, (W/m^2)
q_d	Dimensionless axial volumetric flow rate, (-)
q_h, q, Q	Flux of sensible energy
q_{PT}	Flux of pseudo-thermal energy
Q	Solids mass flow rate (kg/s) or volume flow rate (m^3/s) or, Net heat transfer (W), also a factor in Craya-Curtet number determination
r	Radius of particle path in bed, m (ft)
r_o	Radius at bed surface, m (ft)
$\bar{r}$	Diffusion flux (1/s)
R	Cylinder radius or kiln internal radius, (m, ft), or Specific gas constant (kJ/kg K), Resistance to heat flow, also Rosin-Rammler relation
Re	Reynolds Number (-)
R',R_o	Universal gas constant, (kJ/kmol K)
s	Kiln slope, (degree, radians, ft/ft)
S	Deviatoric stress
S	Molar entropy (kJ/kmol K)
St_p	Strouhal Number
t	Temperature (°C) or time (s)

T	Temperature (K)
TKE	Turbulent kinetic energy
u	Velocity parallel to bed surface (m/s), or specific internal energy (kJ/kg)
U	Velocity (m/s) or Molar internal energy, (kJ/kmol)
u_{ax}	Averaged axial bulk velocity, m/s (ft/s)
$\bar{U}$	Tangential velocity of rotary drum (m/s)
V_s	Solids velocity in axial direction (m/s)
v_p	Percolation velocity (m/s)
VM	Volatile matter
W	Mass of water in material (free moisture) (kg)
w_s	Reaction rate (1/s)
y	Distance variable, arbitrary distance in active layer (m) or Bed depth, m (ft)
Y	Mass fraction
z	Axial distance (m)
z_o	Particle axial advance per cascade, m (ft)

Greek

α	Thermal diffusivity (m^2/s), also dimension in active layer (m)
α_g	Absorbtivity
β	Kiln slope (radians), or ratio relating hydrodynamic force to weight of particle, or coefficient of expansion
ε	Emissivity
γ	Energy dissipation due to inelastic collisions, also specific heat ratio
Γ	Effective mass flux, (kg/m.s)
δ, δ_x	Active layer depth at distance, *x,* from apex (m)
Δ	Active layer depth at mid-chord (m)
η	Expression for coefficient of restitution of particle (-), also ceramic or aggregate expansion factor
$\bar{\eta}$	Particle number ratio
θ	Angle subtended by bed material at cylinder center (radians) or half bed angle, (degree, radians)
θ'	Variance on residence time
κ	Ratio of surface velocity to plug flow velocity near yield line (-)
$\bar{\lambda}$	Dilation factor
λ	Conductivity (granular of thermal), also, latent heat of water vapor, also mean free path

μ	Dynamic viscosity (kg/m.s)
ν	Solids volume concentration (solids fraction) (-), or kinematic viscosity (m^2/s)
ρ	Bulk density (kg/m^3)
ρ_p	Particle density (kg/m^3)
σ	Stefan Boltzmann's constant
σ_{xx}, σ_{yy}	Normal stress components
$\bar{\sigma}$	Particle size ratio (-)
σ_{ox}	Oxidizer mass fraction
τ	Shear stress, also time
$\bar{\tau}$	Residence time
$\bar{\tau}_d$	Dimensionless residence time
$\tilde{T}$	Granular temperature (grain temperature) (m^2/s^2)
ϕ	Static angle of repose of material or Kiln slope in angular measure, (degree, radians)
Φ	Equivalent ratio
ω	Angular velocity (1/s)
ψ	Angle between surface of bed material and kiln axis, (degree, radian)
ξ	Dynamic angle of repose

Subscript

ax	Axial
AL	Active layer
b	Bed
c	Collisional
cb	Covered bed
cw	Covered wall
eb	Exposed bed
ew	Exposed wall
eff	Effective
f	Frictional
g	Freeboard gas
k	Kinetic
L	Large
m	Mean
PF	Plug flow
s	Small
w	Wall
Shell	Outer wall (shell)

SI to British Conversion Factors

Mass: $1\,\text{kg} = 1/0.45359237\,\text{lb} = 2.205\,\text{lb}$

Length: $1\,\text{m} = 1/0.3048\,\text{ft} = 3.281\,\text{ft}$

Volume: $1\,\text{m}^3 = 10^3\,\text{dm}^3$ (l) $= 35.31\,\text{ft}^3 = 220.0\,\text{gal}$ (UK) $= 264\,\text{gal}$ (US)

Time: $1\,\text{s} = 1/60\,\text{min} = 1/3600\,\text{hr}$

Temperature unit: $1\,\text{K} = 1.8\,\text{R}$

Force: $1\,\text{N}$ (or kg/m/s^2) $= 10^5\,\text{dyn} = 1/9.80665\,\text{kg}_\text{f} = 7.233\,\text{pdl} = 7.233/32.174$ or $0.2248\,\text{lb}_\text{f}$

Pressure p: $1\,\text{bar} = 10^5\,\text{N/m}^2$ (or Pa) $= 14.50\,\text{lb}_\text{f}/\text{in}^2 = 750\,\text{mmHg} = 10.20\,\text{mH}_2\text{O}$

Specific volume v: $1\,\text{m}^3/\text{kg} = 16.02\,\text{ft}^3/\text{lb}$

Density ρ: $1\,\text{kg/m}^3 = 0.06243\,\text{lb/ft}^3$

Energy: $1\,\text{kJ} = 10^3\,\text{Nm} = 1/4.1868\,\text{kcal} = 0.9478\,\text{Btu} = 737.6\,\text{ft}\cdot\text{lbf}$

Power: $1\,\text{kW} = 1\,\text{kJ/s} = 10^3/9.80665\,\text{kg}_\text{f}\text{m/s} = 10^3/(9.80667 \times 75)$ metric hp $= 737.6\,\text{ft}\cdot\text{lb}_\text{f}/\text{s} = 737.6/550$ or $1/0.7457$ British hp $= 3412\,\text{Btu/hr}$

Specific energy (u, h): $1\,\text{kJ/kg} = 1/2.326\,\text{Btu/lb} = 0.4299\,\text{Btu/lb}$

Specific heat (c, R, s): $1\,\text{kJ/kg K} = 1/4.1868\,\text{Btu/lb R} = 0.2388\,\text{Btu/lb R}$

Thermal conductivity k: $1\,\text{kW/mK} = 577.8\,\text{Btu/ft hr R}$

Heat transfer coefficient: $1\,\text{kW/m}^2\text{K} = 176.1\,\text{Btu/ft}^2$ hr R

Dynamic viscosity μ: $1\,\text{kg/m/s} = \text{IN s/m}^2 = 1\,\text{Pa}\cdot\text{s} = 10\,\text{dyn}\cdot\text{s/cm}^2$ (or poise) $= 2419\,\text{lb/ft}\cdot\text{h} = 18.67 \times 10^{-5}\,\text{pdl}\cdot\text{hr/ft}^2$

Kinematic viscosity υ: $1\,\text{m}^2/\text{s} = 10^4\,\text{cm}^2/\text{s}$ (or stokes) $= 38{,}750\,\text{ft}^2/\text{h}$

General Information

Standard acceleration: $g_o = 9.80665\,\text{m/s}^2 = 32.1740\,\text{ft/s}^2$

Standard atmospheric pressure: $1\,\text{Atm} = 1.01325\,\text{bar} = 760\,\text{mmHg} = 10.33\,\text{mH}_2\text{O} = 1.0332\,\text{kg}_f/\text{cm}^2 = 29.92\,\text{in./Hg} = 33.90\,\text{ft./H}_2\text{O} = 14.696\,\text{lb}_f/\text{in.}^2$

Molar (universal) gas constant: $R_o = 8.3144\,\text{kJ/kmol K}^* = 1.986\,\text{Btu/lb} \cdot \text{mol R} = 1545\,\text{ft lbf/lb} \cdot \text{mol R}$

1 kmol occupies $22.41\,\text{m}^3$ at 1 Atm and 0°C

$1\,\text{lb} \cdot \text{mol}$ occupies $359.0\,\text{ft}^3$ at 1 Atm and 32°F

Composition of Air

Table A.2 Composition of Air

	Volume Basis	Mass Basis
Nitrogen ($N_2 = 28.013\,\text{kg/kmol}$)	0.7809	0.7553
Oxygen ($O_2 = 31.999\,\text{kg/kmol}$)	0.2095	0.2314
Argon ($\text{Ar} = 39.948\,\text{kg/kmol}$)	0.0093	0.0128
Carbon dioxide ($CO_2 = 44.010\,\text{kg/kmol}$)	0.0003	0.0005
Molar mass $M = 28.96\,\text{kg/kmol}$		
Specific gas constant		
$R = 0.2871\,\text{kJ/kg}$ $\text{K} = 0.06856\,\text{Btu/lb}$ $\text{R} = 53.35\,\text{ft lbf/lb R}$		

* The kilomole (kmol) is the amount of substance of a system which contains as many elementary entities as there are atoms in 12 kg of carbon 12. The elementary entities must be specified, but for problems involving mixtures of gases and combustion they will be molecules or atoms.

The Stefan-Boltzmann Constant

$\sigma = 56.7 \times 10^{-12}\,\text{kW/m}^2\,\text{K}^4 = 0.171 \times 10^{-8}\,\text{Btu/ft}^2\,\text{hr}\,\text{R}^4$

Mass

1 metric ton = 1000 kg

1 short ton (sht) = 2000 lb = 907.2 kg

1 long ton (ton) = 2240 lb = 1015.9 kg

Velocity

1 rpm = 0.1047 radian/s

1 mph = 0.4470 m/s = 1.609 km/h

1 knot = 0.5144 m/s

Temperature

$$C = \frac{5}{9} \times (F - 32)$$

$$F = \frac{9}{5} \times (C + 32)$$

$$K = C + 273.15$$

$$R = F + 459.67$$

Heat Content

1 cal/g = 1.80 Btu/lb = 4187 J/kg

$1\,\text{cal/cm}^3 = 112.4\,\text{Btu/ft}^3$

$1\,\text{kcal/m}^3 = 0.1124\,\text{Btu/ft}^3 = 4187\,\text{J/m}^3$

1 cal/g°C = 1 Btu/lb°F = 4187 J/kg°K

1 Btu/lb = 0.5556 cal/g = 2326 J/kg

$1\,\text{Btu/US gal} = 0.666\,\text{kcal/l}$

$1\,\text{hp} = 33{,}000\,\text{ft} \cdot \text{lb/min} = 745.7\,\text{J/s} = 641.4\,\text{kcal/hr}$

Pressure

Technical Atmosphere

$1\,\text{bar} = 1\,\text{Atm} = 1\,\text{kg/cm}^2$

$10\,\text{m/H}_2\text{O} = 100\,\text{kPa}$

Normal Atmosphere

$$\begin{aligned} 1\,\text{Atm} &= 101.3\,\text{kPa} = 101{,}325\,\text{N/m}^2 \\ &= 10{,}330\,\text{mm/H}_2\text{O} = 407.3\,\text{in./H}_2\text{O} \\ &= 760.0\,\text{mmHg} = 29.92\,\text{in./Hg} \\ &= 235.1\,\text{oz/in.}^2 = 14.70\,\text{lb/in.}^2 \\ &= 1.033\,\text{kg/cm}^2 \\ &= 1.013\,\text{bar} \end{aligned}$$

Thermodynamic Tables—Gases

Reference: C. F. C. Rogers and Y. R. Mayhew. *Thermodynamic and Transport Properties of Fluids*. Basil Blackwell Publishers, Oxford, 1982.

