The extra credit problems (must be turned in before the final)

#1 (5 points)

Photon Carnot engine.

Consider a Carnot engine that uses as a working substance a photon gas.

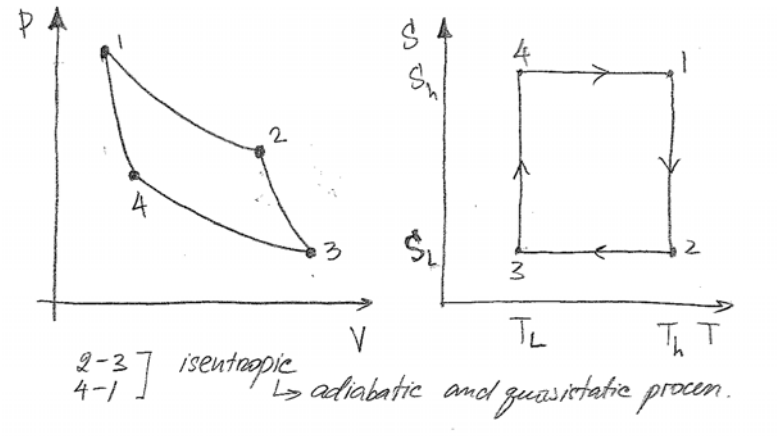
(a) Given T_h and T_l as well as V_1 and V_2, determine V_3 and V_4.

(b) What is the heat Q_h taken up and the work done by the gas during the first isothermal expansion? Are they equal to each other, as for the ideal gas?

(c) Do two isentropic stages cancel each other, as for the ideal gas? (isentropic process is adiabatic process that is also quite slow so that the pressure is uniform through the system in every stage of expansion or compression)

(d) Calculate the ratio of the net generated work to the heat Q_h supplied to the engine at temperature T_h and show that the energy conversion efficiency is the Carnot efficiency.

The figure shows the Carnot cycle in P-V and S-T axis. For the phonon gas we have the following relationships: Energy density $\frac{U}{V} = \alpha T^4$, entropy density (amount of entropy per volume of photon gas) $\frac{S}{V} = \alpha T^3$, radiation pressure $P = \frac{1}{3}\frac{U}{V} = \frac{1}{3}\alpha T^4$, the constant α is defined in Schroeder .



#2 (5 points)

Estimate the maximum size of aluminum dust particle that under the influence of the sun radiation moves in space out of the Sun. Make all needed reasonable assumptions. You will need to find out what is the sun radiation pressure.

#3 (5 points)

Gas under pressure *P* fills the vessel located in vacuum space. There is a small hole with area *A* in a wall of the vessel. The size of the hole is small compare to the mean free path of gas molecules in the vessel. Find the propulsion force exerted on the vessel as a result of effusion of the gas molecules through the hole.