1. (40 pts.) Air at 300 kPa, 100°C is in a piston/cylinder arrangement with a volume of 0.1 m^3. It is now compressed in a polytropic process with exponent, n = 1.2, to a final temperature of 200°C. You may assume constant properties for air in your calculations.

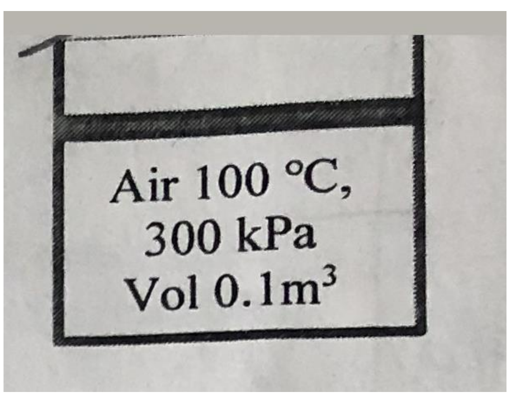
   a. **(5) Calculate the mass of air. R_{air} = 0.2870 kJ/kg K.**

   b. **(5) Calculate the work (and direction) done by the air in the process. The polytropic work equation is $W = \frac{mR}{1-n}(T_2 - T_1)$**

   c. **(10) Calculate the heat transfer and direction for the process. (C_p and C_v air are 1.005 and .718 KJ/kg K respectively).**

   d. **(10) Derive the work equation in (b) above, don't just write down the equation.**

   e. **(10) Plot (using three points?) the process on a Pv and Tv diagram. Include the equation corresponding to the line you plotted and draw lines of constant temperature and constant pressure on the Pv and Tv diagrams respectively.**



2. (60 pts.) A combined gas-steam power cycle uses a simple gas turbine for the topping cycle and simple Rankine cycle for the bottoming cycle. Atmospheric air enters the gas compressor at 101 kPa and 20 °C, and the maximum gas cycle temperature is 1100 °C. The compressor pressure ratio is 8; the compressor isentropic efficiency is 85 percent; and the gas turbine isentropic efficiency is 90 percent. The gas stream enters and leaves the heat exchanger at points 8 and 9 respectively. Steam flows through the heat exchanger with a pressure of 6000 kPa (T_{sat} 275.6 °C), and leaves at 320 °C. The steam-cycle condenser operates at 20 kPa (T_{sat} 60.1 °C), and the isentropic efficiency of the steam turbine is 90 percent. Use constant specific heats for air at room temperature.

   a. (5) Draw a schematic of the system (a diagram of labeled components with lines connecting them and numbers placed according to the Ts diagram of the process below).

   b. (5) Draw actual processes (non-ideal) 3-4 and 5-6, and the ideal isentropic process 7-8 on the T-s diagram below. Label heat in, heat out, work in and work out on every process where they occur.

   c. (5) Why does process 4 – 1 occur at 20kPa. Does this present any difficulties?

   d. (45) Using symbols only, e.g. T_5 or h_2, etc. write equations to describe how you would find each of items (i) – (ix) below. If you would consult tables, provide variables used to find the value, e.g. $T_x = T_{sat\ @\ y\text{-}pressure}$. If quality (x) or work (w) are required, show the steps required to find them. You should have a basis for every independent variable in your equation that you've used to find the dependent variables below, e.g. "given in problem statement as...," or "calculated using...".

i. T_{6s} and T_{6a}
ii. T_{8s} and T_{8a}
iii. T_9
iv. h_l and v_l
v. $w_{pump\ in}$
vi. $h_{2\ isentropic}$
vii. $h_{4\ isentropic}$
viii. $w_{net,\ gas\ cycle}$
ix. $w_{net,\ steam\ cycle}$