T = Temperature in Kelvin

c_p = Molar heat in cal/mol

G = Free enthalpy in kcal/mol

H = Enthalpy in kcal/mol

B = B-function $B(T) = -10^3 G(T)/4.575T$

Table A.3 Useful Conversion Factors

Physical Quantity	Symbol	SI to English Conversion	English to SI Conversion
Length	L	$1\,\text{m} = 3.2808\,\text{ft}$	$1\,\text{ft} = 0.3048\,\text{m}$
Area	A	$1\,\text{m}^2 = 10.7639\,\text{ft}^2$	$1\,\text{ft}^2 = 0.092903\,\text{m}^2$
Volume	V	$1\,\text{m}^3 = 35.3134\,\text{ft}^3$	$1\,\text{ft}^3 = 0.028317\,\text{m}^3$
Velocity	v	$1\,\text{m/s} = 3.2808\,\text{ft/s}$	$1\,\text{ft/s} = 0.3048\,\text{m/s}$
Density	p	$1\,\text{kg/m}^3 = 0.06243\ \text{lb}_\text{m}/\text{ft}^3$	$1\,\text{lb}_\text{m}/\text{ft}^3 = 16.018\ \text{kg/m}^3$
Force	F	$1\,\text{N} = 0.2248\,\text{lb}_\text{f}$	$1\,\text{lb}_\text{f} = 4.4482\,\text{N}$
Mass	m	$1\,\text{kg} = 2.20462\,\text{lb}_\text{m}$	$1\,\text{lb}_\text{m} = 0.45359237\,\text{kg}$
Pressure	p	$1\,\text{N/m}^2 = 1.45038 \times 10^{-4}\,\text{lb}_\text{f}/\text{in.}^2$	$1\,\text{lb}_\text{f}/\text{in.}^2 = 6894.76\ \text{N/m}^2$
Energy, heat	q	$1\,\text{kJ} = 0.94783\,\text{Btu}$	$1\,\text{Btu} = 1.05504\,\text{kJ}$
Heat flow	q	$1\,\text{W} = 3.4121\,\text{Btu/hr}$	$1\,\text{Btu/hr} = 0.29307\,\text{W}$
Heat flux per unit area	q/A	$1\,\text{W/m}^2 = 0.317\ \text{Btu/hr}\cdot\text{ft}^2$	$1\,\text{Btu/hr}\cdot\text{ft}^2 = 3.154\ \text{W/m}^2$
Heat flux per unit length	q/L	$1\,\text{W/m} = 1.0403\ \text{Btu/hr}\cdot\text{ft}$	$1\,\text{Btu/hr}\cdot\text{ft} = 0.9613\ \text{W/m}$
Heat generation per unit volume	$\dot{q}$	$1\,\text{W/m}^3 = 0.096623\ \text{Btu/hr}\cdot\text{ft}^3$	$1\,\text{Btu/hr}\cdot\text{ft}^3 = 10.35\ \text{W/m}^3$
Energy per unit mass	q/m	$1\,\text{kJ/kg} = 0.4299\ \text{Btu/lb}_\text{m}$	$1\,\text{Btu/lb}_\text{m} = 2.326\ \text{kJ/kg}$
Specific heat	c	$1\,\text{kJ/kg}\cdot{}^\circ\text{C} = 0.23884\,\text{Btu/lb}_\text{m}\cdot{}^\circ\text{F}$	$1\,\text{Btu/lb}_\text{m}\cdot{}^\circ\text{F} = 4.1869\,\text{kJ/kg}\cdot{}^\circ\text{C}$
Thermal conductivity	k	$1\,\text{W/m}\cdot{}^\circ\text{C} = 0.5778\,\text{Btu/hr}\cdot\text{ft}\cdot{}^\circ\text{F}$	$1\,\text{Btu/hr}\cdot\text{ft}\cdot{}^\circ\text{F} = 1.7307\,\text{W/m}\cdot{}^\circ\text{C}$
Convection heat transfer coefficient	h	$1\,\text{W/m}^2\cdot{}^\circ\text{C} = 0.1761\,\text{Btu/hr}\cdot\text{ft}^2\cdot{}^\circ\text{F}$	$1\,\text{Btu/hr}\cdot\text{ft}^2\cdot{}^\circ\text{F} = 5.6782\,\text{W/m}^2\cdot{}^\circ\text{C}$
Dynamic viscosity	μ	$1\,\text{kg/m}\cdot\text{s} = 0.672\ \text{lb}_\text{m}/\text{ft}\cdot\text{s} = 2419.2\ \text{lb}_\text{m}/\text{ft}\cdot\text{hr}$	$1\,\text{lb}_\text{m}/\text{ft}\cdot\text{s} = 1.4881\,\text{kg/m}\cdot\text{s}$
Kinematic viscosity and thermal diffusivity		$1\,\text{m}^2/\text{s} = 10.7639\ \text{ft}^2/\text{s}$	$1\,\text{ft}^2/\text{s} = 0.092903\,\text{m}^2/\text{s}$

Table A.4 Dry Air at Low Pressure

							At 1 Atm	
T/[K]	c_p [kJ/kg K]	c_v	γ	μ 10^{-5} [kg/m s]	k 10^{-5} [kW/mK]	Pr	ρ [kg/m^3]	ν 10^{-5} [m^2/s]
175	1.0023	0.7152	1.401	1.182	1.593	0.744	2.017	0.586
200	1.0025	0.7154	1.401	1.329	1.809	0.736	1.765	0.753
225	1.0027	0.7156	1.401	1.467	2.020	0.728	1.569	0.935
250	1.0031	0.7160	1.401	1.599	2.227	0.720	1.412	1.132
275	1.0038	0.7167	1.401	1.725	2.428	0.713	1.284	1.343
300	1.0049	0.7178	1.400	1.846	2.624	0.707	I.k 77	1.568
325	1.0063	0.7192	1.400	1.962	2.816	0.701	1.086	1.807
350	1.0082	0.7211	1.398	2.075	3.003	0.697	1.009	2.056
375	1.0106	0.7235	1.397	2.181	3.186	0.692	0.9413	2.317
400	1.0135	0.7264	1.395	2.286	3.365	0.688	0.8824	2.591
450	1.0206	0.7335	1.391	2.485	3.710	0.684	0.7844	3.168
500	1.0295	0.7424	1.387	2.670	4.041	0.680	0.7060	3.782
550	1.0398	0.7527	1.381	2.849	4.357	0.680	0.6418	4.439
600	1.0511	0.7640	1.376	3.017	4.661	0.680	0.5883	5.128
650	1.0629	0.7758	1.370	3.178	4.954	0.682	0.5430	5.853
700	1.0750	0.7879	1.364	3.332	5.236	0.684	0.5043	6.607
750	1.0870	0.7999	1.359	3.482	5.509	0.687	0.4706	7.399
800	1.0987	0.8116	1.354	3.624	5.774	0.690	0.4412	8.214
850	1.1101	0.8230	1.349	3.763	6.030	0.693	0.4153	9.061
900	1.1209	0.8338	1.344	3.897	6.276	0.696	0.3922	9.936
950	1.1313	0.8442	1.340	4.026	6.520	0.699	0.3716	10.83
1000	1.1411	0.8540	1.336	4.153	6.754	0.702	0.3530	11.76
1050	1.1502	0.8631	1.333	4.276	6.985	0.704	0.3362	12.72
1100	1.1589	0.8718	1.329	4.396	7.209	0.707	0.3209	13.70
1150	1.1670	0.8799	1.326	4.511	7.427	0.709	0.3069	14.70
1200	1.1746	0.8875	1.323	4.626	7.640	0.711	0.2941	15.73
1250	1.1817	0.8946	1.321	4.736	7.849	0.713	0.2824	16.77
1300	1.1884	0.9013	1.319	4.846	8.054	0.715	0.2715	17.85
1350	1.1946	0.9075	1.316	4.952	8.253	0.717	0.2615	18.94
1400	1.2005	0.9134	1.314	5.057	8.450	0.719	0.2521	20.06
1500	1.2112	0.9241	1.311	5.264	8.831	0.722	0.2353	22.36
1600	1.2207	0.9336	1.308	5.457	9.199	0.724	0.2206	24.74
1700	1.2293	0.9422	1.305	5.646	9.554	0.726	0.2076	27.20
1800	1.2370	0.9499	1.302	5.829	9.899	0.728	0.1961	29.72
1900	1.2440	0.9569	1.300	6.008	10.233	0.730	0.1858	32.34

(Continued)

Table A.4—Cont'd

							At 1 Atm	
T/[K]	c_p [kJ/kg K]	c_v	γ	μ 10^{-5} [kg/m s]	k 10^{-5} [kW/mK]	Pr	ρ [kg/m^3]	ν 10^{-5} [m^2/s]
2000	1.2505	0.9634	1.298	—	—		0.1765	—
2100	1.2564	0.9693	1.296	—	—		0.1681	—
2200	1.2619	0.9748	1.295	—	—		0.1604	—
2300	1.2669	0.9798	1.293	—	—		0.1535	—
2400	1.2717	0.9846	1.292	—	—		0.1471	—
2500	1.2762	0.9891	1.290	—	—		0.1412	—
2600	1.2803	0.9932	1.289	—	—		0.1358	—
2700	1.2843	0.9972	1.288	—	—		0.1307	—
2800	1.2881	1.0010	1.287	—	—		0.1261	—
2900	1.2916	1.0045	1.286	—	—		0.1217	—
3000	1.2949	1.0078	1.285	—	—		0.1177	—

Table A.5 Specific Heat c_p for Some Gases and Vapors

T/[K]	CO_2	CO	H_2	N_2	O_2	H_2O	CH_4	C_2H_4	C_2H_6
175	0.709	1.039	13.12	′1.039	0.910	1.850	2.083	1.241	—
200	0.735	1.039	13.53	1.039	0.910	1.851	2.087	1.260	—
225	0.763	1.039	13.83	1.039	0.911	1.852	2.121	1.316	—
250	0.791	1.039	14.05	1.039	0.913	1.855	2.156	1.380	1.535
275	0.819	1.040	14.20	1.039	0.915	1.859	2.191	1.453	1.651
300	0.846	1.040	14.31	1.040	0.918	1.864	2.226	1.535	1.766
325	0.871	1.041	14.38	1.040	0.923	1.871	2.293	1.621.	1.878
350	0.895	1.043	14.43	1.041	0.928	1.880	2.365	1.709	1.987
375	0.918	1.045	14.46	1.042	0.934	1.890	2.442	1.799	2.095
400	0.939	1.048	14.48	1.044	0.941	1.901	2.525	1.891	2.199
450	0.978	1.054	14.50	1.049	0.956	1.926	2.703	2.063	2.402
500	1.014	1.064	14.51	1.056	0.972	1.954	2.889	2.227	2.596
550	1.046	1.075	14.53	1.065	0.988	1.984	3.074	2.378	2.782
600	1.075	1.087	14.55	1.075	1.003	2.015	3.256	2.519	2.958
650	1.102	1.100	14.57	1.086	1.017	2.047	3.432	2.649	3.126
700	1.126	1.113	14.60	1.098	1.031	2.080	3.602	2.770	3.286
750	1.148	1.126	14.65	1.110	1.043	2.113	3.766	2.883	3.438

