4–134 Two rigid tanks are connected by a valve. Tank A contains 0.2 m³ of water at 400 kPa and 80 percent quality. Tank B contains 0.5 m³ of water at 200 kPa and 250°C. The valve is now opened, and the two tanks eventually come to the same state. Determine the pressure and the amount of heat transfer when the system reaches thermal equilibrium with the surroundings at 25°C.   *Answers:* 3.17 kPa, 2170 kJ
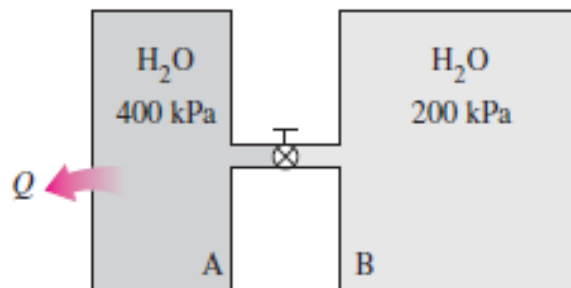

H_2O
400 kPa

H_2O
200 kPa

Q

A

B

FIGURE P4–134

4–141 An insulated rigid tank initially contains 1.4-kg saturated liquid water and water vapor at 200°C. At this state, 25 percent of the volume is occupied by liquid water and the rest by vapor. Now an electric resistor placed in the tank is turned on, and the tank is observed to contain saturated water vapor after 20 min. Determine (*a*) the volume of the tank, (*b*) the final temperature, and (*c*) the electric power rating of the resistor. *Answers:* (*a*) 0.00648 m³, (*b*) 371°C, (*c*) 1.58 kW
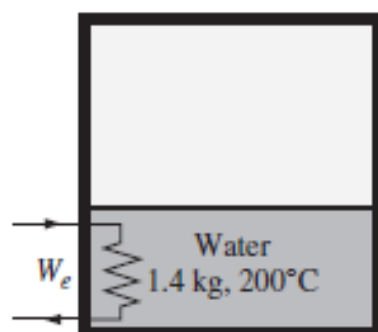

FIGURE P4–141

4–38 A piston–cylinder device initially contains steam at 200 kPa, 200°C, and 0.5 m³. At this state, a linear spring ($F \propto x$) is touching the piston but exerts no force on it. Heat is now slowly transferred to the steam, causing the pressure and the volume to rise to 500 kPa and 0.6 m³, respectively. Show the process on a *P-v* diagram with respect to saturation lines and determine (*a*) the final temperature, (*b*) the work done by the steam, and (*c*) the total heat transferred. *Answers:* (*a*) 1132°C, (*b*) 35 kJ, (*c*) 808 kJ
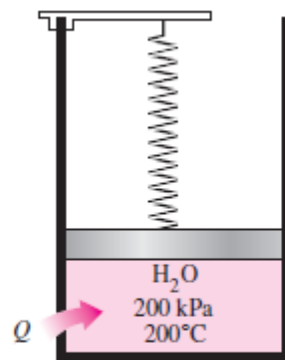
FIGURE P4–38

4–40 A piston–cylinder device initially contains 0.8 m³ of saturated water vapor at 250 kPa. At this state, the piston is resting on a set of stops, and the mass of the piston is such that a pressure of 300 kPa is required to move it. Heat is now slowly transferred to the steam until the volume doubles. Show the process on a *P-v* diagram with respect to saturation lines and determine (*a*) the final temperature, (*b*) the work done during this process, and (*c*) the total heat transfer. *Answers:* (*a*) 662°C, (*b*) 240 kJ, (*c*) 1213 kJ

