Table E.1 Thermodynamic notation and definitions (note that parameters V, S, U, H, F and G refer to arbitrary mass, m, but C_V and C_P refer to unit mass)

Specific heat, constant P	$C_P = (T/m)(\partial S/\partial T)_P$
constant V	$C_V = (T/m)(\partial S/\partial T)_V$
	$C'_S = (\partial \ln C_V/\partial \ln V)_S$; $C'_T = (\partial \ln C_V/\partial \ln V)_T$
Helmholtz free energy	$F = U - TS$
Gibbs free energy	$G = U - TS + PV$
Enthalpy	$H = U + PV$
Bulk modulus, adiabatic	$K_S = -V(\partial P/\partial V)_S$
	$K'_S = (\partial K_S/\partial P)_S$; $K''_S = (\partial K'_S/\partial P)_S$
isothermal	$K_T = -V(\partial P/\partial V)_T$
	$K'_T = (\partial K_T/\partial P)_T$; $K''_T = (\partial K'_T/\partial P)_T$
Pressure	P
	$q = (\partial \ln \gamma/\partial \ln V)_T = (\partial \ln(\gamma C_V)/\partial \ln V)_S$
	$q_S = (\partial \ln \gamma/\partial \ln V)_S = q - C'_S$
Heat	Q
Entropy	$S = \int dQ/T$
Temperature	T
Internal energy	U
Volume	V
Volume expansion coefficient	$\alpha = (1/V)(\partial V/\partial T)_P$
Grüneisen parameter	$\gamma = \alpha K_T/\rho C_V = \alpha K_S/\rho C_P$
Anderson–Grüneisen parameter, adiabatic	$\delta_S = -(1/\alpha)(\partial \ln K_S/\partial T)_P = (\partial \ln(\alpha T/C_P)/\partial \ln V)_S$
isothermal	$\delta_T = -(1/\alpha)(\partial \ln K_T/\partial T)_P = (\partial \ln \alpha/\partial \ln V)_T$
Density	$\rho = m/V$
	$\lambda = (\partial \ln q/\partial \ln V)_T$

Table E.2 First order derivatives of thermodynamic parameters

Differential element	Constant T	P	V	S	U	H	F	G
∂T	–	1	1	γT	$P - \alpha K_T T$	$1 - \alpha T$	P	1
∂P	$-K_T/V$	–	$\alpha K_T = \gamma\rho C_V$	K_S	$-\rho C_V(K_S - \gamma P)$	$-\rho C_P$	$K_T(S/V+\alpha P)$	S/V
∂V	1	αV	–	$-V$	mC_V	$\alpha V(1 + 1/\gamma)$	$-S$	$\alpha V - S/K_T$
∂S	$\alpha K_T = \gamma\rho C_V$	mC_P/T	mC_V/T	–	$mC_V P/T$	mC_P/T	$mC_V(P/T - \gamma S/V)$	$mC_P/T - \alpha S$
∂U	$\alpha K_T T - P$	$mC_P - \alpha VP$	mC_V	PV	–	$mC_P - PV\alpha (1 + 1/\gamma)$	$mC_V P - S\alpha K_T T + SP$	$mC_P - \alpha TS - P\alpha V + SP/K_T$
∂H	$-K_T(1 - \alpha T)$	mC_P	$mC_V(1 + \gamma)$	$K_S V$	$mC_V[P(1 + \gamma) - K_S]$	–	$SK_T(1 - \alpha T) + mC_V P(1 + \gamma)$	$mC_P + S(1 - \alpha T)$
∂F	$-P$	$-S - \alpha VP$	$-S$	$PV - \gamma TS$	$\rho C_V(\gamma TS - PV) - PS$	$-S(1 - \alpha T) - PV\alpha(1 + 1/\gamma)$	–	$-S(1 - P/K_T) - P\alpha V$
∂G	$-K_T$	$-S$	$-S + \alpha K_T V$	$K_S V - \gamma TS$	$mC_V(\gamma TS/V + \gamma P - K_S) - PS$	$-S(1 - \alpha T) - mC_P$	$S(K_T - P) + PV\alpha K_T$	–

Table E.3 Thermodynamic derivatives extended to second order at constant T, P, V and S