(Continued)

Table A.5—Cont'd

T/[K]	CO_2	CO	H_2	N_2	O_2	H_2O	CH_4	C_2H_4	C_2H_6
800	1.168	1.139	14.71	1.122	1.054	2.147	3.923	2.989	3.581
850	1.187	1.151	14.77	1.134	1.065	2.182	4.072	3.088	3.717
900	1.204	1.163	14.83	1.146	1.074	2.217	4.214	3.180	3.846
950	1.220	1.174	14.90	1.157	1.082	2.252	4.348	3.266	—
1000	1.234	1.185	14.98	1.167	1.090	2.288	4.475	3.347	—
1050	1.247	1.194	15.06	1.177	1.097	2.323	4.595	3.423	—
1100	1.259	1.203	15.15	1.187	1.103	2.358	4.708	3.494	—
1150	1.270	1.212	15.25	1.196	1.109	2.392	4.814	3.561	—
1200	1.280	1.220	15.34	1.204	1.115	2.425			—
1250	1.290	1.227	15.44	1.212	1.120	2.458	*T*/[K]	C_6H_6	C_8H_{18}
1300	1.298	1.234	15.54	1.219	1.125	2.490			
1350	1.306	1.240	15.65	1.226	1.130	2.521	250	0.850	1.308
1400	1.313	1.246	15.77	1.232	1.134	2.552	275	0.957	1.484
1500	1.326	1.257	16.02	1.244	1.143	2.609	300	1.060	1.656
1600	1.338	1.267	16.23	1.254	1.151	2.662	325	1.160	1.825
1700	1.348	1.275	16.44	1.263	1.158	2.711	350	1.255	1.979
1800	1.356	1.282	16.64	1.271	1.166	2.756	375	1.347	2.109
1900	1.364	1.288	16.83	1.278	1.173	2.798	400	1.435	2.218
2000	1.371	1.294	17.D1	1.284	1.181	2.836	450	1.600	2.403
2100	1.377	1.299	17.18	1.290	1.188	2.872	500	1.752	2.608
2200	1.383	1.304	17.35	1.295	1.195	2.904	550	1.891	2.774
2300	1.388	1.308	17.50	1.300	1.202	2.934	600	2.018	2.924
2400	1.393	1.311	17.65	1.304	1.209	2.962	650	2.134	3.121
2500	1.397	1.315	17.80	1.307	1.216	2.987	700	2.239	3.232
2600	1.401	1.318	17.93	1.311	1.223	3.011	750	2.335	3.349
2700	1.404	1.321	18.06	1.314	1.230	3.033	800	2.422	3.465
2800	1.408	1.324	18.17	1.317	1.236	3.053	850	2.500	3.582
2900	1.411	1.326	18.28	1.320	1.243	3.072	900	2.571	3.673
3000	1.414	1.329	18.39	1.323	1.249	3.090	—	—	—
3500	1.427	1.339	18.91	1.333	1.276	3.163	—	—	—
4000	1.437	1.346	19.39	1.342	1.299	3.217	—	—	—
4500	1.446	1.353	19.83	1.349	1.316	3.258	—	—	—
5000	1.455	1.359	20.23	1.355	1.328	3.292	—	—	—
5500	1.465	1.365	20.61	1.362	1.337	3.322	—	—	—
6000	1.476	1.370	20.96	1.369	1.344	3.350	—	—	—

The specific heats of atomic H, N, and O are given with adequate accuracy by $c_p = 2.5R_o/M$, where M is the molar mass of the atomic species.

H, U, S, G for Some Gases and Vapors

By definition $U = H - R_oT$ and $G = H - TS$. H and U are virtually independent of pressure. S and G are tabulated for states at 1 Atm and are denoted by S^a and G^a. (Note that superscript "0" has been used in some parts of the text). At any other pressure p, S, and G at a given temperature T can be found from

$$S - S^a = R_o \ln\left[\frac{p}{\text{Atm}}\right]$$

$$G - G^a = (H - H^a) - T(S - S^a) = +R_oT \ln\left[\frac{p}{\text{Atm}}\right]$$

For individual gases and vapors, changes in S and G between states (p_1, T_1) and (p_2, T_2) are given by

$$\begin{aligned} S_2 - S_1 &= (S_2 - S_2^a) + (S_2^a - S_1^a) + (S_1^a - S_1) \\ &= (S_2^a - S_1^a) - R_o \ln \frac{p_2}{p_1} \\ G_2 - G_1 &= (G_2 - G_2^a) + (G_2^a - G_1^a) + (G_1^a - G_1) \\ &= (G_2^a - G_1^a) + R_oT_2 \ln \frac{p_2}{[\text{Atm}]} R_oT_1 \ln \frac{p_1}{[\text{Atm}]} \end{aligned}$$

where p_1 and p_2 are partial pressures of a constituent mixture.

Table A.6 H, U, S, G for Some Gases and Vapors

Carbon Dioxide (CO_2)					Water Vapor (H_2O)			
H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]	T/[K]	H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]
−9364	−9,364	0	−9,364	0	−9,904	−9,904	0	−9,904
−6456	−7,287	178.90	−24,346	100	−6,615	−7,446	152.28	−21,843
−3414	−5,077	199.87	−43,387	200	−3,280	−4,943	175.38	−38,356
0	−2,479	213.69	−63,710	298.15	0	−2,479	188.72	−56,268
67	−2,427	213.92	−64,108	300	63	−2,432	188.93	−56,616
4,008	683	225.22	−86,082	400	3,452	126	198.67	−76,017
12,916	7,927	243.20	−133,000	600	10,498	5,509	212.93	−117,260
22,815	16,164	257.41	−183,110	800	17,991	11,340	223.69	−160,960
33,405	25,091	269.22	−235,810	1,000	25,978	17,664	232.60	−206,620
44,484	34,507	279.31	−290,680	1,200	34,476	24,499	240.33	−253,920
55,907	44,266	288.11	−347,440	1,400	43,447	31,806	247.24	−302,690
67,580	54,277	295.90	−405,860	1,600	52,844	39,541	253.51	−352,780
79,442	64,476	302.88	−465,750	1,800	62,609	47,643	259.26	−404,060
91,450	74,821	309.21	−526,970	2,000	72,689	56,060	264.57	−456,450
103,570	85,283	314.99	−589,400	2,200	83,036	64,744	269.50	−509,860
115,790	95,833	320.30	−652,940	2,400	93,604	73,650	274.10	−564,230
128,080	106,470	325.22	−717,490	2,600	104,370	82,752	278.41	−619,490
140,440	117,160	329.80	−782,990	2,800	115,290	92,014	282.45	−675,580
152,860	127,920	334.08	−849,390	3,000	126,360	10,1420	286.27	−732,460
165,330	138,720	338.11	−916,620	3,200	137,550	110,950	289.88	−790,080
177,850	149,580	341.90	−984,620	3,400	148,850	120,590	293.31	−848,390
190,410	160,470	345.49	−1,053,360	3,600	160,250	130,320	296.57	−907,390
203,000	171,400	348.90	−1,122,800	3,800	171,720	140,130	299.67	−967,010
215,630	182,370	352.13	−1,192,900	4,000	183,280	150,020	302.63	−102,725

Table A.7 H, U, S, G for Some Gases and Vapors

Hydrogen (H_2)					Carbon Monoxide (CO)			
H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]	T/[K]	H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]
−8,468	8,468	0	−8,468	0	−8,699	−8,669	0	−8,669
−5,293	−6,124	102.04	−15,496	100	−5,770	−6,601	165.74	−22,344
−2,770	−4,433	119.33	−26,635	200	−2,858	−4,521	185.92	−40,041
0	−2,479	130.57	−38,931	298.15	0	−2,479	197.54	−58,898
54	−2,440	130.75	−39,172	300	54	−2,440	197.72	−59,263
2,958	−368	139.11	−52,684	400	2,975	−351	206.12	−79,475
8,812	3,823	150.97	−81,769	600	10,196	5,208	218.20	−12,0730
14,703	8,051	159.44	−112,850	800	15,175	8,524	227.16	−166,550
20,686	12,371	166.11	−145,430	1,000	21,686	13,371	234.42	−212,740
26,794	16,817	171.68	−179,220	1,200	28,426	18,449	240.56	−260,250
33,062	21,422	176.51	−214,050	1,400	35,338	23,698	245.89	−308,910
39,522	26,219	180.82	−249,790	1,600	42,384	29,081	250.59	−358,560
46,150	31,184	184.72	−286,350	1,800	49,522	34,556	254.80	−409,110
52,932	36,303	188.30	−323,660	2,000	56,739	40,110	258.60	−460,460
59,860	41,569	191.60	−361,650	2,200	64,019	45,728	262.06	−512,520
66,915	46,960	194.67	−400,290	2,400	71,346	51,391	265.25	−565,260
74,090	52,473	197.54	−439,510	2,600	78,714	57,096	268.20	−618,610
81,370	58,090	200.23	−479,280	2,800	86,115	62,835	270.94	−672,530
88,743	63,799	202.78	−519,590	3,000	93,542	68,598	273.51	−726,980
96,199	69,592	205.18	−560,390	3,200	101,000	74,391	275.91	−781,930
103,740	75,469	207.47	−601,650	3,400	108,480	80,210	278.18	−837,340
111,360	81,430	209.65	−643,370	3,600	115,980	86,044	280.32	−893,190
119,060	87,469	211.73	−685,510	3,800	123,490	91,900	282.36	−949,460
126,850	93,589	213.73	−728,060	4,000	131,030	97,769	284.29	−1,006,120

Table A.8 H, U, S, G for Some Gases and Vapors

Oxygen (O_2)					Nitrogen (N_2)			
H [kJ/kmol]	U [kJ/kmol]	S^a [kJ/kmol K]	G^a [kJ/kmol]	T/[K]	H [kJ/kmol]	U [kJ/kmol]	S^a [kJ/kmol K]	G^a [kJ/kmol]
−8,682	−8,682	0	−8,682	0	−8,669	−8,669	0	−8,669
−5,778	−6,610	173.20	−23,098	100	−5,770	−6,601	159.70	−21,740
−2,866	−4,529	193.38	−41,541	200	−2,858	−4,521	179.88	−38,833
0	−2,479	205.03	−61,131	298.15	0	−2,479	191.50	−57,096
54	−2,440	205.21	−61,509	300	54	−2,440	191.68	−57,450
3,029	−297	213.76	−82,477	400	2,971	−355	200.07	−77,058
9,247	4,258	226.35	−126,560	600	8,891	3,902	212.07	−118,350
15,841	9,189	235.81	−172,810	800	15,046	8,394	220.91	−161,680
22,707	14,392	243.48	−220,770	1,000	21,460	13,145	228.06	−206,600
29,765	19,788	249.91	−270,120	1,200	28,108	18,131	234.12	−252,830
36,966	25,325	255.45	−320,670	1,400	34,936	23,296	239.38	−300,190
44,279	30,976	260.34	−372,260	1,600	41,903	28,600	244.03	−348,540
51,689	36,723	264.70	−424,770	1,800	48,982	34,016	248.19	−397,770
59,199	42,571	268.65	−478,110	2,000	56,141	39,512	251.97	−447,800
66,802	48,510	272.28	−532,210	2,200	63,371	45,079	255.41	−498,540
74,492	54,537	275.63	−587,010	2,400	70,651	50,696	258.58	−549,940
82,274	60,657	278.74	−642,440	2,600	77,981	56,364	261.51	−601,950
90,144	66,864	281.65	−698,490	2,800	85,345	62,065	264.24	−654,530
98,098	73,155	284.40	−755,100	3,000	92,738	67,795	266.79	−707,640
106,130	79,521	286.99	−812,240	3,200	100,160	73,555	269.19	−761,230
114,230	85,963	289.44	−869,880	3,400	107,610	79,339	271.45	−815,310
122,400	92,467	291.78	−928,010	3,600	115,080	85,149	273.58	−869,800
130,630	99,034	294.01	−986,590	3,800	122,570	90,976	275.60	−924,730
138,910	105,660	296.13	−1,045,590	4,000	130,080	96,819	277.53	−980,040