4–41 Two tanks (Tank A and Tank B) are separated by a partition. Initially Tank A contains 2-kg steam at 1 MPa and 300°C while Tank B contains 3-kg saturated liquid–vapor mixture with a vapor mass fraction of 50 percent. Now the partition is removed and the two sides are allowed to mix until the mechanical and thermal equilibrium are established. If the pressure at the final state is 300 kPa, determine (a) the temperature and quality of the steam (if mixture) at the final state and (b) the amount of heat lost from the tanks.
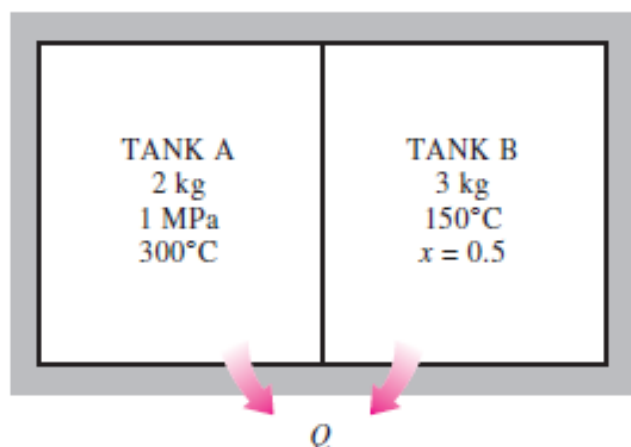

TANK A	TANK B
2 kg	3 kg
1 MPa	150°C
300°C	$x = 0.5$

Q

FIGURE P4–41

5–76 Liquid water at 300 kPa and 20°C is heated in a chamber by mixing it with superheated steam at 300 kPa and 300°C. Cold water enters the chamber at a rate of 1.8 kg/s. If the mixture leaves the mixing chamber at 60°C, determine the mass flow rate of the superheated steam required. *Answer:* 0.107 kg/s

5–51 Steam enters an adiabatic turbine at 10 MPa and 500°C and leaves at 10 kPa with a quality of 90 percent. Neglecting the changes in kinetic and potential energies, determine the mass flow rate required for a power output of 5 MW. *Answer:* 4.852 kg/s

5–35 Air at 600 kPa and 500 K enters an adiabatic nozzle that has an inlet-to-exit area ratio of 2:1 with a velocity of

$P_1 = 3$ MPa
$T_1 = 400°C$
$V_1 = 40$ m/s

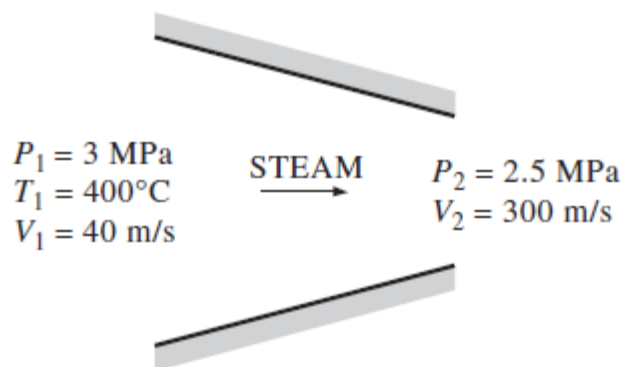STEAM

$P_2 = 2.5$ MPa
$V_2 = 300$ m/s

FIGURE P5–34

120 m/s and leaves with a velocity of 380 m/s. Determine (a) the exit temperature and (b) the exit pressure of the air. *Answers:* (a) 436.5 K, (b) 330.8 kPa

5–8 A hair dryer is basically a duct of constant diameter in which a few layers of electric resistors are placed. A small fan pulls the air in and forces it through the resistors where it is heated. If the density of air is 1.20 kg/m³ at the inlet and 1.05 kg/m³ at the exit, determine the percent increase in the velocity of air as it flows through the dryer.
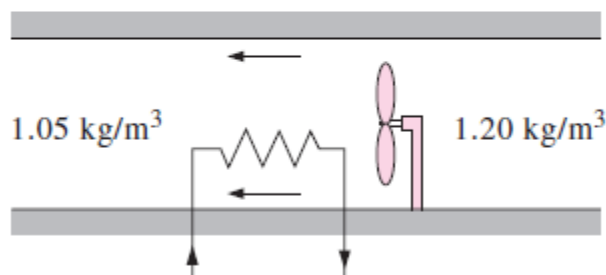
1.05 kg/m³   1.20 kg/m³

