6. **Water bottle in a hot car.** In the American Southwest, the temperature in a closed car parked in sunlight during the summer can be high enough to burn flesh. Suppose a bottle of water at a refrigerator temperature of 5.00°C is opened, then closed, and then left in a closed car with an internal temperature of 75.0°C. Neglecting the thermal expansion of the water and the bottle, find the pressure in the air pocket trapped in the bottle. (The pressure can be enough to push the bottle cap past the threads that are intended to keep the bottle closed.)

ANS: 1.25 atm.

12. **Submarine rescue.** When the U. S. submarine *Squalus* became disabled at a depth of 80 m, a cylindrical chamber was lowered from a ship to rescue the crew. The chamber had a radius of 1.00 m and a height of 4.00 m, was open at the bottom, and held two rescuers. It slid along a guide cable that a diver had attached to a hatch on the submarine. Once the chamber reached the hatch and clamped to the hull, the crew could escape into the chamber. During the descent, air was released from tanks to prevent water from flooding the chamber. Assume that the interior air pressure matched the water pressure at depth \( h \) as given by \( p = p_0 + \rho g h \), where \( p_0 = 1.000 \text{ atm} \) is the surface pressure and \( \rho = 1024 \text{ kg/m}^3 \) is the density of seawater. Assume a surface temperature of 20.0°C and a submerged water temperature of -30.0°C. (a) What is the air volume in the chamber at the surface? (b) If air had not been released from the tanks, what would have been the air volume in the chamber at depth \( h = 80.0 \text{ m} \)? (c) How many moles of air were needed to be released to maintain the original air volume in the chamber?

ANS: (a) 12.6 m³ (b) 1.16 m³ (c) 5.10 x 10³ mol

15. Suppose 0.825 mol of an ideal gas undergoes an isothermal expansion as energy is added to it as heat \( Q \). If Fig. 19-20 shows the final volume \( V_f \) versus \( Q \), what is the gas temperature? The scale of the vertical axis is set by \( V_s = 0.30 \text{ m}^3 \), and the scale of the horizontal axis is set by \( Q_s = 1200 \text{ J} \).

ANS: \( T = 360 \text{ K} \)

17. Container A in Fig. 19-22 holds an ideal gas at a pressure of 5.0x10⁶ Pa and a temperature of 300 K. It is connected by a thin tube (and a closed valve) to container B, with four times the volume of A. Container B holds the same ideal gas at a pressure of 1.0 x 10⁵ Pa and a temperature of 400 K. The valve is opened to allow the pressures to equalize, but the temperature of each container is maintained. What then is the pressure in the two containers?

ANS: 2x10⁶ Pa
20. Calculate the rms speed of helium atoms at 1200K. See Appendix F for the molar mass of helium atoms.

ANS: 2.5x10^3 m/s

23. A beam of hydrogen molecules (H₂) is directed toward a wall, at an angle of 55° with the normal to the wall. Each molecule in the beam has a speed of 1.0 km/s and a mass of 3.3X10^{-24} g. The beam strikes the wall over an area of 2.0 cm², at the rate of 10²³ molecules per second. What is the beam’s pressure on the wall?

ANS: 1.9x10³ Pa

28. At what frequency would the wavelength of sound in air be equal to the mean free path of oxygen molecules at 1.0 atm pressure and 0.00°C? The molecular diameter is 3.0X10^{-6} cm.

ANS: 3.7x10^9 Hz

32. At 20°C and 750 torr pressure, the mean free paths for argon gas (Ar) and nitrogen gas (N₂) are λ_{Ar} = 9.9X10^{-6} cm and λ_{N₂} = 27.5X10^{-6} cm. (a) Find the ratio of the diameter of an Ar atom to that of an N₂ molecule. What is the mean free path of argon at (b) 20°C and 150 torr, and (c) -40°C and 750 torr?

ANS: (a) 1.7 (b) 5.0x10^{-5} cm (c) 7.9x10^{-6} cm

42. What is the internal energy of 2.0 mol of an ideal monatomic gas at 273 K?

ANS: 6.8X10³ J

47. The temperature of 2.00 mol of an ideal monatomic gas is raised 15.0 K at constant volume. What are (a) the work W done by the gas, (b) the energy transferred as heat Q, (c) the change ΔE_{int} in the internal energy of the gas, and (d) the change ΔK in the average kinetic energy per atom?

ANS: (a) 0 (b) +374 J (c) +374 J (d) 3.11 x 10²² J.

54. We know that for an adiabatic process pV^n = a constant. Evaluate “a constant” for an adiabatic process involving exactly 2.0 mol of an ideal gas passing through the state having exactly p = 1.5 atm and T = 300 K. Assume a diatomic gas whose molecules rotate but do not oscillate.

ANS: 1277.67 N/m².²
58. Opening champagne. In a bottle of champagne, the pocket of gas (primarily carbon dioxide) between the liquid and the cork is at pressure of \( p_i = 5.00 \) atm. When the cork is pulled from the bottle, the gas undergoes an adiabatic expansion until its pressure matches the ambient air pressure of 1.00 atm. Assume that the ratio of the molar specific heats is \( \gamma = 4/3 \). If the gas has initial temperature \( T_i = 5.00^\circ C \), what is its temperature at the end of the adiabatic expansion?

ANS: -87°C