Equations for the Exam on Unit T

$dU = mc\,dT$ $\quad PV = Nk_BT$ $\quad U = \frac{f}{2}Nk_BT$ $\quad \Delta U = Q + W$

$K_{avg} = \frac{1}{2}m\left[v^2\right]_{avg} = \frac{3}{2}k_BT$ $\quad v_{rms} = \sqrt{\left[v^2\right]_{avg}}$ $\quad W = -\int P\,dV$ $\quad W = -Nk_BT\ln\frac{V_f}{V_i}$

adiabatic: $TV^{\gamma-1} = \text{constant}$ $\quad PV^{\gamma} = \text{constant}$

$\Omega(N,U) = \frac{(q+3N-1)!}{q!(3N-1)!}$ $\quad q = U/\varepsilon$ $\quad \Omega_{AB} = \Omega_A\Omega_B$ $\quad S = k_B\ln\Omega$

$S_{AB} = S_A + S_B$ $\quad \frac{1}{T} = \frac{dS}{dU}$ $\quad \Delta S = mc\ln\frac{T_f}{T_i};\frac{V_f}{V_i}$ $\quad dS = \frac{dQ}{T}$

$\Pr(E) = \frac{1}{Z}e^{-E/k_BT}$ $\quad Z = \sum_{\text{all states}} e^{-E_i/k_BT}$ $\quad E_{avg} = \sum E_n\left(\frac{e^{-E_n/k_BT}}{Z}\right)$ $\quad Q = mL$

$v_p = \sqrt{\frac{2k_BT}{m}}$ $\quad D(v) = \frac{4}{\sqrt{\pi}}\left(\frac{v}{v_p}\right)^2 e^{-(v/v_p)^2}$ $\quad \Pr(v_1 < v < v_2) = \int_{v_1}^{v_2} D(v)\frac{dv}{v_p}$

$e = \frac{|W|}{|Q_H|} \le \frac{T_H - T_C}{T_H}$ $\quad \text{COP} = \frac{|Q_C|}{|W|} \le \frac{T_C}{T_H - T_C}$

Physical Constants and Data

$k_B = 1.38\times10^{-23}\,\text{J/K} = 8.62\times10^{-5}\,\text{eV/K}$ $\quad$ $1\text{ eV} = 1.602\times10^{-19}\text{ J}$

$N_A = 6.02\times10^{23}$ molecules/mole $\quad$ $m_{\text{proton}} \approx m_{neutron} \approx 1.7\times10^{-27}\text{ kg}$

$m_e = 9.11\times10^{-31}$ kg $\quad$ 1 atm = 101.3 kPa

Avogadro's number of nucleons (protons and/or neutrons) has a mass of about 1 g

$\gamma = 5/3$ (for monatomic gas) $\quad$ $\gamma = 7/5$ (for diatomic gas)

a monatomic gas has 3 degrees of freedom; a diatomic gas has 5 degrees of freedom

specific heat of water = 4186 J/(kg·K) $\quad$ latent heat of melting ice = 333 kJ/kg

Propagation of Uncertainties

In general: $f(a,b,\cdots)$ $\quad U[f] = \sqrt{\left(\frac{\partial f}{\partial a}U[a]\right)^2 + \left(\frac{\partial f}{\partial b}U[b]\right)^2 + \cdots}$

If $f = \frac{ab\cdots}{cd\cdots}$ $\quad U[f] = |f|\sqrt{\left(\frac{U[a]}{a}\right)^2 + \left(\frac{U[b]}{b}\right)^2 + \left(\frac{U[c]}{c}\right)^2 + \cdots}$

If $f = a + b + \cdots - c - d - \cdots$ $\quad U[f] = \sqrt{(U[a])^2 + (U[b])^2 + (U[c])^2 + \cdots}$