FIGURE P5–8

5–97 Hot exhaust gases of an internal combustion engine are to be used to produce saturated water vapor at 2 MPa pressure. The exhaust gases enter the heat exchanger at 400°C at a rate of 32 kg/min while water enters at 15°C. The heat exchanger is not well insulated, and it is estimated that 10 percent of heat given up by the exhaust gases is lost to the surroundings. If the mass flow rate of the exhaust gases is 15 times that of the water, determine (a) the temperature of the exhaust gases at the heat exchanger exit and (b) the rate of heat transfer to the water. Use the constant specific heat properties of air for the exhaust gases.
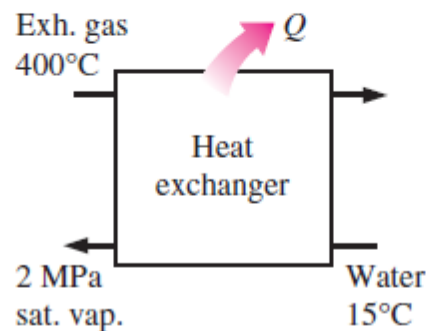
Exh. gas
400°C

Q

Heat
exchanger

2 MPa
sat. vap.

Water
15°C

FIGURE P5–97

5–96 An air-conditioning system involves the mixing of cold air and warm outdoor air before the mixture is routed to the conditioned room in steady operation. Cold air enters the mixing chamber at 5°C and 105 kPa at a rate of 1.25 m³/s while warm air enters at 34°C and 105 kPa. The air leaves the room at 24°C. The ratio of the mass flow rates of the hot to cold air streams is 1.6. Using variable specific heats, determine (*a*) the mixture temperature at the inlet of the room and (*b*) the rate of heat gain of the room.
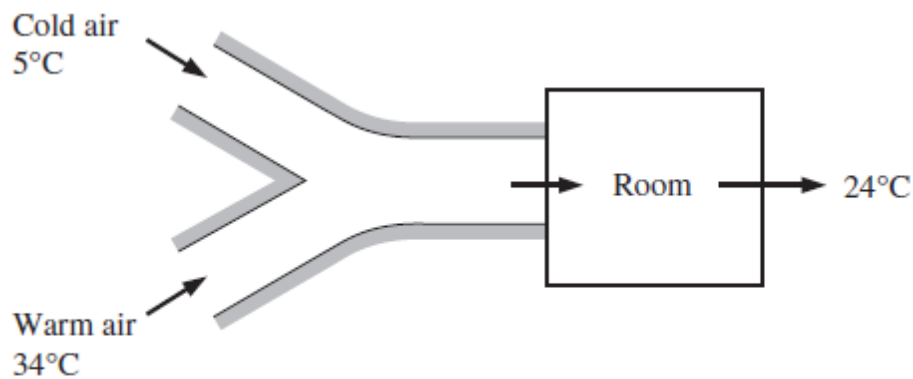
Cold air
5°C

Room   24°C

Warm air
34°C

FIGURE P5–96

5–103 A long roll of 2-m-wide and 0.5-cm-thick 1-Mn manganese steel plate ($\rho = 7854$ kg/m³ and $c_p = 0.434$ kJ/kg · °C) coming off a furnace at 820°C is to be quenched in an oil bath at 45°C to a temperature of 51.1°C. If the metal sheet is moving at a steady velocity of 10 m/min, determine the required rate of heat removal from the oil to keep its temperature constant at 45°C. *Answer:* 4368 kW
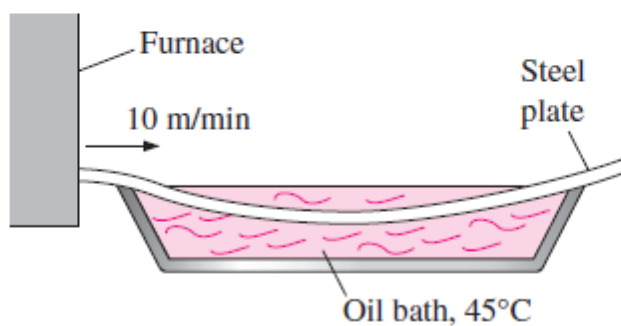

