lecture 5 - applications

- thermodynamic functions → Maxwell relations
- reversible, $TdS = \delta Q$
- internal energy $U(S, V)$

$$dU = TdS - PdV \quad (1)$$
$$\frac{\partial T}{\partial V}|_S = -\frac{\partial P}{\partial S}|_V \quad (2)$$
$$\frac{\partial T}{\partial V}|_{adiab} = -\frac{dP}{\delta Q}|_V \quad (3)$$

- "Helmholtz" free energy $F(T, V) = U - TS$
  dF work that can be done at constant T

$$dF = -SdT - PdV \quad (4)$$
$$\frac{\partial S}{\partial V}|_T = \frac{\partial P}{\partial T}|_V \quad (5)$$
$$\frac{1}{T}\frac{\delta Q}{dV}|_T = \frac{\partial P}{\partial T}|_V \quad (6)$$

- enthalpy $H(P, S) = U + PV$

$$dH = TdS + VdP \quad (7)$$
$$\frac{\partial T}{\partial P}|_S = \frac{\partial V}{\partial S}|_P \quad (8)$$
$$\frac{\partial T}{\partial P}|_{adiab} = T\frac{dV}{\delta Q}|_P \quad (9)$$

- "Gibbs" free energy - "thermodynamic potential" -
  $G(P, T) = U + PV - TS$

$$dG = VdP - SdT \quad (10)$$
$$\frac{\partial S}{\partial P}|_T = -\frac{\partial V}{\partial T}|_P \quad (11)$$
$$\frac{1}{T}\frac{\delta Q}{dP}|_T = -\frac{\partial V}{\partial T}|_P \quad (12)$$

- eq. of state + 1 thermodynamic function at given state → all thermodynamic functions for all states
- Joule adiabatic expansion - coefficient

$$U(T_1, V_1) = U(T_2, V_2) \tag{13}$$

$$\frac{\partial T}{\partial V}|_U = \frac{1}{c_V m}(P - T\frac{\partial P}{\partial T}|_V) \tag{14}$$

- Joule-Kelvin expansion (throttling)

$$H(S_1, P_1) = H(S_2, P_2) \tag{15}$$

$$\frac{\partial T}{\partial P}|_H = \frac{1}{c_P m}(T\frac{\partial V}{\partial T}|_P - V) \tag{16}$$

- Clausius-Clapeyron relation

$$\frac{dP}{dT} = \frac{L}{T\Delta V} \tag{17}$$

  L is latent heat
- Vant'Hoff isochore, F =constant

$$\Delta U = W - \frac{dW}{dT} \tag{18}$$