Table A.9 H, U, S, G for Some Gases and Vapors

Hydroxyl (OH)					Nitric Oxide (NO)			
H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]	T/[K]	H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]
−9,171	−9,171	0	−9,171	0	−9,192	−9,192	0	−9,192
−6,138	−6,969	149.48	−21,086	100	−6,071	−6,902	176.92	−23,763
−2,975	−4,638	171.48	−37,271	200	−2,950	−4,613	198.64	−42,678
0	−2,479	183.60	−54,740	298.15	0	−2,479	210.65	−62,806
54	−2,440	183.78	−55,080	300	54	−2,440	210.84	−63,198
3,033	−292	192.36	−73,909	400	3,042	284	219.43	−84,729
8,941	3,953	204.33	−113,660	600	9,146	4,158	231.78	−129,920
14,878	8,227	212.87	−115,420	800	15,548	8,896	240.98	−177,240
20,933	12,618	219.62	−198,690	1,000	22,230	13,915	248.43	−226,200
27,158	17,181	225.30	−243,200	1,200	29,121	19,143	254.71	−276,540
33,568	21,928	230.23	−288,760	1,400	36,166	24,526	260.14	−328,030
40,150	26,847	234.63	−335,250	1,600	43,321	30,018	264.92	−380,550
46,890	31,924	238.59	−382,580	1,800	50,559	35,594	269.18	−433,960
53,760	37,131	242.22	−430,670	2,000	57,861	41,232	273.03	−488,190
60,752	42,460	245.55	−479,450	2,200	65,216	46,924	276.53	−543,150
67,839	47,885	248.63	−528,870	2,400	72,609	52,655	279.75	−598,780
75,015	53,397	251.50	−578,890	2,600	80,036	58,418	282.72	−655,030
82,266	58,985	254.19	−629,460	2,800	87,492	64,211	285.48	−711,860
89,584	64,640	256.71	−680,540	3,000	94,977	70,034	288.06	−769,220
96,960	70,354	254.09	−732,130	3,200	102,480	75,873	290.48	−827,070
10,4390	76,118	261.34	−784,170	3,400	110,000	81,733	292.77	−885,410
111,860	81,927	263.48	−836,670	3,600	117,550	87,613	294.92	−944,170
119,380	87,783	265.51	−889,550	3,800	125,100	93,507	296.96	−1,003,360
126,940	93,680	267.45	−942,860	4,000	132,670	99,417	298.90	−1,062,950

Table A.10 H, U, S, G for Some Gases and Vapors

Methane Vapor (CH_4)					Ethylene Vapor (C_2H_4)			
H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]	T/[K]	H [kJ/kmol]	U [kJ/kmol]	S[a] [kJ/kmol K]	G[a] [kJ/kmol]
−10,025	−10,025	0	−10,025	0	−10,519	−10,519	0	−10,519
−6,699	−7,530	149.39	−21,638	100	−7,192	−8,024	180.44	−25,236
−3,368	−5,031	172.47	−37,863	200	−3,803	−5,466	203.85	−44,573
0	−2,479	186.15	−55,499	298.15	0	−2,479	291.22	−65,362
67	−2,427	186.37	−55,843	300	79	−2,415	291.49	−65,767
3,862	536	197.25	−75,038	400	4,883	−1,557	233.24	−88,412
13,129	8,141	215.88	−116,400	600	17,334	12,346	258.24	−137,610
24,673	18,022	232.41	−161,260	800	32,849	26,197	280.47	−191,520
38,179	29,865	247.45	−209,270	1,000	50,664	42,350	300.30	−249,640
53,271	43,293	261.18	−260,150	1,200	70,254	60,276	318.13	−311,510
69,609	57,969	273.76	−313,660	1,400	91,199	79,558	334.27	−376,780
86,910	73,607	285.31	−369,590	1,600	113,180	99,878	348.94	−445,120
104,960	89,994	295.93	−427,720	1,800	135,970	121,010	362.36	−516,270
123,600	106,970	305.75	−487,900	2,000	159,390	142,760	374.69	−589,990

Table A.11 International Standard Atmosphere

z [m]	p [bar]	T/[K]	ρ/ρ_0	ν 10^{-5} [m^2/s]	k 10^{-5} [kW/mK]	a [m/s]	λ 10^{-8} [m]
−2,500	1.3521	304.4	1.2631	1.207	2.661	349.8	5.251
−2,000	1.2778	301.2	1.2067	1.253	2.636	347.9	5.497
−1,500	1.2070	297.9	1.1522	1.301	2.611	346.0	5.757
−1,000	1.1393	294.7	1.0996	1.352	2.585	344.1	6.032
−500	1.0748	291.4	1.0489	1.405	2.560	342.2	6.324
0	1.01325	288.15	1.0000	1.461	2.534	340.3	6.633
500	0.9546	284.9	0.9529	1.520	2.509	338.4	6.961
1,000	0.8988	281.7	0.9075	1.581	2.483	336.4	7.309
1,500	0.8456	278.4	0.8638	1.646	2.457	334.5	7.679
2,000	0.7950	275.2	0.8217	1.715	2.431	332.5	8.072
2,500	0.7469	271.9	0.7812	I.787	2.405	330.6	8.491
3,000	0.7012	268.7	0.7423	1.863	2.379	328.6	8.936
3,500	0.6578	265.4	0.7048	1.943	2.353	326.6	9.411
4,000	0.6166	262.2	0.6689	2.028	2.327	324.6	9.917
4,500	0.5775	258.9	0.6343	2.117	2.301	322.6	10.46
5,000	0.5405	255.7	0.6012	2.211	2.275	320.5	11.03
5,500	0.5054	252.4	0.5694	2.311	2.248	318.5	11.65
6,000	0.4722	249.2	0.5389	2.416	2.222	316.5	12.31
6,500	0.4408	245.9	0.5096	2.528	2.195	314.4	13.02
7,000	0.4111	242.7	0.4817	2.646	2.169	312.3	13.77
7,500	0.3830	239.5	0.4549	2.771	2.142	310.2	14.58
8,000	0.3565	236.2	0.4292	2.904	2.115	308.1	15.45
8,500	0.3315	233.0	0.4047	3.046	2.088	306.0	16.39
9,000	0.3080	229.7	0.3813	3.196	2.061	303.8	17.40
9,500	0.2858	226.5	0.3589	3.355	2.034	301.7	18.48
10,000	0.2650	223.3	0.3376	3.525	2.007	299.5	19.65
10,500	0.2454	220.0	0.3172	3.706	1.980	297.4	20.91
11,000	0.2270	216.8	0.2978	3.899	1.953	295.2	22.27
11,500	0.2098	216.7	0.2755	4.213	1.952	295.1	24.08
12,000	0.1940	216.7	0.2546	4.557	1.952	295.1	26.05
12,500	0.1793	216.7	0.2354	4.930	1.952	295.1	28.18
13,000	0.1658	216.7	0.2176	5.333	1.952	295.1	30.48
13,500	0.1533	216.7	0.2012	5.768	1.952	295.1	32.97
14,000	0.1417	216.7	0.1860	6.239	1.952	295.1	35.66
14,500	0.1310	216.7	0.1720	6.749	I.952	295.1	38.57
15,000	0.1211	216.7	0.1590	7.300	1.952	295.1	41.72
15,500	0.1120	216.7	0.1470	7.895	1.952	295.1	45.13
16,000	0.1035	216.7	0.1359	8.540	1.952	295.1	48.81
16,500	0.09572	216.7	0.1256	9.237	1.952	295.1	52.79

(Continued)

Table A.11—Cont'd

z [m]	p [bar]	T/[K]	ρ/ρ_0	ν 10^{-5} [m^2/s]	k 10^{-5} [kW/mK]	a [m/s]	λ 10^{-8} [m]
17,000	0.08850	216.7	0.1162	9.990	1.952	295.1	57.10
17,500	0.08182	216.7	0.1074	10.805	1.952	295.1	61.76
18,000	0.07565	216.7	0.09930	11.686	1.952	295.1	66.79
18,500	0.06995	216.7	0.09182	12.639	1.952	295.1	72.24
19,000	0.06467	216.7	0.08489	13.670	I.952	295.1	78.13
19,500	0.05980	216.7	0.07850	14.784	1.952	295.1	84.50
20,000	0.05529	216.7	0.07258	15.989	I.952	295.1	91.39
22,000	0.04047	218.6	0.05266	22.201	1.968	296.4	126.0
24,000	0.02972	220.6	0.03832	30.743	1.985	297.7	173.1
26,000	0.02188	222.5	0.02797	42.439	2.001	299.1	237.2
28,000	0.01616	224.5	0.02047	58.405	2.018	300.4	324.0
30,000	0.01197	226.5	0.01503	80.134	2.034	301.7	441.3
32,000	0.00889	228.5	0.01107	109.62	2.051	303.0	599.4

Density at sea level $\rho_o = 1.225\,\mathrm{kg/m^3}$.

Thermodynamic Tables—Inorganic Materials

Ref: O. Knacke, O. Kubaschewski, and K. Hesselmann (Eds.). *Thermochemical Properties of Inorganic Substances, Volumes I and II*. Springer-Verlag, New York, 1991.

