

**PHYSICS 140A : STATISTICAL PHYSICS**  
**HW ASSIGNMENT #7**

**(1)** A strange material satisfies  $E(S, V, N) = a S^6 / V^3 N^2$ .

- (a) What are the SI dimensions of  $a$ ?
- (b) Find the equation of state relating  $p$ ,  $T$ , and  $n = N/V$ .
- (c) Find the coefficient of thermal expansion  $\alpha_p = \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_p$ . Express your answer in terms of  $T$ .
- (d) Find the coefficient of isothermal compressibility  $\kappa_T = -\frac{1}{V} \left( \frac{\partial V}{\partial p} \right)_T$ . Express your answer in terms of  $p$ .

**(2)**  $\nu$  moles of the substance in problem 1 execute a Carnot cycle between reservoirs at temperatures  $T_1$  and  $T_2$ . The top isotherm extends from volume  $V_A$  to  $V_B$ . Find the heat  $Q$  and work  $W$  for each leg of the cycle, and compute the cycle efficiency.

**(3)** An interacting diatomic gas obeys the equation of state

$$p(v - b) = RT e^{-a/v},$$

where  $v = N_A V / N$  is the molar volume.

- (a) Show that  $E(T, V, N) = \frac{f}{2} N k_B T$ , the same as for an ideal gas.
- (b) Find the molar specific heat  $c_p$  as a function of  $T$  and  $v$ .