$$PV = nRT = Nk_BT, \quad T_K = T_C - 273.15, \qquad (1/2)mv^2 = (3/2)k_BT = E_{INT}$$

$$v_{rms} = \sqrt{3k_BT/m}, \qquad N_v\ dv = 4\pi N(\frac{m}{2\pi k_BT})^{3/2}v^2e^{-mv^2/(2K_BT)}dv$$

$$\Delta L = \alpha L\Delta T, \qquad \Delta A = \gamma A\Delta T, \qquad \Delta V = \beta V\Delta T$$

$$W_{done\ by\ gas} = \int_{V_i}^{V_f} PdV, \qquad \Delta E_{INT} = Q - W, \qquad dE_{INT} = dQ - dW$$

$$PV^\gamma = \text{constant}\ (adiabatic\ process), \quad W = Nk_BT\ln V_f/V_i\ (isothermal\ process)$$

$$\Delta E_{INT} = nC_V\Delta T\ (isovolumetric\ process), \quad Q = nC_P\Delta T\ (isobaric\ process)$$

$$\epsilon = W/Q_H, \quad COP: \ \ Q_H/W\ (Heat\ Pump), \ \ |Q_C|/W\ (Fridge)$$

$$\Delta S = \int \frac{dQ}{T}, \quad \epsilon = 1 - T_C/T_H\ (Carnot), \quad \epsilon < 1, \quad \frac{T_C}{T_H} = \frac{Q_C}{Q_H}\ (Carnot)$$

$$p(E) = g(E)f(E), \quad < E >= \int Eg(E)f(E)dE, \quad (in\ general) < x >= \frac{\int xh(x)dx}{\int h(x)dx}$$

$$f_{MB}(E) = A^{-1}\mathrm{e}^{-E/k_BT}, \ f_{BE}(E) = \frac{1}{(A\mathrm{e}^{E/k_BT} - 1)}, \ f_{FD}(E) = \frac{1}{(A\mathrm{e}^{E/k_BT} + 1)}$$

$$< V - \overline{V} >= \frac{\partial V}{\partial x} < x - \overline{x} > + \frac{\partial V}{\partial y} < y - \overline{y} > + ..., \quad \sigma_V^2 = (\frac{\partial V}{\partial x})^2\sigma_x^2 + (\frac{\partial V}{\partial y})^2\sigma_y^2 + ...$$

$$\sigma_V^2 = (\frac{\partial V}{\partial x})^2\sigma_x^2 + (\frac{\partial V}{\partial y})^2\sigma_y^2 + 2\frac{\partial V}{\partial x}\frac{\partial V}{\partial y}cov(x,y) + ..., \quad \chi^2 = \sum_i \frac{(y_i - f(x_i))^2}{\sigma_i^2}$$

$$\overline{x} = \frac{\sum_i \frac{x_i}{\sigma_i^2}}{\sum_j \frac{1}{\sigma_i^2}}, \quad \sigma_{\overline{x}}^2 = \frac{1}{\sum_j \frac{1}{\sigma_i^2}}, \quad \sigma_N = \sqrt{N}(counting), \quad G(x) = A\mathrm{e}^{(-\frac{1}{2}\frac{(x-\overline{x})^2}{\sigma^2})}$$

Constants

$R = 8.315\ J/(mol\ K) = 0.0821\ L\ atm/(mol\ K), \qquad hc = 1240\ eVnm$
$m_ec^2 = 511,000eV, \qquad k_B = 1.38 \times 10^{-23}\ J/K = 8.617 \times 10^{-5}eV/K$
$N_A = 6.022 \times 10^{23}$