$$R = 8.314 \ \frac{J}{K\ mol}$$
$$R = 0.08314 \ \frac{L\ bar}{K\ mol}$$
$$R = 0.08206 \ \frac{L\ atm}{K\ mol}$$
$$1\ bar = 1.000 \cdot 10^5\ Pa$$
$$1\ atm = 1.0133\ bar$$
$$h = 6.63 \cdot 10^{-34} Js$$
$$N_A = 6.02 \cdot 10^{23}/mol$$
$$c = 2.998 \cdot 10^8\ m/s$$
$$k_B = 1.38 \cdot 10^{-23} J/K$$
$$1\ cal = 4.18\ J$$
$$1eV = 96.5 \frac{kJ}{mol}$$
$$PV_m = RT$$
$$P = \frac{RT}{V_m - b} - \frac{a}{V_m^2}$$
$$Z = \frac{PV_m}{RT}$$
$$Z_{vdW} = \frac{1}{1 - b/V_m} - \frac{a}{RTV_m}$$
$$\Delta U = q + w$$
$$C_V = \left(\frac{\partial U}{\partial T}\right)_V$$
$$\delta w = -PdV$$
$$H = U + PV$$
$$\Delta H = q_P = C_P \Delta T$$
$$C_P - C_V = nR$$
$$C_P = \left(\frac{\partial H}{\partial T}\right)_P$$
$$V_f T_f^c = V_i T_i^c$$
$$c = \frac{C_{V,m}}{R}$$
$$\gamma = \frac{C_P}{C_V} = \frac{Mc^2}{RT}$$
$$P_i V_i^\gamma = P_f V_f^\gamma$$
$$\frac{T_f}{T_i} = \left(\frac{P_f}{P_i}\right)^{(\gamma-1)/(\gamma)}$$
$$w = -nRT ln\left(\frac{V_f}{V_i}\right)$$

$$\Delta S = \int_i^f \frac{\delta q_{rev}}{T}$$
$$S(T_f) = S(T_i) + \int_i^f \frac{C_p}{T} dT$$
$$A = U - TS$$
$$G = H - TS = A + PV$$
$$dU = TdS - PdV$$
$$dH = TdS + VdP$$
$$dA = -S\,dT - PdV$$
$$dG = -S\,dT + VdP$$
$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$$
$$\kappa = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$$
$$\left(\frac{\partial(\Delta G/T)}{\partial T}\right)_P = -\frac{\Delta H}{T^2}$$
$$\mu_i = \left(\frac{\partial G}{\partial n_i}\right)_{T,P,n'}$$
$$\mu_{i,l} = \mu_{i,g} \ \text{ at equilibrium}$$
$$\mu = \mu^0 + RT ln\left(\frac{P}{P^0}\right)$$
$$\mu = \mu^0 + RT ln\left(\frac{f}{P^0}\right)$$
$$f = \phi p$$
$$\ln \phi = \int_0^p \left(\frac{Z-1}{P'}\right) dP'$$
$$\frac{dP}{dT} = \frac{\Delta S_{trs}}{\Delta V_{trs}}$$
$$\frac{dlnP}{d(1/T)} = \frac{-\Delta H_{vap}}{R}$$
$$\ln \frac{P_2}{P_1} = \frac{\Delta H(T_2 - T_1)}{RT_1 T_2}$$
$$V_j = \left(\frac{\partial V}{\partial n_J}\right)_{P,T,n'}$$
$$V = n_A V_A + n_B V_B$$
$$G = n_A \mu_A + n_B \mu_B$$
$$n_A d\mu_A + n_B d\mu_B = 0$$
$$\Delta G_{mix} = nRT(x_A \ln x_A + x_B \ln x_B)$$
$$P_A = x_A P_A^*$$
$$P_B = x_B K_B$$
$$\Delta T = \frac{RT^2}{\Delta H_{fus}} \ln(1 - x)$$

$$\mu_A = \mu_A^* + RT \ln a_A$$
$$a_A = P_A / P_A^*$$
$$\mu_B = \mu_B^\dagger + RT \ln a_B$$
$$a_B = P_B / K_B$$
$$\Omega(n_o, n_1, n_2, ...) = \frac{N!}{n_o! n_1! n_2}$$
$$\ln x! \sim x \ln x - x$$
$$\frac{n_i}{N} = \frac{e^{-\beta\epsilon_i}}{\sum_j e^{-\beta\epsilon_j}} \text{ where } \beta = \frac{1}{k_B T}$$
$$q = \sum_i e^{-\beta\epsilon_i} = \sum_j g_j e^{-\beta\epsilon_j}$$
$$<\epsilon> = -\frac{1}{q}\frac{dq}{d\beta}$$
$$C_V = \left(\frac{\partial <\epsilon>}{\partial T}\right)_v$$
$$q = q_{trans}\ q_{rot}\ q_{vib}\ q_{el}$$
$$q_{trans} = \frac{V}{\Lambda^3}$$
$$\Lambda = h\sqrt{\beta/2\pi m}$$
$$q_{rot} = \sum_{J=0}^{\infty} (2J+1) e^{-\beta BJ(J+1)}$$
$$B = h^2/8\pi^2 \mu r^2 = k_B \Theta_{rot}$$
$$q_{rot} \to \frac{T}{\sigma \Theta_{rot}} \ \text{ as } \ T \to \infty$$
$$q_{rot} = \frac{\sqrt{\pi}}{\sigma}\left(\frac{T^3}{\Theta_a \Theta_b \Theta_c}\right)^{1/2}$$
$$q_{vib} = \frac{1}{1 - exp(-h\nu\beta)}$$
$$q_{vib} \to \frac{k_B T}{h\nu} = \frac{T}{\Theta_{vib}} \ \text{ as } \ T \to \infty$$
$$< E_{vib} > = \frac{nR\Theta_{vib}}{exp(\Theta_{vib}/T) - 1}$$
$$C_{V,vib} = \frac{nR(\Theta_{vib}/T)^2 exp(\Theta_{vib}/T)}{(exp(\Theta_{vib}/T) - 1)^2}$$
$$Q = q^N \quad \text{or} \quad Q = q^N/N!$$
$$U(T,V) = U(0,V) - \left(\frac{\partial \ln Q}{\partial \beta}\right)_V$$
$$S = k_B \ln \Omega$$
$$S = \frac{U}{T} + k_B \ln Q$$
$$S = -Nk_B \sum_i p_i \ln p_i$$
$$S = Nk_B \ln \frac{e^{5/2} V}{N\Lambda^3}$$
$$A = -k_B T \ln Q$$
$$P = k_B T \left(\frac{\partial \ln Q}{\partial V}\right)_{N,T}$$

$$\mu = -RT \ln \frac{q}{N} \qquad \mu_s = -3tRT\ \Pi_j \left(1 - e^{-\Theta_j/T}\right)$$

$$\mu_g = \Delta E_0^0 - RT \ln\left[\left(\frac{2\pi m k_B T}{h^2}\right)^{3/2} \frac{k_B T}{P} \frac{T}{\sigma\Theta_{rot}} \frac{1}{(1 - e^{-\Theta_{vib}/T})}\right]$$