19. Determine the elongation of the rod in Figure P9.19 if it is under a tension of 5.8×10^3 N.

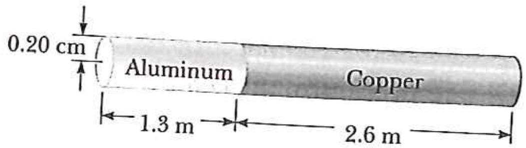
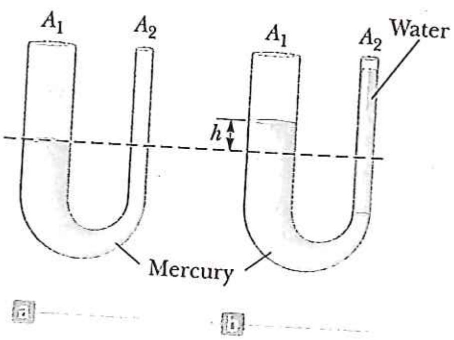


Figure P9.19

22. Mercury is poured into a U-tube as shown in Figure P9.22a on page 324. The left arm of the tube has cross-sectional area A_1 of 10.0 cm², and the right arm has a cross-sectional area A_2 of 5.00 cm². One hundred grams of water are then poured into the right arm as shown in Figure P9.22b. (a) Determine the length of the water column in the right arm of the U-tube. (b) Given that the density of mercury is 13.6 g/cm³, what distance h does the mercury rise in the left arm?



25. A container is filled to a depth of 20.0 cm with water. On top of the water floats a 30.0-cm-thick layer of oil with specific gravity 0.700. What is the absolute pressure at the bottom of the container?

37. Q|C On October 21, 2001, Ian Ashpole of the United Kingdom achieved a record altitude of 3.35 km (11 000 ft) powered by 600 toy balloons filled with helium. Each filled balloon had a radius of about 0.50 m and an estimated mass of 0.30 kg. (a) Estimate the total buoyant force on the 600 balloons. (b) Estimate the net upward force on all 600 balloons. (c) Ashpole parachuted to Earth after the balloons began to burst at the high altitude and the system lost buoyancy. Why did the balloons burst?

38. The gravitational force exerted on a solid object is 5.00 N as measured when the object is suspended from a spring scale as in Figure P9.38a. When the suspended object is submerged in water, the scale reads 3.50 N (Figure P9.38b). Find the density of the object.

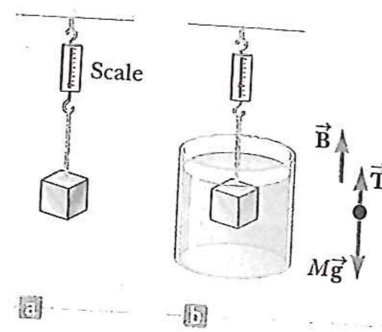


Figure P9.38

42. An object weighing 300 N in air is immersed in water after being tied to a string connected to a balance. The scale now reads 265 N. Immersed in oil, the object appears to weigh 275 N. Find (a) the density of the object and (b) the density of the oil.

43. A 1.00-kg beaker containing 2.00 kg of oil (density = 916 kg/m³) rests on a scale. A 2.00-kg block of iron is suspended from a spring scale and is completely submerged in the oil (Fig. P9.43). Find the equilibrium readings of both scales.

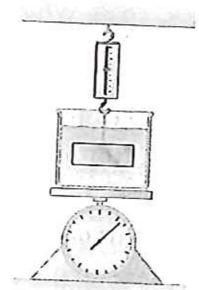


Figure P9.43

class 21
chapter 9

45. **BIO** (a) Calculate the mass flow rate (in grams per second) of blood ($\rho = 1.0\ g/cm^3$) in an aorta with a cross-sectional area of 2.0 cm^2 if the flow speed is 40 cm/s. (b) Assume that the aorta branches to form a large number of capillaries with a combined cross-sectional area of $3.0 \times 10^3\ cm^2$. What is the flow speed in the capillaries?

