Information for the Exam on Units O and T

Things You Must Know

(1) Rule for reflection
(2) How to calculate when total internal reflection will occur
(3) How to draw principle rays and to locate an image
(4) 0^{th} Law of Thermodynamics
(5) 1^{st} Law of Thermodynamics
(6) 2^{nd} Law of Thermodynamics
(7) Gas processes
(8) Definitions of microstate, macrostate, and macropartition
(9) The fundamental assumption of statistical mechanics

Potential Useful Information

$$n_1 \sin\theta_1 = n_2 \sin\theta_s$$

$$|f| = R/2 \qquad \frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \qquad M \equiv \frac{h'}{h} = -\frac{S'}{S}$$

$$m = 1 + \frac{25\text{ cm}}{f} \quad \text{or} \quad \frac{25\text{ cm}}{f} \qquad m_{micro} \approx -\left(\frac{T}{f_o}\right)\left(\frac{25\text{ cm}}{f_e}\right) \qquad m_{tele} = -\frac{f_o}{f_e}$$

$$dU = mc\,dT \qquad PV = Nk_BT \qquad U = \frac{f}{2}Nk_BT$$

$$K_{avg} = \tfrac{1}{2}m\left[v^2\right]_{avg} = \tfrac{3}{2}k_BT \qquad v_{rms} = \sqrt{\left[v^2\right]_{avg}}$$

$$dW = -PdV$$

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

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

$$S = k_B \ln\Omega \qquad S_{AB} = S_A + S_B \qquad \frac{1}{T} = \frac{dS}{dU}$$

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

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

$$dS = \frac{dQ}{T} \qquad Q = mL$$

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

Physical Constants and Data

$n \approx 1$ for air

$k_B = 1.38 \times 10^{-23}$ J/K $= 8.62 \times 10^{-5}$ eV/K

1 eV = 1.602 × 10^{-19} J

$N_A = 6.02 \times 10^{23}$ molecules/mole

$m_{\text{proton}} \approx m_{neutron} \approx 1.7 \times 10^{-27}$ kg

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

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

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

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

specific heat of water = 4186 J/(kg·K)

latent heat of melting ice = 333 kJ/kg

Propagation of Uncertainties

In general: $f(a, b, \cdots)$

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

If $f = \dfrac{ab\cdots}{cd\cdots}$

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

If $f = a + b + \cdots - c - d - \cdots$

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