FIGURE P5–103

5–109 A computer cooled by a fan contains eight PCBs, each dissipating 10 W power. The height of the PCBs is 12 cm and the length is 18 cm. The cooling air is supplied by a 25-W fan mounted at the inlet. If the temperature rise of air as it flows through the case of the computer is not to exceed 10°C, determine (*a*) the flow rate of the air that the fan needs to deliver and (*b*) the fraction of the temperature rise of air that is due to the heat generated by the fan and its motor. *Answers:* (*a*) 0.0104 kg/s, (*b*) 24 percent
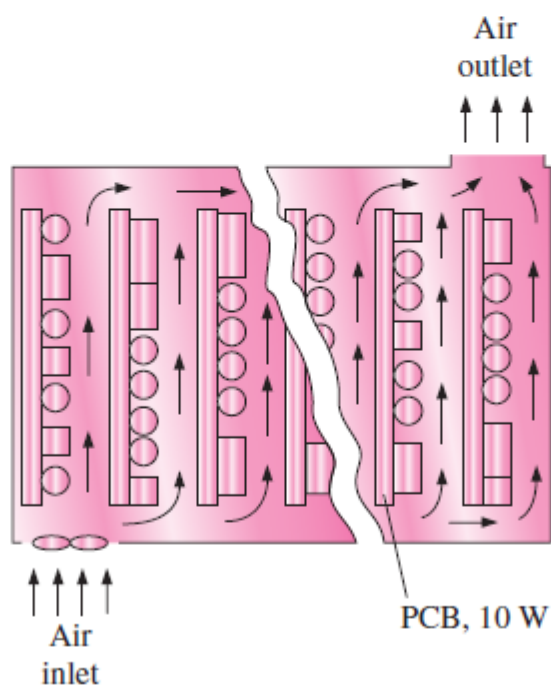

FIGURE P5–109

5–17 Consider a 300-L storage tank of a solar water heating system initially filled with warm water at 45°C. Warm water is withdrawn from the tank through a 2-cm diameter hose at an average velocity of 0.5 m/s while cold water enters the tank at 20°C at a rate of 5 L/min. Determine the amount of water in the tank after a 20-minute period. Assume the pressure in the tank remains constant at 1 atm. *Answer:* 212 kg
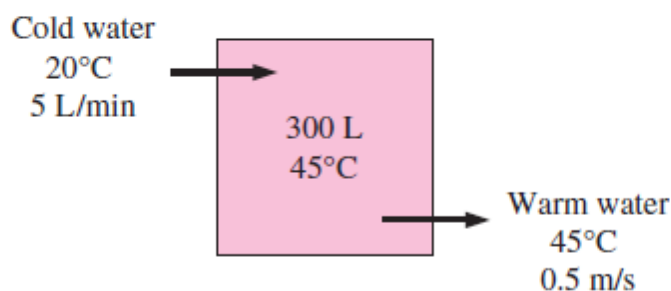
Cold water
20°C
5 L/min

300 L
45°C

Warm water
45°C
0.5 m/s

FIGURE P5–17

5–123 A vertical piston–cylinder device initially contains 0.25 m³ of air at 600 kPa and 300°C. A valve connected to the cylinder is now opened, and air is allowed to escape until three-quarters of the mass leave the cylinder at which point the volume is 0.05 m³. Determine the final temperature in the cylinder and the boundary work during this process.
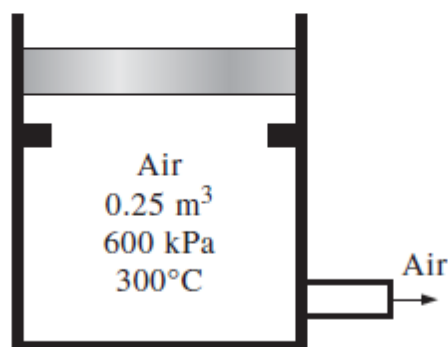
Air
0.25 m³
600 kPa
300°C