51. **GP** In a water pistol, a piston drives water through a larger tube of radius 1.00 cm into a smaller tube of radius 1.00 mm as in Figure P9.51. (a) If the pistol is fired horizontally at a height of 1.50 m, use ballistics to determine the time it takes water to travel from the nozzle to the ground. (Neglect air resistance and assume atmospheric pressure is 1.00 atm.) (b) If the range of the stream is to be 8.00 m, with what speed must the stream leave the nozzle? (c) Given the areas of the nozzle and cylinder, use the equation of continuity to calculate the speed at which the plunger must be moved. (d) What is the pressure at the nozzle? (e) Use Bernoulli's equation to find the pressure needed in the larger cylinder. Can gravity terms be neglected? (f) Calculate the force that must be exerted on the trigger to achieve the desired range. (The force that must be exerted is due to pressure over and above atmospheric pressure.)

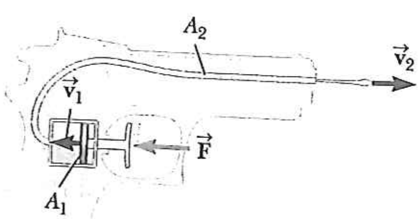


Figure P9.51

52. Water moves through a constricted pipe in steady, ideal flow. At the lower point shown in Figure P9.52, the pressure is 1.75×10^5 Pa and the pipe radius is 3.00 cm. At the higher point located at y = 2.50 m, the pressure is 1.20×10^5 Pa and the pipe radius is 1.50 cm. Find the speed of flow (a) in the lower section and (b) in the upper section. (c) Find the volume flow rate through the pipe.

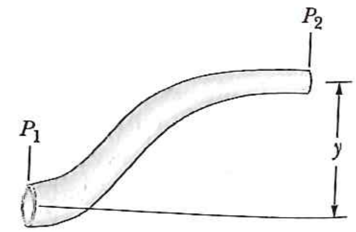
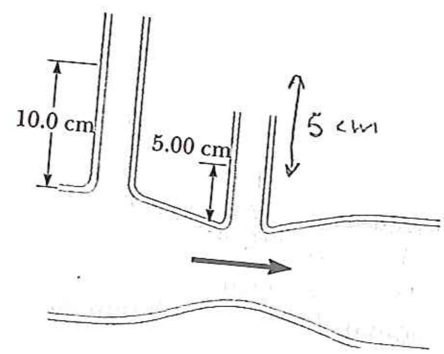


Figure P9.52

55. The inside diameters of the larger portions of the horizontal pipe depicted in Figure P9.55 are 2.50 cm. Water flows to the right at a rate of $1.80 \times 10^{-4}\ m^3/s$. Determine the inside diameter of the constriction.



58. The Venturi tube shown in Figure P9.58 may be used as a fluid flowmeter. Suppose the device is used at a service station to measure the flow rate of gasoline ($\rho = 7.00 \times 10^2\ kg/m^3$) through a hose having an outlet radius of 1.20 cm. If the difference in pressure is measured to be $P_1 - P_2 = 1.20$ kPa and the radius of the inlet tube to the meter is 2.40 cm, find (a) the speed of the gasoline as it leaves the hose and (b) the fluid flow rate in cubic meters per second.

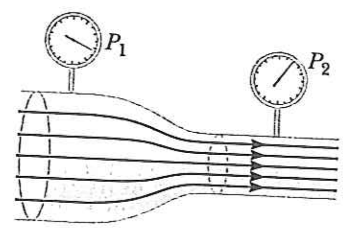


Figure P9.58

class 22
chapter 9

60. **BIO** To lift a wire ring of radius 1.75 cm from the surface of a container of blood plasma, a vertical force of 1.61×10^{-2} N greater than the weight of the ring is required. Calculate the surface tension of blood plasma from this information.

64. A thin 1.5-mm coating of glycerine has been placed between two microscope slides of width 1.0 cm and length 4.0 cm. Find the force required to pull one of the microscope slides at a constant speed of 0.30 m/s relative to the other slide.

65. A straight horizontal pipe with a diameter of 1.0 cm and a length of 50 m carries oil with a coefficient of viscosity of $0.12\ \mathrm{N \cdot s/m^2}$. At the output of the pipe, the flow rate is $8.6 \times 10^{-5}\ \mathrm{m^3/s}$ and the pressure is 1.0 atm. Find the *gauge* pressure at the pipe input.

69. **BIO** What radius needle should be used to inject a volume of 500 $\mathrm{cm^3}$ of a solution into a patient in 30 min? Assume the length of the needle is 2.5 cm and the solution is elevated 1.0 m above the point of injection. Further, assume the viscosity and density of the solution are those of pure water, and that the pressure inside the vein is atmospheric.

