

A Short Compendium of Particularly Delightful Formulas

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT \quad \left(P + A \frac{n^2}{T^{1/2}V(V+nB)}\right)(V - nB) = nRT$$

$$Z = 1 + B(T) \frac{n}{V} + C(T) \left(\frac{n}{V}\right)^2 + D(T) \left(\frac{n}{V}\right)^3 + \dots$$

$$f(x) = f(x_0) + f'(x_0) \frac{(x-x_0)}{1!} + f''(x_0) \frac{(x-x_0)^2}{2!} + f'''(x_0) \frac{(x-x_0)^3}{3!} + \dots + f^{(n)}(x_0) \frac{(x-x_0)^n}{n!}$$

$$q = \int_0^t VI dt \quad q = V I t \quad J_q = -\mathcal{K} \frac{dT}{dx} \quad J_{q,\text{radiative}} = \sigma T^4$$

$$C_p \frac{dT}{dt} = -\frac{\mathcal{K}A}{\delta} (T - T_{\text{surr}}) \quad (T - T_{\text{surr}}) = (T_o - T_{\text{surr}}) e^{-\frac{\mathcal{K}A}{\delta C_p} t}$$

$$dU = dq - P_{\text{ext}}dV + F dx \quad dw = \gamma d\sigma = f dx = mg dh = \phi dq_i \quad w = z_i n_i F \Delta\phi$$

$$C_p(A) = a(A) + b(A)T + c(A)T^2 \quad \Delta \frac{dq_p}{dt} = \left(\frac{dq_p}{dt}\right)_{\text{sample}} - \left(\frac{dq_p}{dt}\right)_{\text{ref}}$$

$$\Delta C_p = \Delta \left(\frac{dq_p}{dT}\right) = \Delta \left(\frac{dq_p}{dt}\right) \left(\frac{dt}{dT}\right) \quad \Delta dq_p - \Delta dq_{\text{baseline}} = dq_{\text{tr}} \quad \int \frac{dq_{\text{tr}}}{dt} dt = q_{\text{tr}} = \Delta_r H$$

$$\alpha = \frac{1}{V} \left(\frac{\partial V}{\partial T}\right)_P \quad \beta = \kappa_T = -\frac{1}{V} \left(\frac{\partial V}{\partial P}\right)_T \quad \left(\frac{\partial P}{\partial T}\right)_V = \frac{\alpha}{\kappa_T} \quad \Delta V = V_o \alpha \Delta T$$

$$\Delta V = -V_o \kappa_T \Delta P \quad V - V_o = V_o \alpha (T - T_o) + V_o \alpha^2 \frac{(T - T_o)^2}{2} \quad V = V_o e^{\alpha(T - T_o)}$$

$$\left(\frac{\partial U}{\partial T}\right)_P = \left(\frac{\partial U}{\partial T}\right)_V + \left(\frac{\partial U}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P \quad C_p - C_v = \left(\left(\frac{\partial U}{\partial V}\right)_T + P\right) \left(\frac{\partial V}{\partial T}\right)_P \quad C_p - C_v = \frac{\alpha^2 TV}{\kappa_T}$$

$$\left(\frac{\partial H}{\partial T}\right)_V = \left(\frac{\partial H}{\partial T}\right)_P + \left(\frac{\partial H}{\partial P}\right)_T \left(\frac{\partial P}{\partial T}\right)_V \quad \mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H = \frac{-\left(\frac{\partial H}{\partial P}\right)_T}{\left(\frac{\partial H}{\partial T}\right)_P} \quad \left(\frac{\partial H}{\partial P}\right)_T = -\mu_{JT} C_p$$

$$C_v \ln \left(\frac{T_2}{T_1}\right) = -nR \ln \left(\frac{V_2}{V_1}\right) \quad V_1 T_1^c = V_2 T_2^c \quad P_2 V_2^\gamma = P_1 V_1^\gamma \quad c = \frac{C_v}{nR} \quad \gamma = \frac{C_p}{C_v}$$

$$C_v(T_2 - T_1) = -P_2 (V_2 - V_1) \quad C_v(T_2 - T_1) = -P_2 \left(\frac{nRT_2}{P_2} - \frac{nRT_1}{P_1}\right)$$

