Thermodynamics lecture 6.

W.A.L.T.

A. Introduce chemical potential
B. Euler relation, Gibbs-Duhem relation
C. Thermodynamic potentials
D. Obtaining one potential from another
E. Maxwell relations
F. Some applications

Total entropy (also called *absolute entropy*) of a given physical entity:

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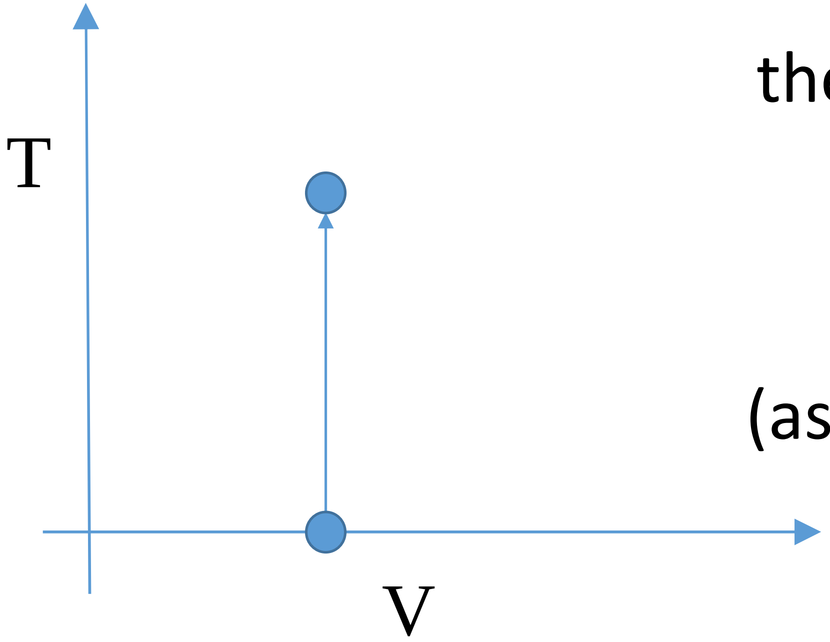

therefore

$$S(V, T_{\mathrm{f}}) = \int_0^{T_{\mathrm{f}}} \frac{C_V(V,T)}{T}\mathrm{d}T + \sum_i \frac{L_i}{T_i}$$

Latent heat

Temperature of *i*'th phase change

(assuming $S(V, 0) = 0$)

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internal energy U $\qquad dU = T\,dS - p\,dV + \mu\,dN$

Helmholtz function $F = U - TS$ $\qquad dF = -S\,dT - p\,dV + \mu\,dN$

internal energy U	$\mathrm{d}U = T\mathrm{d}S - p\mathrm{d}V + \mu\mathrm{d}N$
enthalpy $H = U + pV$	$\mathrm{d}H = T\mathrm{d}S + V\mathrm{d}p + \mu\mathrm{d}N$
Helmholtz function $F = U - TS$	$\mathrm{d}F = -S\mathrm{d}T - p\mathrm{d}V + \mu\mathrm{d}N$
Gibbs function $G = U + pV - TS$	$\mathrm{d}G = -S\mathrm{d}T + V\mathrm{d}p + \mu\mathrm{d}N$
$\tilde{U} = U - \mu N$	$\mathrm{d}\tilde{U} = T\mathrm{d}S - p\mathrm{d}V - N\mathrm{d}\mu$
$\tilde{H} = H - \mu N$	$\mathrm{d}\tilde{H} = T\mathrm{d}S + V\mathrm{d}p - N\mathrm{d}\mu$
Grand potential $\Omega = F - \mu N$	$\mathrm{d}\Omega = -S\mathrm{d}T - p\mathrm{d}V - N\mathrm{d}\mu$
$G - \mu N = 0$	

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Function	Significance	Natural variables	Maxwell relation
U	Energy content	S, V, N	$\left.\frac{\partial T}{\partial V}\right\|_S = -\left.\frac{\partial p}{\partial S}\right\|_V$
F	Effective potential energy for system at fixed T	T, V, N	$\left.\frac{\partial S}{\partial V}\right\|_T = \left.\frac{\partial p}{\partial T}\right\|_V$
H	Related to energy changes at fixed pressure $\Delta H =$ process energy, latent heat, heat of reaction	S, p, N	$\left.\frac{\partial T}{\partial p}\right\|_S = \left.\frac{\partial V}{\partial S}\right\|_p$
G	Determines direction of phase and chemical changes	T, p, N	$-\left.\frac{\partial S}{\partial p}\right\|_T = \left.\frac{\partial V}{\partial T}\right\|_p$
Ω	Useful in general study of open systems	T, V, μ	