71. **BIO** The aorta in humans has a diameter of about 2.0 cm, and at certain times the blood speed through it is about 55 cm/s. Is the blood flow turbulent? The density of whole blood is 1 050 $\mathrm{kg/m^3}$, and its coefficient of viscosity is $2.7 \times 10^{-3}\ \mathrm{N \cdot s/m^2}$.

Class 23
chapter 9

75. The viscous force on an oil drop is measured to be equal to 3.0×10^{-13} N when the drop is falling through air with a speed of 4.5×10^{-4} m/s. If the radius of the drop is 2.5×10^{-6} m, what is the viscosity of air?

4. Death Valley holds the record for the highest recorded temperature in the United States. On July 10, 1913, at a place called Furnace Creek Ranch, the temperature rose to 134°F. The lowest U.S. temperature ever recorded occurred at Prospect Creek Camp in Alaska on January 23, 1971, when the temperature plummeted to −79.8° F. (a) Convert these temperatures to the Celsius scale. (b) Convert the Celsius temperatures to Kelvin.

23. The band in Figure P10.23 is stainless steel (coefficient of linear expansion = 17.3×10^{-6} °C^{-1}; Young's modulus = 18×10^{10} N/m^2). It is essentially circular with an initial mean radius of 5.0 mm, a height of 4.0 mm, and a thickness of 0.50 mm. If the band just fits snugly over the tooth when heated to a temperature of 80°C, what is the tension in the band when it cools to a temperature of 37°C?

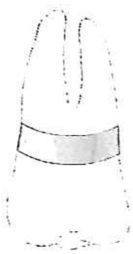


Figure P10.23

24. QIC The Trans-Alaskan pipeline is 1 300 km long, reaching from Prudhoe Bay to the port of Valdez, and is subject to temperatures ranging from −73°C to +35°C. (a) How much does the steel pipeline expand due to the difference in temperature? (b) How can one compensate for this expansion?

25. The average coefficient of volume expansion for carbon tetrachloride is 5.81×10^{-4} (°C)$^{-1}$. If a 50.0-gal steel container is filled completely with carbon tetrachloride when the temperature is 10.0°C, how much will spill over when the temperature rises to 30.0°C?

30. GP A 20.0-L tank of carbon dioxide gas (CO_2) is at a pressure of 9.50×10^5 Pa and temperature of 19.0°C. (a) Calculate the temperature of the gas in Kelvin. (b) Use the ideal gas law to calculate the number of moles of gas in the tank. (c) Use the periodic table to compute the molecular weight of carbon dioxide, expressing it in grams per mole. (d) Obtain the number of grams of carbon dioxide in the tank. (e) A fire breaks out, raising the ambient temperature by 224.0 K while 82.0 g of gas leak out of the tank. Calculate the new temperature and the number of moles of gas remaining in the tank. (f) Using a technique analogous to that in Example 10.6b, find a symbolic expression for the final pressure, neglecting the change in volume of the tank. (g) Calculate the final pressure in the tank as a result of the fire and leakage.

36. The density of helium gas at 0°C is $\rho_0 = 0.179$ kg/m^3. The temperature is then raised to $T = 100$°C, but the pressure is kept constant. Assuming the helium is an ideal gas, calculate the new density ρ_f of the gas.

Class 24
chapter 10

32. **M** An automobile tire is inflated with air originally at 10.0°C and normal atmospheric pressure. During the process, the air is compressed to 28.0% of its original volume and the temperature is increased to 40.0°C. (a) What is the tire pressure in pascals? (b) After the car is driven at high speed, the tire's air temperature rises to 85.0°C and the tire's interior volume increases by 2.00%. What is the new tire pressure (absolute) in pascals?

34. Gas is contained in an 8.00-L vessel at a temperature of 20.0°C and a pressure of 9.00 atm. (a) Determine the number of moles of gas in the vessel. (b) How many molecules are in the vessel?

39. What is the average kinetic energy of a molecule of oxygen at a temperature of 300 K?

41. Use Avogadro's number to find the mass of a helium atom.

44. **QIC** A 7.00-L vessel contains 3.50 moles of ideal gas at a pressure of 1.60×10^6 Pa. Find (a) the temperature of the gas and (b) the average kinetic energy of a gas molecule in the vessel. (c) What additional information would you need if you were asked to find the average speed of a gas molecule?

