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Physics 603 **HOMEWORK ASSIGNMENT #2** Spring 2012

Due date for problems on Tuesday, Feb. 14 [deadline on Feb. 16].

1. a) Starting from dU = T dS – p dV, show that the ideal gas equation of state $pV = Nk_BT$ implies that U can only depend on T.

b) Show that the most general equation of state for which the internal energy U(T,V) = U(T), i.e. U depends only on T, has the form p = *f*(V) T, where *f* is an arbitrary function of V.

c) Show that $\left.\frac{\partial C_V}{\partial V}\right|_T = T\left.\frac{\partial^2 p}{\partial T^2}\right|_V$ and use this result to show that $\left.\frac{\partial C_V}{\partial V}\right|_T = 0$ (i.e. C_V is a function of T alone) for the van der Waals equation of state: $\left[p + a\left(\frac{N}{V}\right)^2\right]\cdot(V - Nb) = Nk_BT$

(You might take note of Pathria & Beale, problem 1.4; their *b* is what is called *Nb* here. However, that problem is not assigned!)

2. Pathria & Beale, problem 1.15. (Same in Pathria 2nd ed.) Hint: First show for an ideal gas of atoms, as in this problem, that $C_V = \frac{nR}{\gamma - 1}$. Note that mole fraction f_1 means $n_1/n = n_1/(n_1 + n_2)$.

3. a) Verify the results for the following thermodynamic potentials as written down quickly in class for an ideal gas of indistinguishable particles $Z_N = (1/N!)(V/\lambda_T^3)^N$:

$U = -\partial \ln Z/\partial\beta|_{N,V}$ $F = -k_BT \ln Z$ $H = U + pV$ $p = -\partial F/\partial V|_{N,T}$ $S = (U-F)/T$ $G = H - TS$

b) Repeat this exercise for distinguishable particles, $Z_N = (V/\lambda_T^3)^N$. Which are the same, which different? Which extensive potentials for indistinguishable particles remain so for distinguishable particles?