

4–27 0.5-kg water that is initially at 1 MPa and 10 percent quality occupies a spring-loaded piston–cylinder device. This device is now cooled until the water is a saturated liquid at 100°C. Calculate the total work produced during this process, in kJ.

4–35 A well-insulated rigid tank contains 5 kg of a saturated liquid–vapor mixture of water at 100 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.

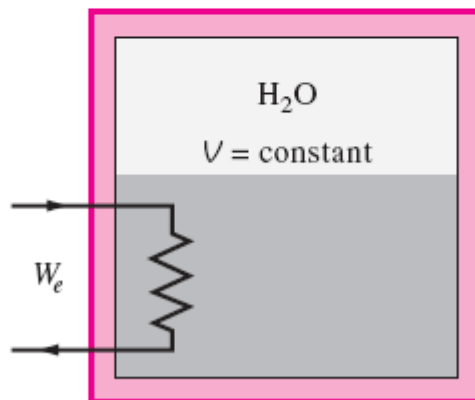


FIGURE P4–35

4–42 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 at 150°C 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.

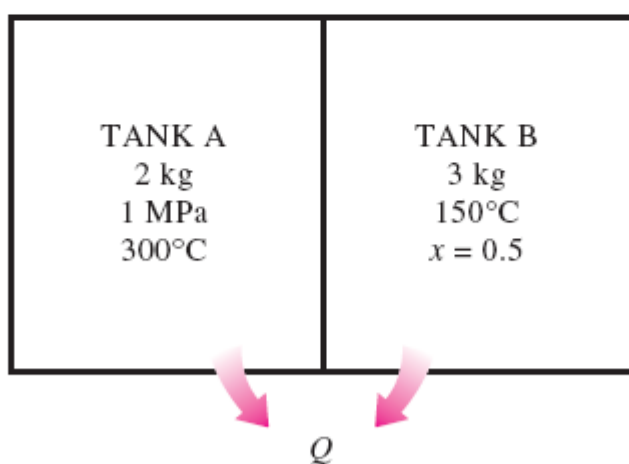


FIGURE P4–42

4–57 A mass of 10-g of nitrogen is contained in the spring-loaded piston–cylinder device shown in Fig. P4–57. The spring constant is 1 kN/m, and the piston diameter is 10 cm. When the spring exerts no force against the piston, the nitrogen is at 120 kPa and 27°C. The device is now heated until its volume is 10 percent greater than the original volume. Determine the change in the specific internal energy and enthalpy of the nitrogen. *Answers: 46.8 kJ/kg, 65.5 kJ/kg*

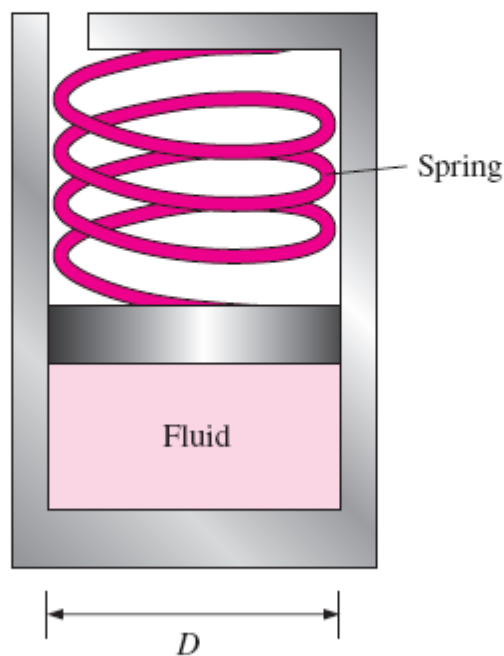


FIGURE P4–57

4–71 1-kg of oxygen is heated from 25 to 300°C. Determine the amount of heat transfer required when this is done during a (a) constant-volume process and (b) isobaric process.

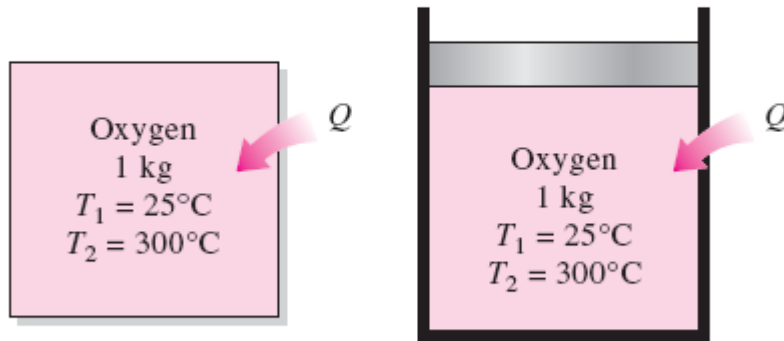


FIGURE P4–71

4–79 A mass of 15 kg of air in a piston–cylinder device is heated from 25 to 77°C by passing current through a resistance heater inside the cylinder. The pressure inside the cylinder is held constant at 300 kPa during the process, and a heat loss of 60 kJ occurs. Determine the electric energy supplied, in kWh.

Answer: 0.235 kWh

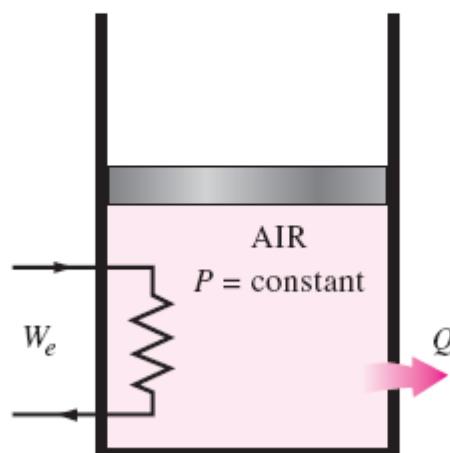


FIGURE P4–79

4-96 Long cylindrical steel rods ($\rho = 7833 \text{ kg/m}^3$ and $c_p = 0.465 \text{ kJ/kg} \cdot ^\circ\text{C}$) of 10-cm diameter are heat-treated by drawing them at a velocity of 3 m/min through an oven maintained at 900°C . If the rods enter the oven at 30°C and leave at a mean temperature of 700°C , determine the rate of heat transfer to the rods in the oven.

