PHYSICS 140A MIDTERM 2 FALL QUARTER 2010
PROF. HIRSCH November 8th

Formulas:

First law $\Delta U = Q + W$; $C_V = \frac{\partial U}{\partial T})_V$; $H = U + PV$; $C_P = \frac{\partial H}{\partial T})_P$

$k = 1.381\times 10^{-23} J/K$, $N_A = 6.02\times 10^{23}$, $R = 8.31\text{J/(mol}^o K)$

Ideal gas: $PV = NkT$ $U = N\frac{f}{2}kT$ $W = -P\Delta V$, $W = -\int PdV$; $C_P = C_V + Nk$

adiabatic process: $PV^\gamma = const.$, $\gamma = (f+2)/f$

$S = k\ln\Omega$; $\frac{1}{T} = \frac{\partial S}{\partial U})_V$; $dS = \frac{Q}{T} = \frac{C_V dT}{T}$ (constant volume)

Stirling's approximation: $n! = n^n e^{-n}\sqrt{2\pi n}$

Ideal gas (monoatomic) : $\Omega_N = C_N V^N U^{3N/2}/N!$

Einstein solid: $\Omega(N,q) = \frac{(q+N-1)!}{q!(N-1)!}$ $\sim (\frac{eq}{N})^N$ for q >> N

Two-state system: $\Omega = \frac{N!}{N_\uparrow ! N_\downarrow !}$

Paramagnetism: $\mathrm{M} = \mathrm{N}\mu\tanh(\mu\mathrm{B/kT})$, $U = -MB$, $M = \mu(N_\uparrow - N_\downarrow)$

$dU = TdS - PdV$; $Q = TdS$, $W = -PdV$ (quasistatic)

$U(S,V)$; $F(T,V) = U - TS$; $H(S,P) = U + PV$; $G(T,P) = U - TS + PV$

$C_V = T\frac{\partial S}{\partial T})_V$; $C_P = T\frac{\partial S}{\partial T})_P$; $\beta = \frac{1}{V}\frac{\partial V}{\partial T})_P$; $\kappa_{T,S} = -\frac{1}{V}\frac{\partial V}{\partial P})_{T,S}$; $\mu = -T\frac{\partial S}{\partial N})_{U,V} = \frac{\partial U}{\partial N})_{S,V}$

$\mu = -kT\ \ln(\frac{V}{N}(\frac{2\pi m\,\mathrm{kT}}{h^2}))$ Ideal gas (monoatomic)

Heat engines: $e = \frac{W}{Q_h} \le 1 - \frac{T_c}{T_h}$; Refrigerators: $COP = \frac{Q_c}{W} \le \frac{T_c}{T_h - T_c}$

Maxwell relations: $\frac{\partial T}{\partial V})_S = -\frac{\partial P}{\partial S})_V$; $\frac{\partial T}{\partial P})_S = \frac{\partial V}{\partial S})_P$; $\frac{\partial S}{\partial V})_T = \frac{\partial P}{\partial T})_V$; $\frac{\partial S}{\partial P})_T = -\frac{\partial V}{\partial T})_P$

Van der Waals: $(P + a\frac{N^2}{V^2})(V - Nb) = NkT$; Virial: $PV = NKT(1 + \frac{N}{V}B_2(T) + \frac{N^2}{V^2}B_3(T) + ...)$

Boltzmann distribution: $P(E_i) = Ce^{-E_i/kT}$; $C = 1/\sum_i e^{-E_i/kT} \equiv 1/Z$; $P(E) = C\Omega(E)e^{-E/kT}$

Justify all your answers to all problems