T = Temperature in Kelvin

c_p = Molar heat in cal/mol

G = Free enthalpy in kcal/mol

H = Enthalpy in kcal/mol

$B = B$-function $B(T) = -10^3 G(T)/4.575T$

Table A.12 Alpha-Aluminum Oxide, Al_2O_3

Phase	T	c_p	H	S	G	B
Solid						
	298	18.871	−400.4	12.174	−404.030	295.202
	300	18.979	−400.365	12.291	−404.052	294.391
	400	22.987	−398.243	18.369	−405.590	221.634
	500	25.179	−395.826	23.754	−407.702	178.231
	600	26.656	−393.230	28.482	−410.319	149.479
	700	27.797	−390.505	32.680	−413.381	129.081
	800	28.757	−387.677	36.456	−416.841	113.891
	900	29.354	−384.770	39.878	−420.661	102.164
	1,000	29.845	−381.809	42.997	−424.807	92.854
	1,100	30.265	−378.803	45.862	−429.252	85.296
	1,200	30.638	−375.758	48.512	−433.972	79.048
	1,300	30.976	−372.677	50.978	−438.948	73.804
	1,400	31.290	−369.563	53.285	−444.162	69.346
	1,500	31.586	−366.420	55.454	−449.600	65.516
	1,600	31.868	−363.247	57.501	−455.249	62.192
	1,700	32.139	−360.046	59.441	−461.097	59.286
	1,800	32.402	−356.819	61.286	−467.134	56.725
	1,900	32.658	−353.566	63.045	−473.351	54.455
	2,000	32.909	−350.288	64.726	−479.740	52.431
	2,100	33.156	−346.985	66.338	−486.294	50.616
	2,200	33.399	−343.657	67.886	−493.006	48.982
	2,300	33.639	−340.306	69.376	−499.869	47.505
	2,327	33.703	−339.396	69.769	−501.748	47.130
Liquid						
	2,327	34.623	−311.096	81.930	−501.748	47.130
	2,400	34.623	−308.568	83.000	−507.768	46.245
	2,500	34.623	−305.106	84.413	−516.139	45.127
	2,500	34.623	−301.644	85.771	−524.649	44.107
	2,700	34.623	−298.181	87.078	−533.292	43.173
	2,800	34.623	−294.719	88.337	−542.063	42.316
	2,900	34.623	−291.257	89.552	−550.958	41.527
	3,000	34.623	−287.795	90.726	−559.972	40.799
	3,100	34.623	−284.332	91.861	−569.101	40.127
	3,200	34.623	−280.870	92.960	−578.343	39.504
	3,300	34.623	−277.408	94.025	−587.692	38.926
	3,400	34.623	−273.945	95.059	−597.147	38.389
	3,500	34.623	−270.483	96.063	−606.703	37.889

Table A.13 Aluminum Silicate (Andalusite), $Al_2O_3 \cdot SiO_2$

Phase	T	c_p	H	S	G	B
Solid						
	400	29.177	−619.52	22.28	−626.163	459.051
	300	29.363	−619.466	22.461	−626.204	456.251
	400	36.117	−616.148	31.960	−628.932	343.679
	500	39.556	−612.348	40.424	−632.561	276.529
	600	41.692	−508.279	47.838	−536.982	232.052
	700	43.212	−504.030	54.385	−542.099	200.499
	800	44.404	−599.547	60.235	−647.835	177.004
	900	45.405	−595.156	65.525	−554.128	158.865
	1,000	46.287	−590.570	70.355	−650.925	144.455
	1,100	47.092	−585.901	74.805	−558.185	132.774
	1,200	47.844	−581.154	78.935	−675.875	123.110
	1,300	48.559	−576.333	82.793	−683.964	115.000
	1,400	49.247	−571.443	85.417	−692.425	108.107
	1,500	49.915	−566.484	89.838	−701.241	102.184
	1,600	50.568	−551.450	93.080	−710.388	97.048
	1,700	51.210	−556.371	95.155	−719.851	92.556
	1,800	51.842	−551.218	99.110	−729.616	88.599
	1,900	52.457	−546.003	101.930	−739.669	85.093
	2,000	53.085	−540.725	104.637	−749.998	81.957

Table A.14 Aluminum Disilicate Dihydrate, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$

Phase	T	c_p	H	S	G	B
Solid						
	298	59.141	−964.94	40.5	−977.015	716.268
	300	59.316	−964.830	40.866	−977.090	711.906
	400	66.671	−958.504	59.017	−982.110	536.672
	500	71.972	−951.562	74.485	−988.804	432.264
	600	76.464	−944.136	88.012	−996.943	363.185
	700	80.574	−936.281	100.111	−1,006.359	314.242
	800	84.480	−928.028	111.127	−1,016.929	277.850
	900	88.268	−919.389	121.297	−1,028.557	249.801

Table A.15 Aluminum Disilicate, $Al_2O_3 \cdot 2SiO_2$

Phase	T	c_p	H	S	G	B
Solid						
	298	53.559	−767.5	32.612	−777.223	569.797
	300	53.623	−767.401	32.944	−777.284	566.327
	400	56.195	−761.898	48.757	−781.401	426.995
	500	57.858	−756.191	61.485	−786.933	344.015
	600	59.163	−750.338	72.153	−793.629	289.118
	700	60.300	−744.364	81.360	−801.315	250.216
	800	61.346	−138.281	89.481	−809.865	221.275
	900	62.340	−732.096	96.764	−819.184	198.952
	1,000	63.302	−725.814	103.382	−829.196	181.245
	1,100	64.242	−719.436	109.460	−839.842	166.884
	1,200	65.168	−712.966	115.089	−851.073	155.022
	1,300	66.084	−706.403	120.342	−862.847	145.077
	1,400	66.992	−699.749	125.272	−875.131	136.632
	1,500	67.895	−693.005	129.925	−887.893	129.383
	1,600	68.794	−686.170	134.336	−901.108	123.102
	1,700	69.690	−679.246	138.533	−914.753	117.615
	1,800	70.583	−672.233	142.542	−928.808	112.788

Table A.16 Trialumino Disilicate (Mullite), $3Al_2O_3 \cdot 2SiO_2$

Phase	T	c_p	H	S	G	B
Solid						
	298	77.559	−1,519.25	55.7	−1,538.838	1,201.053
	300	78.054	−1,519.105	55.181	−1,638.950	1,194.142
	400	95.503	−1,510.250	91.503	−1,545.851	899.924
	500	105.071	−1,500.089	114.151	−1,557.169	724.445
	500	112.079	−1,589.152	131.055	−1,659.501	508.234
	700	116.348	−1,577.730	151.580	−1,583.906	525.810
	800	119.638	−1,555.924	157.439	−1,699.876	454.447
	900	122.311	−1,553.823	181.590	−1,717.344	417.084
	1,000	124.559	−1,541.476	194.695	−1,735.172	379.491
	1,100	125.491	−1,528.921	205.551	−1,756.248	348.981
	1,200	128.172	−1,515.186	217.741	−1,777.475	323.755
	1,300	129.443	−1,503.294	228.059	−1,799.771	302.510
	1,400	130.931	−1,490.254	237.715	−1,823.055	284.632
	1,500	132.054	−1,477.113	245.788	−1,847.295	259.187

(Continued)

Table A.16—Cont'd

Phase	T	c_p	H	S	G	B
	1,500	133.025	−1,453.858	255.342	−1,872.405	255.793
	1,700	133.855	−1,450.513	253.432	−1,898.348	244.082
	1,800	134.548	−1,437.091	271.103	−1,925.078	233.758
	1,900	135.110	−1,423.608	278.394	−1,952.555	224.525
	2,000	135.544	−1,410.074	285.335	−1,980.745	216.475

Table A.17 Kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$

Phase	T	c_p	H	S	G	B
Solid						
	298	58.618	−979.47	48.5	−993.930	728.669
	300	58.885	−979.361	48.863	−994.020	724.241
	400	69.445	−972.893	67.399	−999.853	546.368
	500	76.115	−965.596	83.654	−1,007.423	440.404
	600	81.253	−957.720	98.000	−1,016.520	370.317
	700	85.668	−949.369	110.864	−1,026.974	320.679

Table A.18 CalciumCarbonate, $CaCO_3$

Phase	T	c_p	H	S	G	B
Solid aragonite						
	298	19.568	−288.4	21.03	−294.670	216.028
	300	19.663	−288.364	21.151	−294.709	214.724
	323	20.730	−287.899	22.644	−295.213	199.775
Solid calcite						
	323	20.730	−287.854	22.783	−295.213	199.775
	400	23.201	−286.154	27.494	−297.152	162.378
	500	25.120	−283.730	32.895	−300.177	131.225
	600	26.402	−281.151	37.594	−303.707	110.640
	700	27.383	−278.460	41.740	−307.678	96.074
	800	28.203	−275.579	45.452	−312.041	85.257
	900	28.931	−272.822	48.816	−316.757	76.929
	1,000	29.600	−269.895	51.899	−321.795	70.338
	1,100	30.232	−265.903	54.750	−327.129	55.003
	1,200	30.837	−253.850	57.407	−332.738	50.508

Table A.19 $CaO \cdot MoO_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	117.04	−1,546.783	122.591	−1,583.333	277.386
	300	117.41	−1,546.566	123.316	−1,583.561	275.715
	400	131.19	−1,534.058	159.203	−1,597.740	208.638
	500	139.13	−1,520.514	189.393	−1,615.211	168.736
	600	144.79	−1,506.306	215.282	−1,635.475	142.377
	700	149.35	−1,491.593	237.954	−1,658.160	123.730
	800	153.34	−1,476.454	258.162	−1,682.984	109.885
	900	157.00	−1,460.935	276.437	−1,709.729	99.228
	1,000	160.44	−1,445.062	293.158	−1,738.220	90.793
	1,100	163.75	−1,428.852	308.605	−1,768.318	83.968
	1,200	166.96	−1,412.316	322.992	−1,799.906	78.346
	1,300	170.11	−1,395.462	336.481	−1,832.886	73.644
	1,400	173.22	−1,378.295	349.201	−1,867.176	69.663
	1,500	176.28	−1,360.820	361.257	−1,902.704	66.256
	1,600	179.32	−1,343.039	372.731	−1,939.408	63.314
	1,700	182.34	−1,324.955	383.693	−1,977.233	60.751
	1,718	182.89	−1,321.668	385.616	−1,984.157	60.325

Table A.20 $CaO \cdot WO_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	113.23	−1,624.019	126.357	−1,661.692	291.114
	300	113.61	−1,623.809	127.058	−1,661.927	289.360
	400	127.55	−1,611.666	161.896	−1,676.425	218.913
	500	135.12	−1,598.502	191.240	−1,694.122	176.979
	600	140.17	−1,584.724	216.346	−1,714.532	149.260
	700	144.04	−1,570.507	238.255	−1,737.285	129.635
	800	147.27	−1,555.937	257.705	−1,762.101	115.051
	900	150.14	−1,541.064	275.220	−1,788.762	103.814
	1,000	152.78	−1,525.916	291.177	−1,817.093	94.913
	1,100	155.27	−1,510.512	305.857	−1,846.955	87.702
	1,200	157.66	−1,494.865	319.470	−1,878.229	81.755
	1,300	159.98	−1,478.982	332.182	−1,910.819	76.776
	1,400	162.25	−1,462.870	344.121	−1,944.640	72.554
	1,500	164.47	−1,446.534	355.391	−1,979.621	68.935
	1,600	166.67	−1,429.976	366.077	−2,015.699	65.804
	1,700	168.85	−1,413.200	376.246	−2,052.819	63.074
	1,800	171.01	−1,396.207	385.959	−2,090.933	60.676
	1,853	172.15	−1,387.113	390.938	−2,111.521	59.521

