Problem Solving Session 5

Problem 1:

Heat pumps are being used more and more to reduce heating cost (especially in summer houses where central heating is not available). Consider a heating system for a room that is maintained at a temperature T_h and makes use of a heat source at a high temperature T_{hh} (could be gas combustion) as well as a low temperature source at temperature T_l (could be ground water, or just air outside), where $T_{hh} > T_h > T_l$. Let the heat flow out of the high temperature source be denoted as Q_{hh}, the heat flow from the low temperature source be donated as Q_l and the total heat flow into the room be denoted as Q_h.

(a) Draw an energy flow diagram illustrating this setup. Mark clearly the temperature of each part, as well as the work and heat flow between the various parts of the system.

(b) How much does this system reduce the amount of heat that needs to be drawn from the high temperature source (i.e. compare the amount of heat Q_{hh} that is drawn from the high temperature source by this system to the amount that would be needed in order to deliver the same amount of heat into the room without the low temperature source)? Assume reversible operation. It is convenient to use absolute values here to reduce confusion in the bookkeeping.

Problem 2:

For a certain closed and insulated system, the enthalpy is found to change over a limited pressure interval in a reversible process as

$$H = \alpha + \beta p + \gamma/p^2$$

where α, β and γ are experimentally determined constants.

(a) Why can the entropy of the system be taken to be a constant in this process?

(b) How does the volume of the system vary with pressure over this interval?

(c) How does the internal energy, U, vary with pressure over this interval?