Indian Institute of Technology Kanpur
ESO 201 A: Thermodynamics
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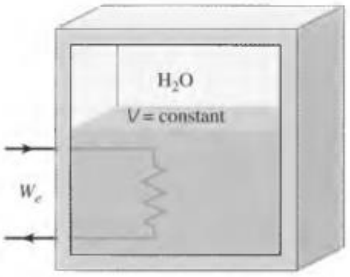
Tutorial- 5

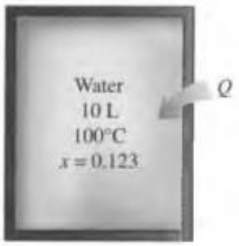
Q 4-32

A well-insulated rigid tank contains 2 kg of a saturated liquid-vapor mixture of water at 150 kPa. Initially, three-quarters of the mass is in the liquid phase. An electric resistor placed in the tank is connected to a 110-V source, and a current of 8 A flows through the resistor when the switch is turned on. Determine how long it will take to vaporize all the liquid in the tank. Also, show the process on a ***T-v*** diagram with respect to saturation lines.



Q 4-35

A rigid 10-L vessel initially contains a mixture of liquid water and vapor at 100°C with 12.3 percent quality. The mixture is then heated until its temperature is 150°C. Calculate the heat transfer required for this process.

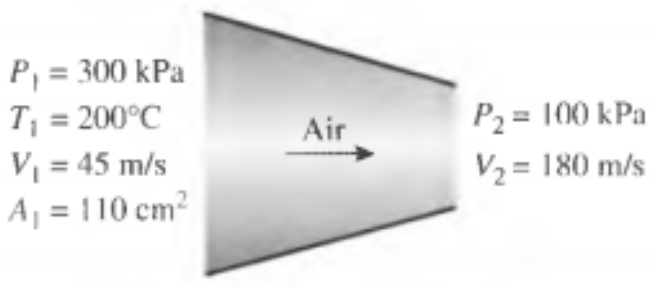


Q 4-82

Air is contained in a piston-cylinder device at 600 kPa and 927°C, and occupies a volume of 0.8 m^3. The air undergoes and isothermal (constant temperature) process until the pressure in reduced to 300 kPa. The piston is now fixed in place and not allowed to move while a heat transfer process takes place until the air reaches 27°C. (a) Sketch the system showing the energies crossing the boundary and the ***P-V*** diagram for the combined processes. ***(b)*** For the combined processes determine the net amount of heat transfer, in kJ, and its direction. Assume air has constant specific heats evaluated at 300 K.

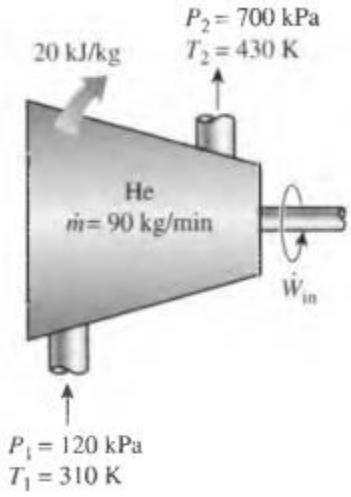
Q 5-30

Air enters an adiabatic nozzle steadily at 300 kPa, 200°C, and 45 m/s and leaves at 100 kPa and 180 m/s. The inlet area of the nozzle is 110 cm^2. Determine ***(a)*** the mass flow rate through the nozzle, (***b)*** the exit temperature of the air, and (c) the exit area of the nozzle.



Q 5-55

Helium is to be compressed from 120 kPa and 310 K to 700 kPa and 430 K. A heat loss of 20 kJ/kg occurs during the compression process. Neglecting kinetic energy changes, determine the power input required or a mass flow rate of 90 kg/min.



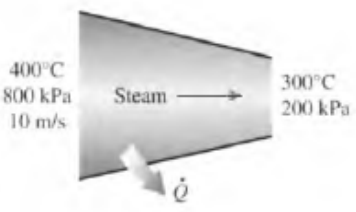
Additional Homework Problems

Q 4-23

A piston-cylinder device initially contains 0.25 kg of nitrogen gas at 130 kPa and 180°C. The nitrogen is now expanded isothermally to a pressure of 80 kPa. Determine the boundary work done during this process.

Q 5-34

Steam enters a nozzle at 400°C and 800 kPa with a velocity of 10 m/s, and leaves at 300°C and 200 kPa while losing heat at a rate of 25 kW. For an inlet area of 800 cm^2, determine the velocity and the volume flow rate of the steam at the nozzle exit.



Q 5-54

Argon gas enters an adiabatic turbine steadily at 1600 kPa and 450°C with a velocity of 55 m/s and leaves at 150 kPa with a velocity of 150 m/s. The inlet area of the turbine is 60 cm^2. If the power output of the turbine is 190 kW, determine the exit temperature of the argon.

Q 5-57

An adiabatic gas turbine expands air at 1300 kPa and 500°C to 100 kPa and 127°C. Air enters the turbine through a 0.2-m^2 opening with an average velocity of 40 m/s, and exhausts through a 1-m^2 opening. Determine ***(a)*** the mass flow rate of air through the turbine and (***b***) the power produced by the turbine.

Q 5-67

Saturated liquid-vapor mixture of water, called wet steam, in a steam line at 2000 kPa is throttled to 100 kPa and 120°C. What is the quality in the steam line?