

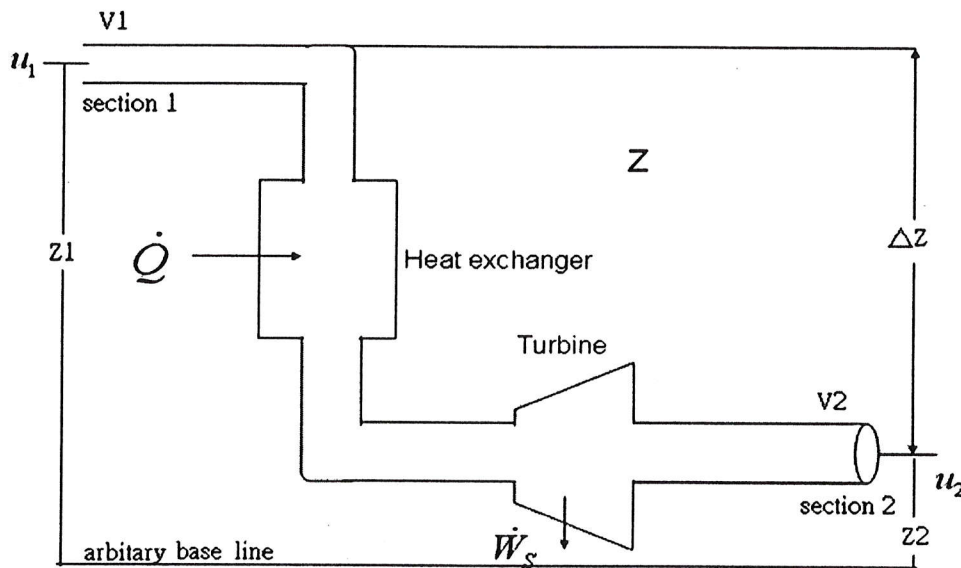


1. (20%)

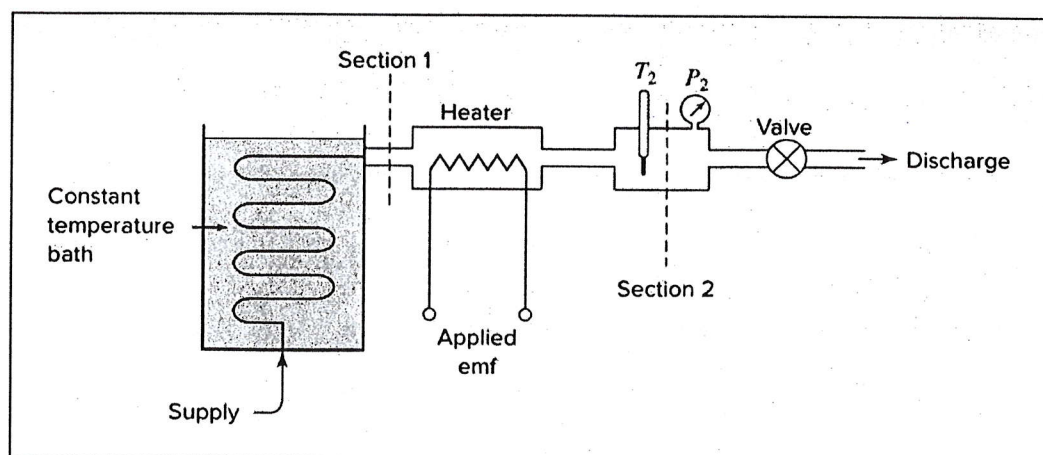
Express properly the four laws of thermodynamics?

2. (20%)

(a) Write the energy balance for the steady-state flow process as illustrated below. (10%)



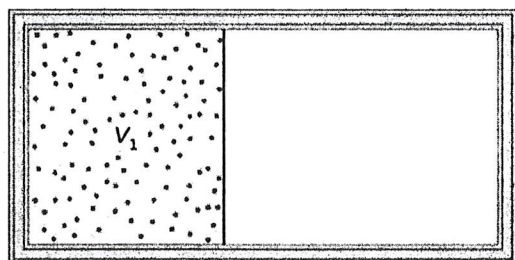
(b) A flow calorimeter for enthalpy measurements is illustrated schematically below. The design provides for minimal velocity and elevation changes from section 1 to section 2, making kinetic- and potential- energy changes of the fluid negligible. Q is the heat added per unit mass of water flowing determined from the resistance of the heater and the current passing through the fluid. With no shaft work entering the system, what will be the reduced energy balance for this laboratory processes. (10%)



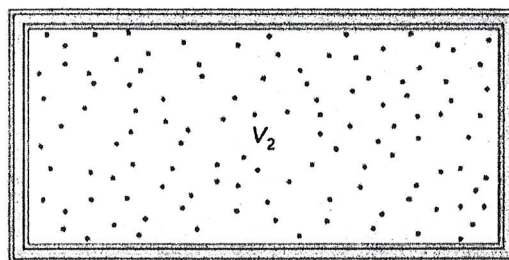


3. (10%)

An ideal gas occupies a partitioned volume V_1 inside a box whose walls are thermally insulating, as shown below. When the partition is removed, the gas expands and fills the entire volume V_2 of the box (i.e., adiabatic free expansion). What is the entropy change of the universe (the system plus its environment)?



(a)



(b)

4. (15%)

A chemical engineer claims to have devised a heat engine that produces power of 95,000 kW by taking heat of 135,000 kW from steam at 750 K and discarding heat to cooling water at 300 K. Show whether or not the engine is possible.

5. (20%)

Saturated liquid water at 1,000 kPa (enthalpy 762.6 kJ/kg) flows adiabatically through an orifice, without any appreciable change in kinetic or potential energy, and immediately into a large flash tank that operates at 101.325 kPa (enthalpy of 419.1 kJ/kg for saturated liquid and of 2676.0 kJ/kg for saturated vapor).

(a) What is the steam quality (%) inside the tank? (10%)

(b) Does the temperature of the steam after flash increase or decrease? Explain why. (10%)

6. (15%)

An ideal gas (constant-volume heat capacity 12.471 J/mol-K) at 1 bar and 70°C is compressed adiabatically and reversibly to 150°C in a closed system. Determine

(a) The minimum compression work? (5%)

(b) The heat transferred and actual work, if the process has a work efficiency of 80%, accomplishing exactly the same changes of state? (10%)