The value of 22.4 L for the volume of 1 mol of an ideal gas at STP is worth remembering, for it sometimes makes calculation simpler.

EXERCISE B What is the volume of 1.00 mol of ideal gas at 20°C?

EXAMPLE 13–11 **Helium balloon.** A helium party balloon, assumed to be a perfect sphere, has a radius of 18.0 cm. At room temperature (20°C), its internal pressure is 1.05 atm. Find the number of moles of helium in the balloon and the mass of helium needed to inflate the balloon to these values.

APPROACH We can use the ideal gas law to find n, since we are given P and T, and can find V from the given radius.

SOLUTION We get the volume V from the formula for a sphere:

$$V = \tfrac{4}{3}\pi r^3$$
$$= \tfrac{4}{3}\pi\,(0.180\text{ m})^3 = 0.0244\text{ m}^3.$$

The pressure is given as $1.05\text{ atm} = 1.064 \times 10^5\text{ N/m}^2$. The temperature must be expressed in kelvins, so we change 20°C to $(20 + 273)\text{K} = 293\text{ K}$. Finally, we choose the value of R to be $R = 8.314\text{ J/(mol}\cdot\text{K)}$ because we are using SI units. Thus

$$n = \frac{PV}{RT} = \frac{(1.064 \times 10^5\text{ N/m}^2)(0.0244\text{ m}^3)}{(8.314\text{ J/mol}\cdot\text{K})(293\text{ K})} = 1.066\text{ mol}.$$

The mass of helium (atomic mass = 4.00 g/mol as given in Appendix B or the periodic Table) can be obtained from

$$\text{mass} = n \times \text{molecular mass} = (1.066\text{ mol})(4.00\text{ g/mol}) = 4.26\text{ g}.$$

EXAMPLE 13–12 **ESTIMATE** **Mass of air in a room.** Estimate the mass of air in a room whose dimensions are 5 m × 3 m × 2.5 m high, at STP.

PHYSICS APPLIED
Mass (and weight) of the air in a room

APPROACH First we determine the number of moles n using the given volume. Then we can multiply by the mass of one mole to get the total mass.

SOLUTION Example 13–10 told us that 1 mol at 0°C has a volume of 22.4 L. The room's volume is 5 m × 3 m × 2.5 m, so

$$n = \frac{(5\text{ m})(3\text{ m})(2.5\text{ m})}{22.4 \times 10^{-3}\text{ m}^3} \approx 1700\text{ mol}.$$

Air is a mixture of about 20% oxygen (O_2) and 80% nitrogen (N_2). The molecular masses are $2 \times 16\text{ u} = 32\text{ u}$ and $2 \times 14\text{ u} = 28\text{ u}$, respectively, for an average of about 29 u. Thus, 1 mol of air has a mass of about $29\text{ g} = 0.029\text{ kg}$, so our room has a mass of air

$$m \approx (1700\text{ mol})(0.029\text{ kg/mol}) \approx 50\text{ kg}.$$

NOTE That is roughly 100 lbs of air!

EXERCISE C At 20°C, would there be more or less air mass in a room than at 0°C?

Frequently, volume is specified in liters and pressure in atmospheres. Rather than convert these to SI units, we can instead use the value of R given in Section 13–7 as $0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K}$.

In many situations it is not necessary to use the value of R at all. For example, many problems involve a change in the pressure, temperature, and