NAME:
AME 20231, Thermodynamics
Examination 2
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1. (20) A cubical mass of 10 kg of cast iron is at 500 K. It comes to thermal equilibrium with its surroundings, that are at $T_\infty = 300$ K. The convective heat transfer coefficient is $\mathsf{h} = 20$ kW/m^2/K. As done in class, assume the temperature of the cast iron is spatially uniform throughout its volume.

   (a) Find an expression for $T(t)$ of the cast iron cube.

   (b) Evaluate the time constant associated with this cooling process.

2. (30) A fixed mass m of calorically imperfect ideal gas (CIIG) with gas constant R and specific heat at constant volume

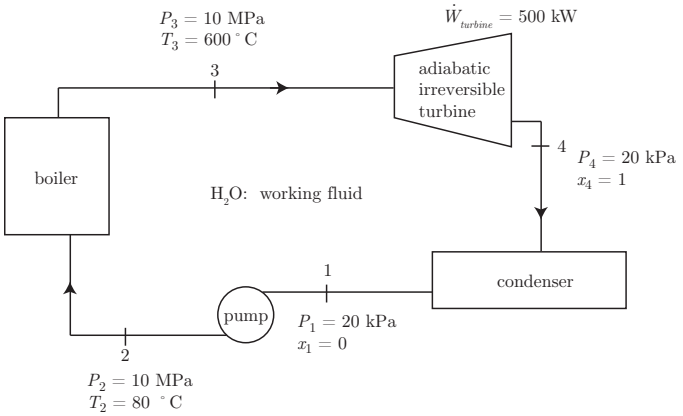
$$c_v = c_{vo} + \alpha T,$$

   is initially at $T = T_1$ and specific volume $v = v_1$.

   (a) Find an expression for the specific entropy s of the gas as a function of T and v, parameterized by c_{vo}, R, and reference state values T_o and v_o.

   (b) The gas *isochorically* comes to thermal equilibrium with its surroundings, which are at $T = T_\infty$. Find the total entropy change of the system, surroundings, and universe.

3. (50) Consider the Rankine cycle below. Find



   (a) the specific work done by the adiabatic irreversible turbine (kJ/kg),

   (b) the mass flow rate (kg/s),

   (c) the heat transfer rate to the boiler (kW),

   (d) the work rate required to power the pump (kW),

   (e) the overall thermal efficiency,

   (f) the thermal efficiency of a Carnot cycle operating between the same temperature limits,

   (g) an accurate sketch of the cycle on a $T - s$ diagram,

   (h) the turbine work rate (kW) that could have been achieved had the adiabatic irreversible turbine been replaced by an adiabatic reversible (isentropic) turbine operating with the same inlet state and between the same pressure limits.