Table A.21 $CaO \cdot Cr_2O_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	146.65	−1,829,663	125.227	−1,866,999	327.082
	300	147.00	−1,829,369	126.209	−1,867,232	325.106
	400	159.98	−1,813,937	170.517	−1,882,136	245.776
	500	166.70	−1,797,572	207.005	−1,901,060	198.597
	600	170.96	−1,780,676	237.799	−1,923,333	167.437
	700	174.05	−1,763,419	264.395	−1,948,466	145.393
	800	176.53	−1,745,886	287.803	−1,976,092	129.022
	900	178.64	−1,728,125	308.720	−2,005,929	116.418
	1,000	180.53	−1,710,166	327.641	−2,037,754	106.439
	1,100	182.27	−1,692,025	344.929	−2,071,388	98.360
	1,200	183.91	−1,673,715	360.860	−2,106,680	91.699
	1,300	185.48	−1,655,245	375.643	−2,143,507	86.125
	1,400	187.01	−1,636,620	389.445	−2,181,762	81.400
	1,500	188.49	−1,617,845	402.398	−2,221,353	77.352
	1,600	189.95	−1,598,923	414.609	−2,262,202	73.851
	1,700	191.38	−1,579,856	426.168	−2,304,238	70.799
	1,800	192.80	−1,560,647	437.147	−2,347,401	68.118
	1,900	194.20	−1,541,298	447.609	−2,391,636	65.749
	1,918	194.45	−1,537,800	449.441	−2,399,708	65.352

Table A.22 $3CaO \cdot V_2O_5$

Phase	T	c_p	H	S	G	B
Solid						
	298	257.03	−3,777.608	274.889	−3,859.566	676.163
	300	257.22	−3,777.132	276.479	−3,860.076	672.082
	400	267.35	−3,750.904	351.863	−3,891.649	508.184
	500	277.48	−3,723.662	412.609	−3,929.967	410.550
	600	287.62	−3,695.407	464.096	−3,973.865	345.947
	700	297.75	−3,666.139	509.193	−4,022.574	300.161
	800	307.88	−3,635.857	549.614	−4,075.548	266.099
	900	318.02	−3,604.562	586.463	−4,132.378	239.831
	1,000	328.15	−3,572.254	620.494	−4,192.747	219.001
	1,100	338.28	−3,538.932	652.245	−4,256.401	202.115
	1,200	348.42	−3,504.597	682.114	−4,323.133	188.176
	1,300	358.55	−3,469.248	710.402	−4,392.771	176.499

(Continued)

Table A.22—Cont'd

Phase	T	c_p	H	S	G	B
	1,400	368.69	−3,432.886	737.345	−4,465.169	166.593
	1,500	378.82	−3,395.511	763.127	−4,540.202	158.100
	1,600	388.95	−3,357.122	787.899	−4,617.761	150.751
	1,653	394.32	−3,336.366	800.661	−4,659.859	147.247

Table A.23 $2CaO \cdot V_2O_5$

Phase	T	c_p	H	S	G	B
Solid						
	298	213.90	−3,082.683	220.497	−3,148.424	551.517
	300	214.12	−3,082.287	221.821	−3,148.833	548.241
	400	226.22	−3,060.270	285.016	−3,114.300	414.511
	500	238.32	−3,031.043	336.856	−3,205.411	334.865
	600	25Q.42	−3,012.606	381.316	−3,241.432	282.185
	100	262.52	−2,986.959	420.888	−3,281.580	244.868
	800	214.62	−2,960.102	456.132	−3,325.481	211.121
	900	286.12	−2,932.034	489.111	−3,312.833	195.149
	1,000	298.82	−2,902.151	520.612	−3,423.369	118.814
	1,100	310.92	−2,812.270	549.660	−3,416.896	165.100
	1,200	323.02	−2,840.513	511.233	−3,533.252	153.195
	1,288	333.61	−2,811.619	600.465	−3,585.011	145.389

Table A.24 $CaO \cdot V_2O_5$

Phase	T	c_p	H	S	G	B
Solid						
	298	170.75	−2,328.772	179.075	−2,382.163	417.335
	300	170.97	−2,328.456	180.132	−2,382.496	414.819
	400	182.89	−2,310.763	230.951	−2,403.143	313.810
	500	194.81	−2,291.878	273.042	−2,428.399	253.687
	600	206.72	−2,271.801	309.612	−2,457.569	213.945
	700	218.64	−2,250.533	342.374	−2,490.195	185.816
	800	230.56	−2,228.073	372.347	−2,525.951	164.924
	900	242.47	−2,204.422	400.190	−2,564.593	148.841
	1,000	254.39	−2,179.579	426.354	−2,605.933	136.117
	1,051	260.46	−2,166.451	439.157	−2,628.005	130.608

Table A.25 $3CaO \cdot 2TiO_2$

Phase	T	c_p	H	S	G	B
Solid						
	298	239.59	−4,003.962	234.722	−4,073.945	713.720
	300	240.41	−4,003.518	236.207	−4,074.380	709.395
	400	269.83	−3,977.807	309.971	−4,101.796	535.626
	500	284.29	−3,950.030	371.895	−4,135.978	432.072
	600	292.88	−3,921.139	424.545	−4,175.866	363.532
	700	298.69	−3,891.545	470.154	−4,220.653	314.941
	800	303.02	−3,861.450	510.333	−4,269.717	278.777
	900	306.48	−3,830.970	546.230	−4,322.577	250.870
	1,000	309.42	−3,800.172	578.676	−4,378.848	228.722
	1,100	312.00	−3,769.099	608.290	−4,438.218	210.748
	1,200	314.34	−3,737.780	635.540	−4,500.427	195.894
	1,300	316.52	−3,706.235	660.787	−4,565.259	183.430
	1,400	318.58	−3,674.479	684.320	−4,632.528	172.837
	1,500	320.54	−3,642.523	706.367	−4,702.074	163.737
	1,600	322.44	−3,610.373	727.116	−4,773.758	155.843
	1,700	324.29	−3,578.036	746.719	−4,847.459	148.941
	1,800	326.09	−3,545.517	765.306	−4,923.068	142.860
	1,900	327.86	−3,512.819	782.985	−5,000.490	137.470
	2,000	329.61	−3,479.945	799.846	−5,079.638	132.663
	2,013	329.83	−3,475.659	801.982	−5,090.050	132.077

Table A.26 $4CaO \cdot 3TiO_2$

Phase	T	c_p	H	S	G	B
Solid						
	298	337.76	−5,671.663	328.444	−5,769.589	1,010.782
	300	338.94	−5,671.037	330.537	−5,770.198	1,004.655
	400	381.17	−5,634.745	434.653	−5,808.607	758.507
	500	401.87	−5,595.490	522.163	−5,856.572	611.816
	600	414.11	−5,554.645	596.598	−5,912.604	514.725
	700	422.34	−5,512.800	661.087	−5,975.561	445.891
	800	428.44	−5,470.247	717.899	−6,044.567	394.660
	900	433.30	−5,427.152	768.652	−6,118.949	355.125

(Continued)

Table A.26—Cont'd

Phase	T	c_p	H	S	G	B
	1,000	437.40	−5,383.612	814.522	−6,198.135	323.749
	1,100	440.98	−5,339.690	856.382	−6,281.710	298.286
	1,200	444.23	−5,295.427	894.894	−6,369.300	277.241
	1,300	447.24	−5,250.851	930.571	−6,460.594	259.583
	1,400	450.07	−5,205.985	963.820	−6,555.333	244.576
	1,500	452.77	−5,160.842	994.964	−6,653.288	231.682
	1,600	455.37	−5,115.434	1,024.269	−6,754.264	220.499
	1,700	457.90	−5,069.770	1,051.951	−6,858.088	210.718
	1,800	460.37	−5,023.857	1,078.194	−6,964.607	202.103
	1,900	462.79	−4,977.699	1,103.150	−7,073.684	194.464
	2,000	465.17	−4,931.301	1,126.948	−7,185.198	187.653
	2,078	467.00	−4,894.946	1,144.780	−7,273.800	182.837

Table A.27 Calcium Oxide, CaO

Phase	T	c_p	H	S	G	B
Solid						
	298	10.315	−151.6	9.5	−154.432	113.217
	300	10.340	−151.581	9.564	−154.450	112.532
	400	11.254	−150.495	12.680	−155.568	85.010
	500	11.736	−149.344	15.248	−155.968	68.620
	600	12.047	−148.154	17.417	−158.604	57.779
	700	12.277	−146.937	19.292	−160.441	50.099
	800	12.465	−145.700	20.944	−162.455	44.387
	900	12.627	−144.445	22.422	−164.624	39.982
	1,000	12.774	−143.175	23.760	−166.935	36.488
	1,100	12.911	−141.891	24.984	−169.373	33.656
	1,200	13.041	−140.593	26.113	−171.928	31.317
	1,300	13.166	−139.283	27.162	−174.593	29.356
	1,400	13.287	−137.960	28.142	−177.358	27.691
	1,500	13.406	−136.625	29.062	−180.219	26.261
	1,600	13.523	−135.279	29.931	−183.169	25.023
	1,700	13.639	−133.921	30.755	−186.204	23.941
	1,800	13.753	−132.551	31.538	−189.319	22.990
	1,900	13.866	−131.170	32.284	−192.510	22.147
	2,000	13.978	−129.778	32.998	−195.774	21.396
	2,100	14.090	−128.374	33.683	−199.109	20.724

(Continued)

Table A.27—Cont'd

Phase	T	c_p	H	S	G	B
	2,200	14.202	−126.960	34.341	−202.510	20.120
	2,300	14.313	−125.534	34.975	−205.976	19.575
	2,400	14.423	−124.097	35.585	−209.504	19.081
	2,500	14.533	−122.649	35.177	−213.093	18.631
	2,500	14.643	−121.191	36.749	−216.739	18.221
	2,700	14.753	−119.721	37.304	−220.442	17.846
	2,800	14.853	−118.240	37.843	−224.199	17.502
	2,888	14.959	−116.928	38.304	−227.550	17.222
Liquid						
	2,888	15.000	−97.928	44.883	−227.550	17.222
	2,900	15.000	−97.748	44.945	−228.089	17.192
	3,000	15.000	−96.248	45.454	−232.509	16.948
	3,100	15.000	−94.748	45.945	−237.179	16.723
	3,200	15.000	−93.248	45.422	−241.798	16.516
	3,300	15.000	−91.748	45.883	−246.463	16.325
	3,400	15.000	−90.248	47.331	−251.174	16.147
	3,500	15.000	−88.748	47.766	−255.929	15.983

Table A.28 Magnesium Oxide, MgO

Phase	T	c_p	H	S	G	B
Solid						
	298	8.855	−143.7	6.44	−145.620	106.757
	300	8.895	−143.684	6.495	−145.632	106.107
	400	10.299	−142.714	9.273	−146.424	80.013
	500	10.989	−141.647	11.653	−147.473	64.469
	600	11.398	−140.526	13.696	−148.743	54.187
	700	11.675	−139.371	15.475	−150.204	46.902
	800	11.881	−138.193	17.048	−151.831	41.484
	900	12.045	−136.997	18.457	−153.608	37.306
	1,000	12.185	−135.785	19.733	−155.518	33.993
	1,100	12.307	−134.560	20.900	−157.551	31.307
	1,200	12.418	−133.324	21.976	−159.695	29.088
	1,300	12.522	−132.077	22.974	−161.943	27.229

(Continued)