$$\Delta_r H_{T_2} - \Delta_r H_{T_1} = \Delta_r C_p \Delta T \quad \Delta_r H_{T_2} = \Delta_r H_{T_1} + \Delta a(T_2 - T_1) + \frac{\Delta b}{2}(T_2^2 - T_1^2) + \frac{\Delta c}{3}(T_2^3 - T_1^3)$$

$$\Delta_r H_T = \Delta_r H_o + \Delta_r aT + \frac{\Delta_r b}{2} T^2 + \frac{\Delta_r c}{3} T^3 + \frac{\Delta_r d}{4} T^4$$

$$E_{\text{str}} = 1/2 k_{s,ij} (r_{ij} - r_o)^2 \quad E_{\text{bend}} = 1/2 k_{b,ij} (\theta_{ij} - \theta_o)^2 \quad E_{\text{str-bend}} = 1/2 k_{sb,ijk} (r_{ij} - r_o) (\theta_{ik} - \theta_o)$$

$$E_{\text{tor}} = 1/2 k_{\text{tor},1} (1 - \cos \phi) + 1/2 k_{\text{tor},2} (1 - \cos 2\phi) + 1/2 k_{\text{tor},3} (1 - \cos 3\phi) \quad E_{\text{vdw}} = -\frac{A}{r_{ij}^6} + \frac{B}{r_{ij}^{12}}$$

$$E_{\text{qq}} = \frac{kQ_i Q_j}{4\pi\epsilon r_{ij}} \quad H = U(0) + \epsilon_{\text{trans}} + \epsilon_{\text{rot}} + \epsilon_{\text{vib}} + \epsilon_{\text{elect}} + RT \quad H(0) = U(0) = \epsilon_{\text{bond}} + \epsilon_{\text{steric}}$$

$$p_i = \frac{n_i}{N} = \frac{e^{-\epsilon_i/kT}}{q} = \frac{e^{-\epsilon_i/RT}}{q} \quad \frac{n_i}{n_j} = \frac{e^{-\epsilon_j/kT}}{e^{-\epsilon_i/kT}} = e^{\frac{-\Delta\epsilon}{kT}} \quad \Delta E = N_A hc\tilde{\nu} = (0.011963 \text{ kJ mol}^{-1} \text{ cm}) \tilde{\nu}$$

$$S = k \ln W \quad \xi = \frac{-w}{q_H} = \frac{q_H + q_L}{q_H} \quad \oint \frac{dq}{T} \leq 0 \quad \Delta S \geq \int \frac{dq}{T} \quad dU = T dS - P dV$$

$$dS = \frac{C_V}{T} dT + \frac{P}{T} dV \quad dS = \frac{C_P}{T} dT - \frac{V}{T} dP \quad \Delta S = C_V \ln T_2/T_1$$

$$dS = \frac{C_V}{T} dT + \frac{nR}{V} dV \quad dS = \frac{C_P}{T} dT - \frac{nR}{P} dP \quad \Delta S = C_P \ln T_2/T_1$$

$$\Delta S = nR \ln V_2/V_1 \quad \Delta S = -nR \ln P_2/P_1 \quad \Delta_r S_{T_2} = \Delta_r S_{T_1} + \Delta_r C_p \ln \frac{T_2}{T_1}$$

$$S^\circ = S^\circ_0 + \int_0^{T_{\text{low}}} \frac{AT^3}{T} dT + \int_{T_{\text{low}}}^{T_{\text{melt}}} \frac{C_p(s)}{T} dT + \frac{\Delta_{\text{melt}} H_m^\circ}{T_{\text{melt}}} + \int_{T_{\text{melt}}}^{T_{\text{bp}}} \frac{C_p(l)}{T} dT + \frac{\Delta_{\text{vap}} H_m^\circ}{T_{\text{bp}}} + \int_{T_{\text{bp}}}^T \frac{C_p(g)}{T} dT$$

$$dS = \frac{dq}{T} + \left(\frac{P - P_{\text{ext}}}{T} \right) dV$$

$$\mu_1 \equiv \left(\frac{\partial U}{\partial n_1} \right)_{S,V,n_2}$$

$$\mu_2 \equiv \left(\frac{\partial U}{\partial n_2} \right)_{S,V,n_1}$$

$$dU = T dS - P dV + \sum_{i=1}^c \mu_i dn_i$$

$$dn_i = v_i d\xi$$

$$dU = T dS - P dV + \sum_{i=1}^{n_s} v_i \mu_i d\xi$$