4-127 A frictionless piston–cylinder device initially contains air at 200 kPa and 0.2 m^3 . At this state, a linear spring ($F \propto x$) is touching the piston but exerts no force on it. The air is now heated to a final state of 0.5 m^3 and 800 kPa. Determine (a) the total work done by the air and (b) the work done against the spring. Also, show the process on a P - v diagram.

Answers: (a) 150 kJ, (b) 90 kJ

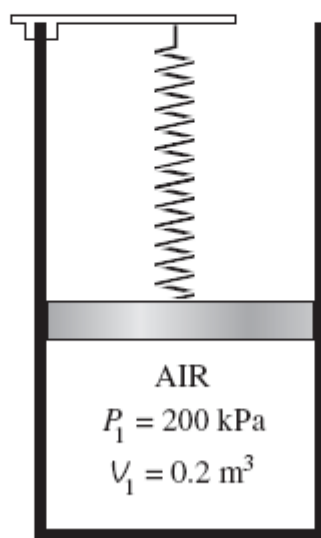


FIGURE P4-127

4–128 A mass of 5 kg of saturated liquid–vapor mixture of water is contained in a piston–cylinder device at 125 kPa. Initially, 2 kg of the water is in the liquid phase and the rest is in the vapor phase. Heat is now transferred to the water, and the piston, which is resting on a set of stops, starts moving when the pressure inside reaches 300 kPa. Heat transfer continues until the total volume increases by 20 percent. Determine (a) the initial and final temperatures, (b) the mass of liquid water when the piston first starts moving, and (c) the work done during this process. Also, show the process on a P - v diagram.

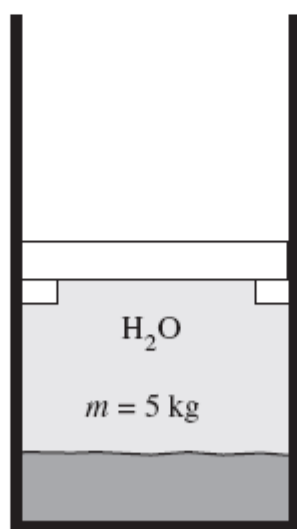


FIGURE P4–128

4–147 A rigid tank containing 0.4 m^3 of air at 400 kPa and 30°C is connected by a valve to a piston–cylinder device with zero clearance. The mass of the piston is such that a pressure of 200 kPa is required to raise the piston. The valve is now opened slightly, and air is allowed to flow into the cylinder until the pressure in the tank drops to 200 kPa . During this process, heat is exchanged with the surroundings such that the entire air remains at 30°C at all times. Determine the heat transfer for this process.

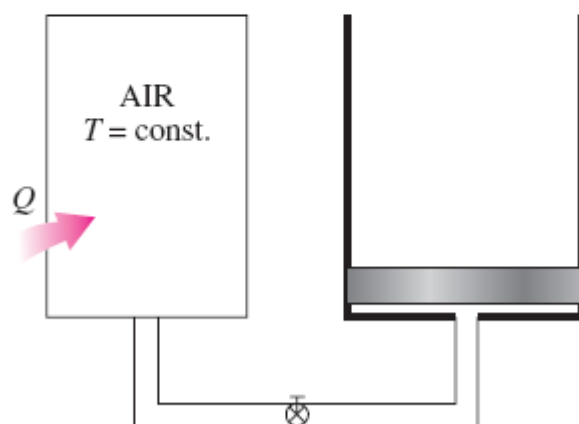


FIGURE P4–147

4–156 Catastrophic explosions of steam boilers in the 1800s and early 1900s resulted in hundreds of deaths, which prompted the development of the ASME Boiler and Pressure Vessel Code in 1915. Considering that the pressurized fluid in a vessel eventually reaches equilibrium with its surroundings shortly after the explosion, the work that a pressurized fluid would do if allowed to expand adiabatically to the state of the surroundings can be viewed as the *explosive energy* of the pressurized fluid. Because of the very short time period of the explosion and the apparent stability afterward, the explosion process can be considered to be adiabatic with no changes in kinetic and potential energies. The closed-system conservation of energy relation in this case reduces to $\dot{W}_{\text{out}} = m(u_1 - u_2)$. Then the explosive energy E_{exp} becomes

$$E_{\text{exp}} = m(u_1 - u_2)$$

where the subscripts 1 and 2 refer to the state of the fluid before and after the explosion, respectively. The specific explosion energy e_{exp} is usually expressed *per unit volume*, and it is obtained by dividing the quantity above by the total V of the vessel:

$$e_{\text{exp}} = \frac{u_1 - u_2}{v_1}$$

where v_1 is the specific volume of the fluid before the explosion.

Show that the specific explosion energy of an ideal gas with constant specific heat is

$$e_{\text{exp}} = \frac{P_1}{k - 1} \left(1 - \frac{T_2}{T_1} \right)$$

Also, determine the total explosion energy of 20 m³ of air at 5 MPa and 100°C when the surroundings are at 20°C.

4-SPECIAL

Derive the coefficients ‘a’ and ‘b’ for van Der Waals’ equation in terms of critical properties for pressure, temperature and volume.