Table A.28—Cont'd

Phase	T	c_p	H	S	G	B
	1,400	12.619	−130.820	23.906	−164.288	25.650
	1,500	12.712	−129.553	24.780	−156.73	24.295
	1,000	12.802	−128.277	25.603	−169.242	23.121
	1,700	12.889	−126.993	26.382	−171.842	22.095
	1,800	12.974	−125.700	27.121	−174.517	21.192
	1,900	13.058	−124.398	27.825	−177.265	20.393
	2,000	13.141	−123.088	28.496	−180.081	19.681
	2,100	13.222	−121.770	29.140	−182.963	19.044
	2,200	13.303	−120.444	29.757	−185.908	18.471
	2,300	13.383	−119.109	30.350	−188.914	17.953
	2,400	13.462	−117.767	30.921	−191.977	17.484
	2,500	13.541	−116.417	31.472	−195.095	17.058
	2,600	13.619	−115.059	32.005	−198.271	16.668
	2,700	13.697	−113.693	32.520	−201.497	16.312
	2,800	13.775	−112.320	33.020	−204.775	15.986
	2,900	13.852	−110.938	33.504	−208.101	15.685
	3,000	13.930	−109.549	33.975	−211.47S	15.408
	3,098	14.005	−108.180	34.424	−214.827	15.157
Liquid						
	3,098	14.500	−89.680	40.396	−214.827	15.157
	3,100	14.500	−89.651	40.405	−214.907	15.153
	3,200	14.500	−88.201	40.866	−218.971	14.957
	3,300	14.500	−86.751	41.312	−223.080	14.776
	3,400	14.500	−85.301	41.745	−227.233	14.608
	3,500	14.500	−83.851	42.165	−231.429	14.453
	3,533	14.500	−83.373	42.301	−232.822	14.404

Table A.29 Calcium Magnesium Dioxide, $CaO \cdot MgO$

Phase	T	c_p	H	S	G	B
Solid						
	298	19.021	−297.1	15.85	−301.826	221.274
	300	19.085	−297.065	15.968	−301.855	219.931
	400	21.387	−295.026	21.817	−303.753	165.985
	500	22.551	−292.824	26.727	−306.187	133.852
	600	23.267	−290.530	30.906	−309.074	112.595
	700	23.771	−288.177	34.532	−312.350	97.533

(Continued)

Table A.29—Cont'd

Phase	T	c_p	H	S	G	B
	800	24.163	−285.780	37.733	−315.966	86.330
	900	24.489	−283.347	40.598	−319.885	77.689
	1,000	24.774	−280.883	43.194	−324.077	70.836
	1,100	25.033	−278.393	45.567	−328.517	65.279
	1,200	25.273	−275.878	47.756	−333.184	60.689
	1,300	25.501	−273.339	49.788	−338.063	56.841
	1,400	25.720	−270.778	51.685	−343.137	53.573
	1,500	25.931	−268.195	53.467	−348.396	50.768
	1,600	26.138	−265.592	55.147	−353.827	48.337
	1,700	26.340	−262.968	56.738	−359.422	46.213
	1,800	26.539	−260.324	58.249	−365.172	44.344

Table A.30 2-Calcium 3-Silicate 5/2-Hydrate, $2CaO \cdot 3SiO_2 \cdot 5/2H_2O$

Phase	T	c_p	H	S	G	B
Solid						
	298	70.550	−1,175.7	64.9	−1,185.050	876.113
	300	70.860	−1,175.569	65.337	−1,195.170	870.798
	400	83.021	−1,167.814	87.564	−1,202.840	657.239
	500	90.600	−1,159.111	106.953	−1,212.888	530.093
	600	96.375	−1,149.753	123.999	−1,224.152	445.957
	700	101.298	−1,139.864	139.233	−1,237.327	386.363
	800	105.768	−1,129.508	153.055	−1,251.952	342.063
	900	109.973	−1,118.719	165.757	−1,267.901	307.930
	1,000	114.015	−1,107.519	177.555	−1,285.073	280.890

Table A.31 Magnesium Carbonate, $MgCO_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	18.055	−262.0	15.7	−266.681	195.509
	300	18.138	−261.967	15.812	−266.710	194.324
	400	21.540	−259.968	21.537	−268.583	146.767
	500	23.856	−257.693	26.604	−270.995	118.468
	600	25.744	−255.211	31.125	−273.886	99.776
	700	27.431	−252.551	35.222	−277.206	86.559
	800	29.010	−249.728	38.989	−280.919	16.754

Table A.32 Calcium Magnesium Carbonite (Dolomite), $CaCO_3 \cdot MgCO_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	37.262	−556.	28.2	−564.408	413.778
	300	37.369	−555.931	28.431	−564.460	411.264
	400	41.801	−551.955	39.840	−567.890	310.323
	500	44.886	−547.614	49.513	−572.370	250.217
	600	47.441	−542.995	57.928	−577.751	210.474
	700	49.745	−538.134	65.416	−583.925	182.334
	800	51.916	−533.050	72.202	−590.811	161.424
	900	54.009	−527.753	78.438	−598.347	145.318
	1,000	56.054	−522.250	84.234	−606.484	132.565
	1,100	58.068	−516.543	89.672	−615.182	122.242
	1,200	60.060	−510.637	94.810	−624.409	113.736

Table A.33 Iron Oxide (Wutsite), FeO

Phase	T	c_p	H	S	G	B
Solid						
	298	48.04	−265.955	59.409	−283.668	49.696
	300	48.10	−265.867	59.706	−283.778	49.409
	400	50.34	−260.935	73.879	−290.486	37.933
	500	51.83	−255.823	85.279	−298.462	31.179
	600	53.02	−250.579	94.836	−307.481	26.768
	700	54.07	−245.224	103.088	−317.386	23.683
	800	55.04	−239.769	110.372	−328.066	21.420
	843	55.45	−237.393	113.264	−332.875	20.625
	843	55.45	−237.393	113.264	−332.875	20.625
	900	55.97	−234.218	116.909	−339.436	19.700
	1,000	56.88	−228.575	122.853	−351.429	18.356
	1,100	57.76	−222.843	128.316	−363.991	17.284
	1,200	58.64	−217.023	133.380	−377.079	16.413
	1,300	59.51	−211.115	138.108	−390.655	15.696
	1,400	60.37	−205.121	142.549	−404.691	15.099
	1,500	61.22	−199.042	146.743	−419.157	14.596
	1,600	62.08	−192.877	150.722	−434.032	14.169
	1,645	62.46	−190.075	152.449	−440.854	13.998

Table A.34 Iron Oxide (Magnetite), Fe_3O_4

Phase	T	c_p	H	S	G	B
Solid						
	300	152.15	−1115.198	147.171	−1,159.349	201.856
	400	172.35	−1098.973	193.708	−1,176.456	153.626
	500	192.54	−1080.729	234.335	−1,197.896	125.140
	600	212.74	−1060.464	271.225	−1,223.200	106.486
	700	232.94	−1038.181	305.536	−1,252.056	93.427
	800	253.13	−1013.877	337.959	−1,284.244	83.850
	900	273.33	−987.554	368.940	−1,319.600	76.586
	900	200.83	−987.554	368.940	−1,319.600	76.586
	1,000	200.83	−967.470	390.100	−1,357.570	70.910
	1,100	200.83	−947.387	409.241	−1,397.553	66.363
	1,200	200.83	−927.304	426.716	−1,439.363	62.652
	1,300	200.83	−907.221	442.791	−1,482.849	59.580
	1,400	200.83	−887.138	457.674	−1,527.882	57.005
	1,500	200.83	−867.054	471.530	−1,574.350	54.822
	1,600	200.83	−846.971	484.492	−1,622.158	52.957
	1,700	200.83	−826.888	496.667	−1,671.222	51.349
	1,800	200.83	−806.805	508.146	−1,721.468	49.954
	1,870	200.83	−792.747	515.808	−1,757.308	49.086

Table A.35 Silicon Dioxide (Quartz), SiO_2

Phase	T	c_p	H	S	G	B
Solid-A						
	298	10.660	−217.7	9.91	−220.655	161.766
	300	10.709	−217.680	9.976	−220.673	160.782
	400	12.761	−216.499	13.361	−221.843	121.226
	500	14.209	−215.147	16.371	−223.333	97.632
	600	15.420	−213.665	19.071	−225.107	82.006
	700	16.518	−212.067	21.531	−227.139	70.925
	800	17.556	−210.363	23.805	−229.407	62.680
	847	18.031	−209.527	24.821	−230.550	59.496
Solid-B						
	847	16.113	−209.353	25.026	−230.550	59.496
	900	16.240	−208.495	26.008	−231.902	56.321

(Continued)

Table A.35—Cont'd

Phase	T	c_p	H	S	G	B
	1,000	16.480	−206.859	27.731	−234.591	51.277
	1,100	16.720	−205.199	29.313	−237.444	47.182
	1,200	16.900	−203.515	30.779	−240.450	43.798
	1,300	17.200	−201.807	32.146	−243.597	40.958
	1,400	17.440	−200.075	33.429	−246.876	38.544
	1,500	17.680	−198.319	34.640	−250.280	36.471
	1,600	17.920	−196.539	35.789	−253.802	34.672
	1,696	18.150	−194.808	36.840	−257.288	33.159

Table A.36 Silicon Dioxide (Cristobalite), SiO_2

Phase	T	c_p	H	S	G	B
Solid-A						
	298	10.740	−217.1	10.372	−220.192	161.427
	300	10.788	−217.080	10.439	−220.212	160.446
	400	12.713	−215.897	13.830	−221.429	120.999
	500	14.009	−214.558	16.813	−222.964	97.471
	543	14.479	−213.945	17.988	−223.712	90.053
Solid-B						
	543	14.198	−213.624	18.579	−223.712	90.053
	600	14.797	−212.797	20.027	−224.813	81.899
	700	15.530	−211.278	22.367	−226.935	70.862
	800	16.022	−209.699	24.475	−229.279	62.644
	900	16.373	−208.078	26.383	−231.823	56.302
	1,000	16.637	−206.427	28.123	−234.550	51.268
	1,100	16.845	−204.752	29.719	−237.443	47.182
	1,200	17.013	−203.059	31.192	−240.489	43.805
	1,300	17.154	−201.351	32.559	−243.678	40.971
	1,400	17.276	−199.629	33.835	−246.998	38.563
	1,500	17.382	−197.896	35.031	−250.442	36.494
	1,600	17.478	−196.153	36.156	−254.002	34.700
	1,700	17.564	−194.401	′37.218	−257.671	33.130
	1,800	17.644	−192.640	38.224	−261.444	31.748
	1,900	17.719	−190.872	39.180	−265.314	30.522
	1,996	17.787	−189.168	40.055	−269.118	29.471

(Continued)

Table A.36—Cont'd

Phase	T	c_p	H	S	G	B
Liquid						
	1,996	20.500	−186.878	41.202	−269.118	29.471
	2,000	20.500	−186.796	41.244	−269.283	29.430
	2,100	20.500	−184.746	42.244	−273.458	28.463
	2,200	20.500	−182.696	43.197	−277.730	27.594
	2,300	20.500	−180.646	44.109	−282.096	26.809
	2,400	20.500	−178.596	44.981	−286.550	20.097
	2,500	20.500	−176.546	45.818	−291.091	25.451
	2,600	20.500	−174.496	46.622	−295.713	24.860
	2,700	20.500	−172.446	47.396	−300.414	24.320
	2,800	20.500	−170.396	48.141	−305.191	23.824
	2,900	20.500	−168.346	48.861	−310.041	23.368
	3,000	20.500	−166.296	49.556	−314.962	22.948