Air

FIGURE P5–123

5–127 A 2-m³ rigid tank initially contains air at 100 kPa and 22°C. The tank is connected to a supply line through a valve. Air is flowing in the supply line at 600 kPa and 22°C. The valve is opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that the air temperature at the final state is 77°C. Determine (a) the mass of air that has entered the tank and (b) the amount of heat transfer. *Answers: (a) 9.58 kg, (b) $Q_{out} = 339$ kJ*
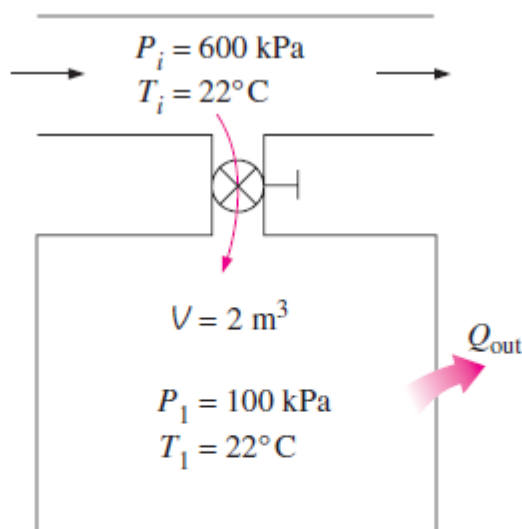
$P_i = 600$ kPa
$T_i = 22°C$

$V = 2$ m³

Q_{out}

$P_1 = 100$ kPa
$T_1 = 22°C$

FIGURE P5–127

5–133 A 0.3-m³ rigid tank is filled with saturated liquid water at 200°C. A valve at the bottom of the tank is opened, and liquid is withdrawn from the tank. Heat is transferred to the water such that the temperature in the tank remains constant. Determine the amount of heat that must be transferred by the time one-half of the total mass has been withdrawn.
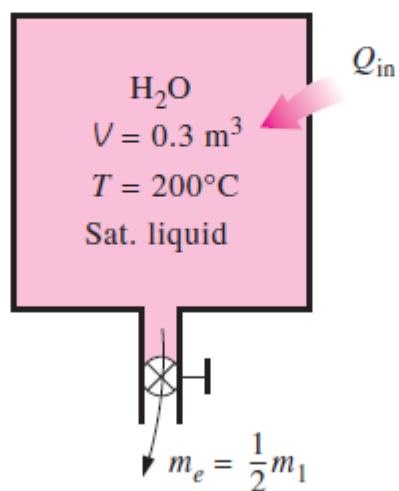

H_2O

$V = 0.3 \text{ m}^3$

$T = 200°C$

Sat. liquid

Q_{in}

$m_e = \frac{1}{2}m_1$

FIGURE P5–133

5–131 An insulated, vertical piston–cylinder device initially contains 10 kg of water, 6 kg of which is in the vapor phase. The mass of the piston is such that it maintains a constant pressure of 200 kPa inside the cylinder. Now steam at 0.5 MPa and 350°C is allowed to enter the cylinder from a supply line until all the liquid in the cylinder has vaporized. Determine (a) the final temperature in the cylinder and (b) the mass of the steam that has entered. *Answers: (a) 120.2°C, (b) 19.07 kg*
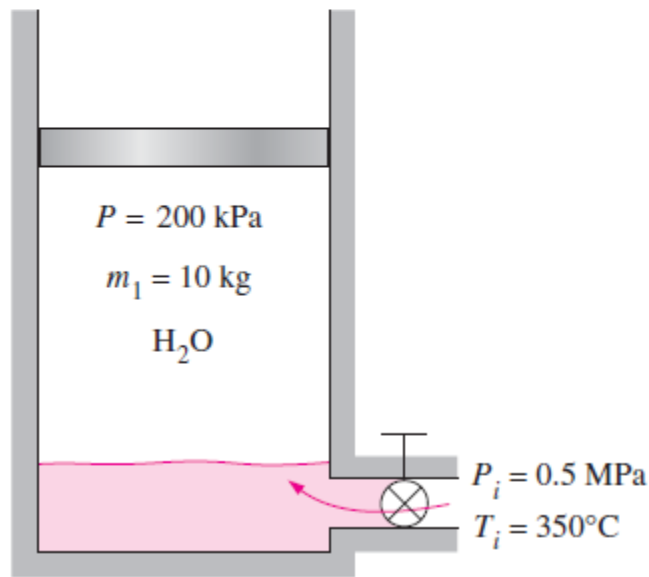
$P = 200$ kPa

$m_1 = 10$ kg

H_2O

$P_i = 0.5$ MPa
$T_i = 350$°C