Formula Sheet

$$\ln n! \approx n \ln n - n \tag{1}$$

Distributions

Binomial distribution $$P(n,N) = \frac{N!}{n!(N-n)!}\, p^n\, q^{N-n} \tag{2}$$

Gaussian Distribution $$P(x)dx = \frac{1}{\sqrt{2\pi}\sigma} e^{-(x-\mu)^2/2\sigma^2} dx \tag{3}$$

Poisson Distribution $$P(n) = \frac{\mu^n}{n!} e^{-\mu} \qquad \mu = Np \tag{4}$$

Thermodynamics

$$dW = \overline{p} dV \qquad \Delta\overline{E} = Q - W \tag{5}$$

$$\beta = \frac{1}{k_B T} = \frac{\partial \ln \Omega(E)}{\partial E} \qquad S \equiv \text{entropy} \equiv k_B \ln \Omega \tag{6}$$

$$\frac{1}{T} = \left.\frac{\partial S}{\partial E}\right|_V \tag{7}$$

$$\overline{X}_\alpha \equiv -\overline{\frac{\partial E_r}{\partial x_\alpha}} \qquad \frac{\partial S}{\partial x_\alpha} = \frac{\overline{X}_\alpha}{T} \tag{8}$$

$$dQ = TdS = d\overline{E} + dW \qquad dW = \sum_{\alpha=1}^{n} \overline{X}_\alpha dx_\alpha \tag{9}$$

$$\Delta S \geq 0 \quad \text{For an isolated system} \tag{10}$$

Numbers

$$T_C = T_K - 273.15 \qquad \text{degrees Celsius} \tag{11}$$

$$R = (8.3143 \pm 0.0012) \ \text{joules} \ \ \text{mole}^{-1} \ \ \text{deg}^{-1} \tag{12}$$

$$k_B = (1.38054 \pm 0.00018) \times \ 10^{-16} \ \ \text{ergs} \ \ \text{degree}^{-1} \tag{13}$$

$$1 \ \ \text{calorie} = 4.1840 \ \ \text{joules} \tag{14}$$

$$N_a = 6.023 \times 10^2 3 \ \ \frac{\text{molecules}}{mole} \tag{15}$$

$$1 \text{ atm} = 1.01325 \times 10^6 \text{ dynes/cm}^2 = 1.013 \times 10^5 \text{ N/m}^2 \tag{16}$$

$$C_y = \left.\frac{dQ}{dT}\right|_y = T \left.\frac{\partial S}{\partial T}\right|_y \tag{17}$$

$$\Delta S = S(T_f) - S(T_i) = \int_{T_i}^{T_f} \frac{C_V(T')}{T'} dT' \ \text{ For fixed volume} \tag{18}$$

Ideal Gas

$$pV = Nk_BT = \nu RT \tag{19}$$

$$c_p = c_V + R \tag{20}$$

$$pV^\gamma = \text{ constant} \qquad \gamma = \frac{c_p}{c_V} \tag{21}$$

$$V^{\gamma-1}T = \text{ constant} \tag{22}$$

Maxwell Relations and Thermodynamic Functions

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial p}{\partial S}\right)_V \qquad \left(\frac{\partial T}{\partial p}\right)_S = \left(\frac{\partial V}{\partial S}\right)_p \tag{23}$$

$$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V \qquad -\left(\frac{\partial S}{\partial p}\right)_T = \left(\frac{\partial V}{\partial T}\right)_p \tag{24}$$

$$\text{Energy} \quad E = E(S,V) \qquad dE = TdS - pdV \tag{25}$$

$$\text{Enthalpy} \quad H = H(S,p) = E + pV \qquad dH = TdS + Vdp \tag{26}$$

$$\text{Helmholtz Free Energy} \quad F = F(T,V) = E - TS \qquad dF = -SdT - pdV \tag{27}$$

$$\text{Gibbs Free Energy} \quad G = G(T,p) = E - TS + pV \quad dG = -SdT + Vdp \tag{28}$$

$$\frac{dp}{dT} = \frac{\Delta s}{\Delta v} \tag{29}$$

Engines and Refrigerators

$$q_1 = w + q_2 \tag{30}$$

$$\text{Efficiency :} \qquad \eta \equiv \frac{w}{q_1} = \frac{q_1 - q_2}{q_1} < 1 \tag{31}$$

$$\eta_{max} = \frac{T_1 - T_2}{T_1} \tag{32}$$

$$\frac{q_2}{q_1} \leq \frac{T_2}{T_1} \tag{33}$$