### * 13–5 Thermal Stresses

*23. (II) An aluminum bar has the desired length when at 15°C. How much stress is required to keep it at this length if the temperature increases to 35°C?

*24. (II) (*a*) A horizontal steel I-beam of cross-sectional area 0.041 $m^2$ is rigidly connected to two vertical steel girders. If the beam was installed when the temperature was 30°C, what stress is developed in the beam when the temperature drops to −30°C? (*b*) Is the ultimate strength of the steel exceeded? (*c*) What stress is developed if the beam is concrete and has a cross-sectional area of 0.13 $m^2$? Will it fracture?

*25. (III) A barrel of diameter 134.122 cm at 20°C is to be enclosed by an iron band. The circular band has an inside diameter of 134.110 cm at 20°C. It is 7.4 cm wide and 0.65 cm thick. (*a*) To what temperature must the band be heated so that it will fit over the barrel? (*b*) What will be the tension in the band when it cools to 20°C?

### 13–6 Gas Laws; Absolute Temperature

26. (I) What are the following temperatures on the Kelvin scale: (*a*) 86°C, (*b*) 78°F, (*c*) −100°C, (*d*) 5500°C, (*e*) −459°F?

27. (I) Absolute zero is what temperature on the Fahrenheit scale?

28. (II) Typical temperatures in the interior of the Earth and Sun are about 4000°C and $15 \times 10^6$ °C, respectively. (*a*) What are these temperatures in kelvins? (*b*) What percent error is made in each case if a person forgets to change °C to K?

### 13–7 and 13–8 Ideal Gas Law

29. (I) If 3.00 $m^3$ of a gas initially at STP is placed under a pressure of 3.20 atm, the temperature of the gas rises to 38.0°C. What is the volume?

30. (I) In an internal combustion engine, air at atmospheric pressure and a temperature of about 20°C is compressed in the cylinder by a piston to $\frac{1}{9}$ of its original volume (compression ratio = 9.0). Estimate the temperature of the compressed air, assuming the pressure reaches 40 atm.

31. (II) Calculate the density of oxygen at STP using the ideal gas law.

32. (II) A storage tank contains 21.6 kg of nitrogen ($N_2$) at an absolute pressure of 3.65 atm. What will the pressure be if the nitrogen is replaced by an equal mass of $CO_2$?

33. (II) A storage tank at STP contains 18.5 kg of nitrogen ($N_2$). (*a*) What is the volume of the tank? (*b*) What is the pressure if an additional 15.0 kg of nitrogen is added without changing the temperature?

34. (II) If 18.75 mol of helium gas is at 10.0°C and a gauge pressure of 0.350 atm, (*a*) calculate the volume of the helium gas under these conditions. (*b*) Calculate the temperature if the gas is compressed to precisely half the volume at a gauge pressure of 1.00 atm.

35. (II) What is the pressure inside a 35.0-L container holding 105.0 kg of argon gas at 385 K?

36. (II) A tank contains 26.0 kg of $O_2$ gas at a gauge pressure of 8.70 atm. If the oxygen is replaced by helium, how many kilograms of the latter will be needed to produce a gauge pressure of 7.00 atm?

37. (II) A hot-air balloon achieves its buoyant lift by heating the air inside the balloon, which makes it less dense than the air outside. Suppose the volume of a balloon is 1800 $m^3$ and the required lift is 2700 N (rough estimate of the weight of the equipment and passenger). Calculate the temperature of the air inside the balloon which will produce the required lift. Assume that the outside air temperature is 0°C and that air is an ideal gas under these conditions. What factors limit the maximum altitude attainable by this method for a given load? (Neglect variables like wind.)

38. (II) A tire is filled with air at 15°C to a gauge pressure of 220 kPa. If the tire reaches a temperature of 38°C, what fraction of the original air must be removed if the original pressure of 220 kPa is to be maintained?

39. (II) If 61.5 L of oxygen at 18.0°C and an absolute pressure of 2.45 atm are compressed to 48.8 L and at the same time the temperature is raised to 50.0°C, what will the new pressure be?

40. (III) A helium-filled balloon escapes a child's hand at sea level and 20.0°C. When it reaches an altitude of 3000 m, where the temperature is 5.0°C and the pressure is only 0.70 atm, how will its volume compare to that at sea level?

### 13–9 Ideal Gas Law in Terms of Molecules; Avogadro's Number

41. (I) Calculate the number of molecules/$m^3$ in an ideal gas at STP.

42. (I) How many moles of water are there in 1.000 L? How many molecules?

43. (II) Estimate the number of (*a*) moles, and (*b*) molecules of water in all the Earth's oceans. Assume water covers 75% of the Earth to an average depth of 3 km.

44. (II) A cubic box of volume $5.1 \times 10^{-2}$ $m^3$ is filled with air at atmospheric pressure at 20°C. The box is closed and heated to 180°C. What is the net force on each side of the box?

45. (III) Estimate how many molecules of air are in each 2.0-L breath you inhale that were also in the last breath Galileo took. [*Hint*: Assume the atmosphere is about 10 km high and of constant density.]

### 13–10 Molecular Interpretation of Temperature

46. (I) (*a*) What is the average translational kinetic energy of an oxygen molecule at STP? (*b*) What is the total translational kinetic energy of 2.0 mol of $O_2$ molecules at 20°C?

47. (I) Calculate the rms speed of helium atoms near the surface of the Sun at a temperature of about 6000 K.

48. (I) By what factor will the rms speed of gas molecules increase if the temperature is increased from 0°C to 100°C?

49. (I) A gas is at 20°C. To what temperature must it be raised to double the rms speed of its molecules?

50. (I) Twelve molecules have the following speeds, given in units of km/s: 6, 2, 4, 6, 0, 4, 1, 8, 5, 3, 7, and 8. Calculate the rms speed.

51. (II) The rms speed of molecules in a gas at 20.0°C is to be increased by 1.0%. To what temperature must it be raised?

52. (II) If the pressure of a gas is doubled while its volume is held constant, by what factor does $v_{rms}$ change?