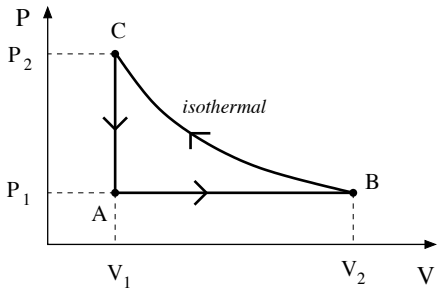
Practice exam

1. Solve the Clausius-Clapeyron relation to find the shape for the phase-boundary curve P vs. T. Take one of the phases to be gas so that you can neglect the volume of the condensed phase.

2. Consider the combustion of one mole of H2 with 1/2 mole of O2 under standard conditions. How much of the heat energy produced comes from a decrease in the internal energy of the system? How comes from work done by the collapsing atmosphere? Treat the volume of liquid water as negligible. ΔH for this reaction is 286 kJ. H = U+PV

3.
(30/100) A thermal machine based on an ideal gas is submitted to the following cycle:



What is the total amount of heat transferred by this machine? Is it an engine or a refrigerator?

4.
A gas of of photons in three-dimensions obeys the relation $PV = \frac{1}{3}U$, where P is pressure, V is volume, and U is the internal energy of the gas. Show that during an adiabatic process, the gas also satisfies the following relation: $PV^{4/3} = \text{const.}$ *Hint:* Start with the first law of Thermodynamics.

5. Calculate density of states for 2D electron gas

6. For an Einstein solid with 3N oscillators total with a large N
(a) What is its partition function?
(b) Calculate average energy.
(c) Calculate free energy
(d) Calculate entropy

7.

Hydrogen can bind quite effectively to certain lattice defects in graphene by a process called chemical adsorption. Suppose that the binding energy of hydrogen to one of those defects is $-\epsilon$, with $\epsilon > 0$. Assume that there are $N \gg 1$ defective sites.

(a) Write down an expression for the *total* adsorption energy U.

(b) Find an expression for the entropy S as a function of U.

(c) Find an expression for U as a function of temperature T.

(d) Find an expression for the heat capacity of this system. How does it behave as the temperature goes to zero?