

23. In the reflection process, only the normal component of the momentum changes, so for one molecule the change in momentum is  $2mv \cos \theta$ , where  $m$  is the mass of the molecule,  $v$  is its speed, and  $\theta$  is the angle between its velocity and the normal to the wall. If  $N$  molecules collide with the wall, then the change in their total momentum is  $2Nmv \cos \theta$ , and if the total time taken for the collisions is  $\Delta t$ , then the average rate of change of the total momentum is  $2(N/\Delta t)mv \cos \theta$ . This is the average force exerted by the  $N$  molecules on the wall, and the pressure is the average force per unit area:

$$\begin{aligned} p &= \frac{2}{A} \left( \frac{N}{\Delta t} \right) mv \cos \theta \\ &= \left( \frac{2}{2.0 \times 10^{-4} \text{ m}^2} \right) (1.0 \times 10^{23} \text{ s}^{-1}) (3.3 \times 10^{-27} \text{ kg}) (1.0 \times 10^3 \text{ m/s}) \cos 55^\circ \\ &= 1.9 \times 10^3 \text{ Pa} . \end{aligned}$$

We note that the value given for the mass was converted to kg and the value given for the area was converted to  $\text{m}^2$ .