Class 25
Chapter 10

20. M A 1.50-kg iron horseshoe initially at 600°C is dropped into a bucket containing 20.0 kg of water at 25.0°C. What is the final temperature of the water–horseshoe system? Ignore the heat capacity of the container and assume a negligible amount of water boils away.

30. GP Into a 0.500-kg aluminum container at 20.0°C is placed 6.00 kg of ethyl alcohol at 30.0°C and 1.00 kg ice at −10.0°C. Assume the system is insulated from its environment. (a) Identify all five thermal energy transfers that occur as the system goes to a final equilibrium temperature T. Use the form "substance at X°C to substance at Y°C." (b) Construct a table similar to the table in Example 11.5. (c) Sum all terms in the right-most column of the table and set the sum equal to zero. (d) Substitute information from the table into the equation found in part (c) and solve for the final equilibrium temperature, T.

31. A 40-g block of ice is cooled to −78°C and is then added to 560 g of water in an 80-g copper calorimeter at a temperature of 25°C. Determine the final temperature of the system consisting of the ice, water, and calorimeter. (If not all the ice melts, determine how much ice is left.) Remember that the ice must first warm to 0°C, melt, and then continue warming as water. (The specific heat of ice is 0.500 cal/g · °C = 2 090 J/kg · °C.)

class 26
chapter 11

57. QIC A student measures the following data in a calorimetry experiment designed to determine the specific heat of aluminum:

Initial temperature of water and calorimeter:	70.0°C
Mass of water:	0.400 kg
Mass of calorimeter:	0.040 kg
Specific heat of calorimeter:	0.63 kJ/kg · °C
Initial temperature of aluminum:	27.0°C
Mass of aluminum:	0.200 kg
Final temperature of mixture:	66.3°C

Use these data to determine the specific heat of aluminum. Explain whether your result is within 15% of the value listed in Table 11.1.

63. An automobile has a mass of 1 500 kg, and its aluminum brakes have an overall mass of 6.00 kg. (a) Assuming all the internal energy transformed by friction when the car stops is deposited in the brakes and neglecting energy transfer, how many times could the car be braked to rest starting from 25.0 m/s before the brakes would begin to melt? (Assume an initial temperature of 20.0°C.) (b) Identify some effects that are neglected in part (a), but are likely to be important in a more realistic assessment of the temperature increase of the brakes.

40. BIO The thermal conductivities of human tissues vary greatly. Fat and skin have conductivities of about 0.20 W/m·K and 0.020 W/m·K, respectively, while other tissues inside the body have conductivities of about 0.50 W/m·K. Assume that between the core region of the body and the skin surface lies a skin layer of 1.0 mm, fat layer of 0.50 cm, and 3.2 cm of other tissues. (a) Find the *R*-factor for each of these layers, and the equivalent *R*-factor for all layers taken together, retaining two digits. (b) Find the rate of energy loss when the core temperature is 37°C and the exterior temperature is 0°C. Assume that both a protective layer of clothing and an insulating layer of unmoving air are absent, and a body area of 2.0 m^2.

44. A thermopane window consists of two glass panes, each 0.50 cm thick, with a 1.0-cm-thick sealed layer of air in between. (a) If the inside surface temperature is 23°C and the outside surface temperature is 0.0°C, determine the rate of energy transfer through 1.0 m^2 of the window. (b) Compare your answer to (a) with the rate of energy transfer through 1.0 m^2 of a single 1.0-cm-thick pane of glass. Disregard surface air layers.

46. A Styrofoam box has a surface area of 0.80 m^2 and a wall thickness of 2.0 cm. The temperature of the inner surface is 5.0°C, and the outside temperature is 25°C. If it takes 8.0 h for 5.0 kg of ice to melt in the container, determine the thermal conductivity of the Styrofoam.

54. BIO The surface area of an unclothed person is 1.50 m^2, and his skin temperature is 33.0°C. The person is located in a dark room with a temperature of 20.0°C, and the emissivity of the skin is $e = 0.95$. (a) At what rate is energy radiated by the body? (b) What is the significance of the sign of your answer?

61. A bar of gold (Au) is in thermal contact with a bar of silver (Ag) of the same length and area (Fig. P11.61). One end of the compound bar is maintained at 80.0°C, and the opposite end is at 30.0°C. Find the temperature at the junction when the energy flow reaches a steady state.

