**Physics 408 Problem Set 6 Due Weds, Oct 13 at beginning of class**

1) Callen 4.7.2

2) Callen 4.10.3

3) Given a system that exhibits the equations of state $P = A\,s^3/v^2$, and $T = 3A\,s^2/v$,
a) Determine $\alpha$, $c_V$, $c_P$, $\kappa_T$, and $\kappa_S$.
b) Show that $c_P = c_V + \frac{Tv\alpha^2}{\kappa_T}$.
c) Show that $\kappa_T = \kappa_S + \frac{Tv\alpha^2}{c_P}$.

4) Carnot cycle with finite heat reservoirs: Suppose that a Carnot cycle has hot and cold reservoirs of finite extent, each having the same T-independent heat capacity C. Because of the finite C, the hot and cold reservoir temperatures will change vs., time, but the Carnot cycle temperatures track these changes vs. time such that the heat transfer to and from the system is always across zero temperature difference. The temperatures start at initial values $T_{Ci}$ and $T_{Hi}$, and as the engine operates these temperatures will approach each other, finally meeting at a common temperature $T_{common}$.
a) Find $T_{common}$.
b) Find the work done by the engine in the entire process.
c) Suppose the two reservoirs contain equal amounts of the same fluid, e.g. water. If instead of running the engine you simply mix the fluids, they will also come to a common temperature. Find the final temperature for this case. Is it lower or higher than the result from part (a)? Explain why this last result must be the case, based on the balance of heat and work for a heat engine of this type.
d) Find the global entropy change for the process in (c).

5) Consider a heat-engine cycle which would be mapped as a rectangular, controlled process in a PV diagram, with constant-$P$ and constant-$V$ processes making up the cycle. With $N$ atoms of a monatomic ideal gas as the working fluid, the system starts at ($P_1$, $V_1$), then doubles it volume to the condition ($P_1$, $2V_1$), then proceeds to ($P_1/2$, $2V_1$) and then ($P_1/2$, $V_1$), and finally back to ($P_1$, $V_1$).
a) This heat engine is connected to one hot and one cold constant-$T$ reservoir, at temperatures equal to the two extreme temperatures of the working gas in this cycle. Find $Q_H$ and $Q_C$ (the magnitudes of the reservoir heat quantities per cycle), and $W_{ext}$ (the net work performed per cycle). Finally, determine the engine efficiency.
b) Find the change of entropy of the universe per cycle.
c) Thinking about the temperatures involved in these processes, explain why this cycle could never be used in reverse as an ordinary refrigerator.