Differential element	Constant T	P	V	S
∂T	–	1	1	γT
∂P	$-K_T/V$	–	$\alpha K_T = \gamma\rho C_V$	K_S
∂V	1	αV	–	$-V$
∂S	$\alpha K_T = \gamma\rho C_V$	mC_P/T	mC_V/T	–
∂U	$\alpha K_T T - P$	$mC_P - \alpha VP$	mC_V	PV
∂H	$-K_T(1-\alpha T)$	mC_P	$mC_V(1+\gamma)$	$K_S V$
∂F	$-P$	$-S - \alpha VP$	$-S$	$PV - \gamma TS$
∂G	$-K_T$	$-S$	$-S + \alpha K_T V$	$K_S V - \gamma TS$
$\partial \alpha$	$\alpha\delta_T/V = -(\partial K_T/\partial T)_P/K_T V$	$\alpha^2(2\delta_T - K_T' + C'_T/\gamma\alpha T)$	$\alpha^2(\delta_T - K_T' + C_T'/\gamma\alpha T)$	$-\alpha[K_S' - 1 + q + \gamma\alpha T(\delta_S + q)]$
∂K_T	$-K_T K_T'/V$	$-\alpha K_T\delta_T = K_T{}^2(\partial\alpha/\partial P)_T$	$\alpha K_T(K_T' - \delta_T)$	$K_T[K_T' + \gamma\alpha T(K_T' - \delta_T)]$
∂K_S	$(-K_T/V)(K_S' + \gamma\alpha T\delta_S)$	$-\alpha K_S\delta_S$	$\alpha K_T(K_S' - \delta_S)$	$K_S K_S'$
∂C_V	$(C_V/V)C_T' = (C_V/V)(1 - q + \delta_T - K_T')$	$(C_P C_T' - C_V C_S')/\gamma T$	$(C_V/\gamma T)(C'_T - C'_S)$	$-TC_V(\partial\gamma\partial T)_V$
∂C_P	$(C_P/V)[C_T' + \gamma\alpha T(q + \delta_T)/(1 + \gamma\alpha T)]$	$(C_P/\gamma T)[C_T' - C_S' + \gamma\alpha T \times(\delta_T - \delta_S + C_T')]$	$(C_P/\gamma T)\{C'_T(1+\gamma\alpha T) + [\gamma^2\alpha T + (\gamma\alpha T)^2 \times(q-1) - C_S']/(1+\gamma\alpha T)\}$	$-C_P[T(\partial\gamma/\partial T)_V + \gamma\alpha T(\delta_S + q)]$
$\partial \gamma$	$\gamma q/V$	$\gamma\alpha q + C_S'/T$	C_S'/T	$-\gamma(q - C_S')$

Table E.4 Relationships between derivatives

$K_S/K_T = C_P/C_V = 1 + \gamma\alpha T$	(E.1)
$K'_T = K'_S(1 + \gamma\alpha T) + \gamma\alpha T[3q - 2 - \gamma + \gamma(\partial \ln C_V/\partial \ln T)_V]$	(E.2)
$K'_S = K'_T(1 + \gamma\alpha T) - \gamma\alpha T(\delta_S + \delta_T + q)$	(E.3)
$\delta_S = -(1/\alpha)(\partial \ln K_S/\partial T)_P = K'_S - 1 + q - \gamma - C'_S = (\partial \ln(\alpha T/C_P)/\partial \ln V)_S$	(E.4)
$\delta_T = -(1/\alpha)(\partial \ln K_T/\partial T)_P = K'_T - 1 + q + C'_T = (\partial \ln \alpha/\partial \ln V)_T$ $= (\delta_S + C'_T)(1 + \gamma\alpha T) + \gamma + C'_S + \gamma\alpha T(2q - 1)$	(E.5)
$C'_S = C'_T - \gamma(\partial \ln C_V/\partial \ln T)_V = (\partial\gamma/\partial \ln T)_V$	(E.6)
$C'_T = \gamma(\partial \ln(\gamma C_V)/\partial \ln T)_V$	(E.7)
$q_S = q - C'_S$	(E.8)
$(\partial \ln(\alpha K_T)/\partial \ln V)_T = \delta_T - K'_T = -(1/\alpha)(\partial \ln K_T/\partial T)_V$	(E.9)
$(\partial \ln(\alpha K_T)/\partial \ln T)_V = (\partial \ln(\gamma C_V)/\partial \ln T)_V = C'_T/\gamma$	(E.10)
$(\partial(\alpha K_T)/\partial T)_P = K_T(\partial\alpha/\partial T)_V$	(E.11)
$(\partial \ln(\alpha K_T)/\partial \ln V)_S = q - 1$	(E.12)
$(\partial \ln(\alpha K_S)/\partial \ln V)_S = q - 1 + \gamma\alpha T(\delta_S + q)$	(E.13)
$(\partial \ln(\gamma\alpha T)/\partial \ln V)_T = \delta_T + q$	(E.14)
$(\partial \ln(\gamma\alpha T)/\partial \ln V)_S = (1 + \gamma\alpha T)(\delta_S + q)$	(E.15)
$(\partial K'_T/\partial T)_P = \alpha\delta_T[\delta_T - K'_T + (\partial \ln \delta_T/\partial \ln V)_T]$	(E.16)
$(\partial K'_S/\partial T)_P = \alpha\delta_S[\delta_S - K'_S + (\partial \ln \delta_S/\partial \ln V)_S]$	(E.17)
$(\partial\delta_T/\partial \ln V)_T = -K_T K''_T + \lambda q + (\partial C'_T/\partial \ln V)_T$	(E.18)
$(\partial\delta_S/\partial \ln V)_S = -K_S K''_S - \gamma q_S + (\partial q_S/\partial \ln V)_S$	(E.19)
$(\partial C_P/\partial P)_T = -(\partial(\alpha/\rho)/\partial \ln T)_P$	(E.20)