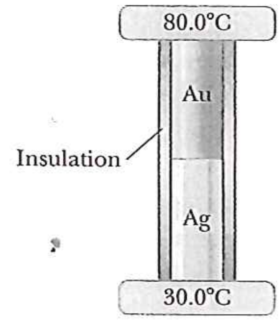


Figure P11.61

66. A wood stove is used to heat a single room. The stove is cylindrical in shape, with a diameter of 40.0 cm and a length of 50.0 cm, and operates at a temperature of 400°F. (a) If the temperature of the room is 70.0°F, determine the amount of radiant energy delivered to the room by the stove each second if the emissivity is 0.920. (b) If the room is a square with walls that are 8.00 ft high and 25.0 ft wide, determine the *R*-value needed in the walls and ceiling to maintain the inside temperature at 70.0°F if the outside temperature is 32.0°F. Note that we are ignoring any heat conveyed by the stove via convection and any energy lost through the walls (and windows!) via convection or radiation.

Class 27
Chapter 11

20. A system consisting of 0.025 6 moles of a diatomic ideal gas is taken from state A to state C along the path in Figure P12.20. (a) How much work is done *on* the gas during this process? (b) What is the lowest temperature of the gas during this process, and where does it occur? (c) Find the change in internal energy of the gas and (d) the energy delivered to the gas in going from A to C. *Hint:* For part (c), adapt the equation in the remarks of Example 12.9 to a diatomic ideal gas.

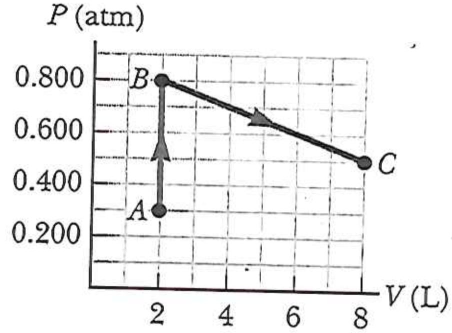


Figure P12.20

23. **GP** An ideal monatomic gas is contained in a vessel of *constant* volume 0.200 m³. The initial temperature and pressure of the gas are 300 K and 5.00 atm, respectively. The goal of this problem is to find the temperature and pressure of the gas after 16.0 kJ of thermal energy is supplied to the gas. (a) Use the ideal gas law and initial conditions to calculate the number of moles of gas in the vessel. (b) Find the specific heat of the gas. (c) What is the work done by the gas during this process? (d) Use the first law of thermodynamics to find the change in internal energy of the gas. (e) Find the change in temperature of the gas. (f) Calculate the final temperature of the gas. (g) Use the ideal gas expression to find the final pressure of the gas.

26. One mole of gas initially at a pressure of 2.00 atm and a volume of 0.300 L has an internal energy equal to 91.0 J. In its final state, the gas is at a pressure of 1.50 atm and a volume of 0.800 L, and its internal energy equals 182 J. For the paths *IAF*, *IBF*, and *IF* in Figure P12.26, calculate (a) the work done *on* the gas and (b) the net energy transferred to the gas by heat in the process.

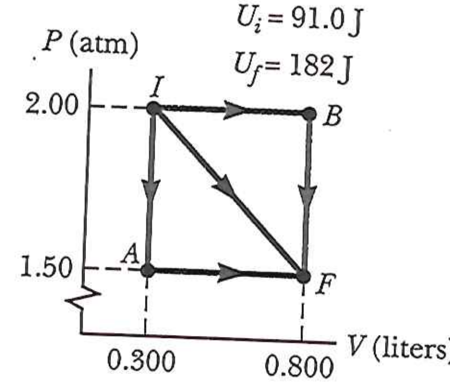


Figure P12.26

29. A gas increases in pressure from 2.00 atm to 6.00 atm at a constant volume of 1.00 m³ and then expands at constant pressure to a volume of 3.00 m³ before returning to its initial state as shown in Figure P12.29. How much work is done in one cycle?