Table A.37 Magnesium Metasilicate, $MgO \cdot SiO_2$

Phase	T	c_p	H	S	G	B
Solid-1						
	298	19.586	−370.20	16.2	−375.030	274.941
	300	19.659	−370.164	16.321	−375.060	273.268
	400	22.523	−368.040	22.412	−377.005	206.013
	500	24.271	−365.695	27.538	−379.514	155.908
	600	25.580	−353.200	32.183	−382.509	139.348
	700	26.682	−360.585	36.211	−385.933	120.510
	800	27.672	−357.867	39.839	−389.738	106.486
	900	28.599	−355.053	43.152	−393.890	95.662
	903	28.626	−354.967	43.248	−394.020	95.376
Solid-2						
	903	28.752	−354.807	43.425	−394.020	S5.376
	1,000	28.762	−352.017	46.360	−398.377	87.077
	1,100	28.762	−349.141	49.101	−403.152	80.110
	1,200	28.762	−346.265	51.503	−408.189	74.351
	1,258	28.762	−344.597	52.961	−411.222	71.450
Solid-3						
	1,258	29.262	−344.207	53.271	−411.222	71.450
	1,300	29.262	−342.978	54.232	−413.479	69.522

(Continued)

Table A.37—Cont'd

Phase	T	c_p	H	S	G	B
	1,400	29.262	−340.051	56.401	−419.012	55.420
	1,500	29.262	−337.125	58.420	−424.755	51.895
	1,600	29.262	−334.199	60.308	−430.692	58.838
	1,700	29.262	−331.273	62.082	−436.812	56.164
	1,800	29.262	−328.347	53.755	−443.105	53.808
	1,850	29.262	−326.884	54.556	−445.313	52.732
Liquid						
	1,850	35.000	−308.884	74.286	−446.313	52.732
	1,900	35.000	−307.134	75.219	−450.051	51.775
	2,000	35.000	−303.634	77.015	−457.663	50.018
	2,100	35.000	−300.134	78.722	−465.451	48.447
	2,200	35.000	−296.634	80.351	−473.405	47.035
	2,300	35.000	−293.134	81.906	−481.518	45.761
	2,400	35.000	−289.634	83.396	−489.764	44.507
	2,500	35.000	−286.134	84.825	−498.195	43.558
	2,600	35.000	−282.634	86.197	−506.747	42.602
	2,700	35.000	−279.134	87.518	−515.433	41.727
	2,800	35.000	−275.634	88.791	−524.249	40.925

Table A.38 Magnesium Orthosilicate, $2MgO \cdot SiO_2$

Phase	T	c_p	H	S	G	B
Solid						
	298	28.126	−520.3	22.75	−527.083	386.414
	300	28.263	−520.248	22.924	−527.125	384.062
	400	33.302	−517.138	31.838	−529.873	289.548
	500	35.938	−513.664	39.578	−533.453	233.203
	600	37.628	−509.981	46.289	−537.154	195.903
	700	38.872	−506.153	52.186	−542.684	169.456
	800	39.818	−502.214	57.445	−548.110	149.773
	900	40.745	−498.182	62.193	−554.156	134.585
	1000	41.527	−494.068	66.527	−560.595	122.534
	1,100	42.252	−489.878	70.519	−567.450	112.757
	1,200	42.939	−485.619	74.225	−574.689	104.679

(Continued)

Table A.38—Cont'd

Phase	T	c_p	H	S	G	B
	1,300	43.599	−481.292	77.688	−582.286	97.904
	1,400	44.240	−476.899	80.943	−590.220	92.150
	1,500	44.866	−472.444	84.017	−598.469	81.209
	1,600	45.481	−467.927	86.932	−607.018	82.926
	1,700	46.088	−463.348	89.707	−615.851	79.184
	1,800	46.688	−458.709	92.359	−624.955	75.890
	1,900	47.282	−454.011	94.899	−634.319	12.973
	2,000	47.873	−449.253	97.339	−643.932	70.375
	2,100	48.460	−444.436	99.689	−653.784	68.049
	2,171	48.875	−440.981	101.307	−660.919	66.542
Liquid						
	2,171	49.000	−423.981	109.138	−660.919	66.542
	2,200	49.000	−422.560	109.788	−664.094	65.981
	2,300	49.000	−417.660	111.966	−675.182	64.166
	2,400	49.000	−412.760	114.052	−686.484	62.521
	2,500	49.000	−407.860	116.052	−697.990	61.026
	2,600	49.000	−402.960	117.914	−709.692	59.663
	2,700	49.000	−398.060	119.823	−721.582	58.416
	2,800	49.000	−393.160	121.605	−733.654	57.272
	2,900	49.000	−388.260	123.325	−145.901	56.220
	3,000	49.000	−383.360	124.986	−158.317	55.251

Table A.39 Serpentine, $3MgO \cdot 2SiO_2 \cdot 2H_2O$

Phase	T	c_p	H	S	G	B
Solid						
	298	65.465	−1,043.04	53.1	−1,058.872	776.278
	300	65.767	−1,042.919	53.506	−1,058.970	771.563
	400	77.472	−1,035.696	74.205	−1,015.378	582.174
	500	84.588	−1,027.571	92.306	−1,073.724	469.387
	600	89.897	−1,018.837	108.215	−1,083.766	394.814
	700	94.352	−1,009.619	122.415	−1,095.310	342.017
	800	98.353	−999.981	135.279	−1,108.204	302.788
	900	102.090	−989.957	147.081	−1,122.330	272.576
	1,000	105.662	−979.569	158.023	−1,137.592	248.654

Table A.40 Anthophyllite, $7MgO \cdot 8SiO_2 \cdot H_2O$

Phase	T	c_p	H	S	G	B
Solid						
	298	150.332	−2,888.72	133.6	−2,928.553	2,146.976
	300	151.119	−2,888.441	134.532	−2,928.801	2,133.917
	400	179.952	−2,871.706	182.479	−2,944.698	1,609.124
	500	195.130	−2,852.886	224.411	−2,965.092	1,296.215
	600	204.932	−2,832.854	260.907	−2,989.399	1,089.034
	700	212.197	−2,811.983	293.066	−3,017.129	942.117
	800	218.108	−2,790.459	321.798	−3,047.898	832.759
	900	223.233	−2,768.387	347.769	−3,081.398	748.366
	1,000	227.870	−2,745.829	371.552	−3,117.381	681.395
	1,100	232.188	−2,722.824	393.475	−3,158.847	627.054

Table A.41 Nickel Carbide, Ni_3C

Phase	T	c_p	H	S	G	B
Solid						
	298	25.491	9.00	25.4	1.427	−1.046
	300	25.500	9.047	25.558	1.380	−1.005
	400	26.000	11.622	32.962	−1.563	0.854
	500	26.500	14.241	38.818	−5.162	2.256
	600	27.000	16.922	43.693	−9.294	3.386
	700	27.500	19.647	47.893	−13.878	4.333
	800	28.000	22.422	51.598	−18.856	5.152

Table A.42 Nickel Carbonate, $NiCO_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	21.454	−162.5	20.4	−168.582	123.591
	300	21.512	−162.460	20.533	−168.620	122.856
	400	23.876	−160.181	27.075	−171.011	93.448
	500	25.470	−157.710	32.582	−174.001	76.066
	600	26.761	−155.096	37.343	−177.502	64.664
	700	27.908	−152.362	41.556	−181.451	56.659

Table A.43 Nickel Monoxide, NiO

Phase	T	c_p	H	S	G	B
Solid-A						
	298	10.591	−57.5	9.1	−60.213	44.143
	300	10.606	−57.480	9.166	−60.230	43.883
	400	12.473	−56.340	12.434	−61.313	33.505
	500	15.356	−54.953	15.516	−62.711	27.415
	525	16.151	−54.560	16.284	−63.109	26.275
Solid-B						
	525	13.880	−54.560	16.284	−63.109	26.275
	565	13.880	−54.004	17.303	−63.781	24.675
Solid-C						
	565	12.321	−54.004	17.303	−63.781	24.675
	600	12.392	−53.572	18.046	−64.399	23.461
	700	12.594	−52.323	19.971	−66.302	20.703
	800	12.796	−51.053	21.666	−68.386	18.685
	900	12.998	−49.763	23.185	−70.630	17.154
	1,000	13.200	−48.453	24.565	−73.018	15.960
	1,100	13.402	−47.123	25.832	−75.539	15.010
	1,200	13.604	−45.773	27.007	−78.182	14.241
	1,300	13.806	−44.403	28.104	−80.938	13.609
	1,400	14.008	−43.012	29.135	−83.800	13.084
	1,500	14.210	−41.601	30.108	−86.763	12.643
	1,600	14.412	−40.170	31.032	−89.820	12.271
	1,700	14.614	−38.719	31.911	−92.968	11.953
	1,800	14.816	−37.247	32.752	−96.201	11.682
	1,900	15.018	−35.755	33.559	−99.517	11.449
	2,000	15.220	−34.243	34.334	−102.912	11.247
	2,100	15.422	−32.711	35.082	−106.383	11.073
	2,200	15.624	−31.159	35.80ft	−109.927	10.922
	2,257	15.739	−30.265	36.205	−111.980	10.845

Table A.44 Zinc Carbonate, $ZnCO_3$

Phase	T	c_p	H	S	G	B
Solid						
	298	19.139	−194.2	19.7	−200.074	146.578
	300	19.200	−194.165	19.819	−200.110	145.800
	400	22.500	−192.080	25.794	−202.397	110.500
	500	25.800	−189.655	31.169	−205.249	89.726

Table A.45 Zinc Oxide, ZnO

Phase	T	c_p	H	S	G	B
Solid						
	298	9.621	−83.2	10.4	−86.301	63.269
	300	9.654	−83.182	10.460	−86.320	62.893
	400	10.835	−82.150	13.421	−87.518	47.824
	500	11.448	−81.033	15.910	−88.988	38.902
	600	11.836	−79.868	18.034	−90.688	33.038
	700	12.119	−78.669	19.881	−92.586	28.911
	800	12.345	−77.446	21.514	−94.657	25.863
	900	12.539	−76.201	22.980	−96.883	23.530
	1,000	12.712	−74.939	24.310	−99.249	21.694
	1,100	12.872	−73.659	25.529	−101.742	20.217
	1,200	13.023	−72.365	26.656	−104.352	19.008
	1,300	13.167	−71.055	27.704	−107.070	18.003
	1,400	13.307	−69.731	28.685	−109.890	17.157
	1,500	13.443	−68.394	29.607	−112.805	16.438
	1,600	13.577	−67.043	30.479	−115.810	15.821
	1,700	13.709	−65.679	31.306	−118.899	15.288
	1,800	13.839	−64.301	32.094	−122.070	14.823
	1,900	13.968	−62.911	32.845	−125.317	14.417
	2,000	14.095	−61.508	33.565	−128.638	14.059
	2,100	14.223	−60.092	34.256	−132.029	13.742
	2,200	14.349	−58.663	34.920	−135.488	13.461
	2,243	14.403	−58.045	35.199	−136.996	13.350