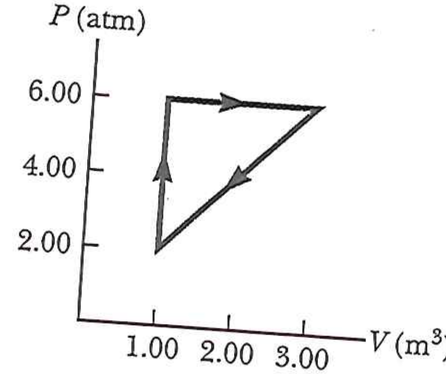
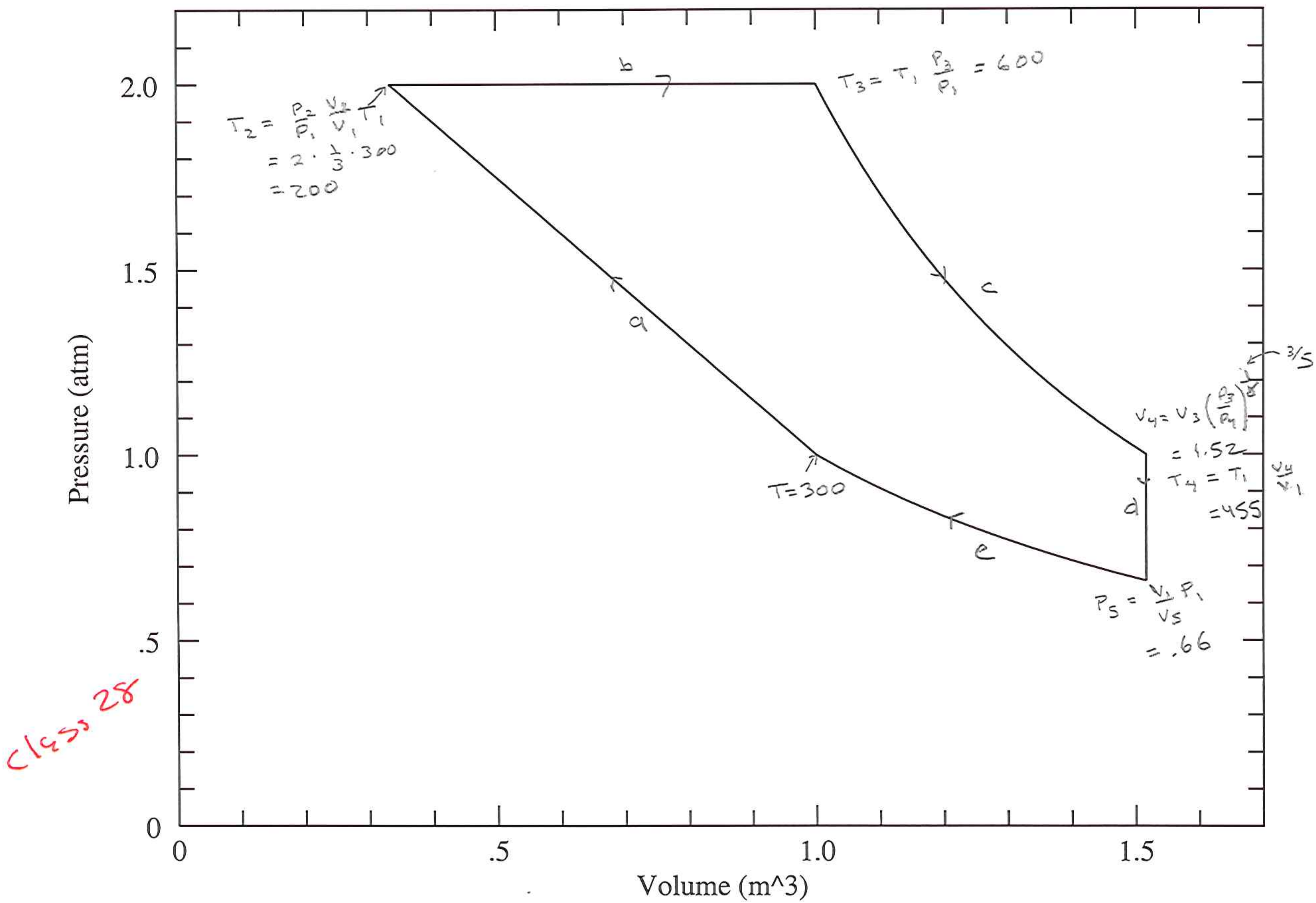


Figure P12.29

class 28
chapter 12

Figure 1



Pressure (atm)
Volume (m^3)
0
.5
1.0
1.5
2.0
a
b
c
d
e
T2 = (P2/P1)(V2/V1) T1
= 2 · 1/3 · 300
= 200
T3 = T1 P3/P1 = 600
T = 300
V4 = V3 (P3/P4)^(1/γ)
3/5
= 1.52
T4 = T1 V4/V1
= 455
P5 = (V1/V5) P1
= .66
Class 28

path	W	Q	ΔU	ΔS
P-constant	$-P\Delta V$	$nC_p\Delta T$	$nC_v\Delta T$	$nC_p \ln(T_f/T_i)$
V-constant	0	$nC_v\Delta T$	$nC_v\Delta T$	$nC_v \ln(T_f/T_i)$
T-constant	$-nRT\ln(V_f/V_i)$	$-W$	0	$nR\ln(V_f/V_i)$
S-constant	$nC_v\Delta T$	0	$nC_v\Delta T$	0
line	$-\frac{1}{2}(P_f+P_i)\Delta V$	$\Delta U - W$	$nC_v\Delta T$	$nC_p\ln(V_f/V_i) + nC_v\ln(P_f/P_i)$
cycle	$-$area	area	0	0

Note: $nR\Delta T = P_fV_f - P_iV_i$

$$C_p = C_v + R \qquad C_v = \frac{f}{2}R \qquad \gamma = \frac{C_p}{C_v} = \frac{f+2}{f}$$

1. Consider the following cycle starting with 1 m^3 of a monoatomic ideal gas at a pressure of 1 atm and a temperature of 300 K.

   (a) The volume is compressed and the pressure increased in such a way that the pV curve is a straight line. Final pressure is 2 atm; final volume is $\frac{1}{3}$ m^3.

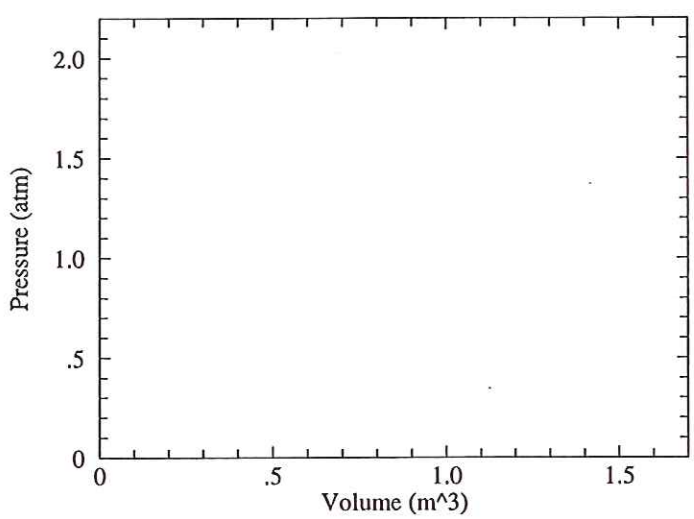
   (b) In a constant-pressure (a.k.a., isobaric) process, the volume is returned to 1 m^3.

   (c) An adiabatic expansion reduces the pressure to 1 atm.

   (d) A constant-volume (a.k.a., isochoric) process returns the temperature to 300 K.

   (e) An isothermal process returns the system to the initial state.

On the below graph, accurately plot and label each leg of this cycle. This will require calculating various pVT values at the end of some cycles. Fill in the below table giving the sign $(+, -, 0)$ of the quantity for each leg of the cycle.



path:	a	b	c	d	e
ΔT					
ΔE_{int}					
Q					
W					
ΔS					

class 28

31. A heat engine operates between a reservoir at 25°C and one at 375°C. What is the maximum efficiency possible for this engine?

34. In each cycle of its operation, a heat engine expels 2 400 J of energy and performs 1 800 J of mechanical work. (a) How much thermal energy must be added to the engine in each cycle? (b) Find the thermal efficiency of the engine.

44. **M** A heat engine operates in a Carnot cycle between 80.0°C and 350°C. It absorbs 21 000 J of energy per cycle from the hot reservoir. The duration of each cycle is 1.00 s. (a) What is the mechanical power output of this engine? (b) How much energy does it expel in each cycle by heat?

45. A Styrofoam cup holding 125 g of hot water at 1.00×10^2°C cools to room temperature, 20.0°C. What is the change in entropy of the room? (Neglect the specific heat of the cup and any change in temperature of the room.)

48. What is the change in entropy of 1.00 kg of liquid water at 100°C as it changes to steam at 100°C?

60. A Carnot engine operates between 100°C and 20°C. How much ice can the engine melt from its exhaust after it has done 5.0×10^4 J of work?

class 29
chapter 12