1. In a 30.0-s interval, 500 hailstones strike a glass window of area 0.600 m^2 at an angle of 45.0° to the window surface. Each hailstone has a mass of 5.00 g and moves with a speed of 8.00 m/s. Assuming the collisions are elastic, find the average force and pressure on the window.

P21.1 $\bar{F} = Nm\frac{\Delta v}{\Delta t} = 500\left(5.00\times 10^{-3}\text{ kg}\right)\frac{\left[8.00\sin 45.0° - \left(-8.00\sin 45.0°\right)\right]\text{ m/s}}{30.0\text{ s}} = \boxed{0.943\text{ N}}$

$P = \frac{\bar{F}}{A} = 1.57\text{ N/m}^2 = \boxed{1.57\text{ Pa}}$

4. A 2.00-mol sample of oxygen gas is confined to a 5.00-L vessel at a pressure of 8.00 atm. Find the average translational kinetic energy of an oxygen molecule under these conditions.

P21.4 Use Equation 21.2, $P = \frac{2N}{3V}\left(\frac{mv^2}{2}\right)$, so that

$$K_{av} = \frac{mv^2}{2} = \frac{3PV}{2N} \quad \text{where } N = nN_A = 2N_A$$

$$K_{av} = \frac{3PV}{2(2N_A)} = \frac{3\left(8.00\text{ atm}\right)\left(1.013\times 10^5\text{ Pa/atm}\right)\left(5.00\times 10^{-3}\text{ m}^3\right)}{2\left(2\text{ mol}\right)\left(6.02\times 10^{23}\text{ molecules/mol}\right)}$$

$$K_{av} = \boxed{5.05\times 10^{-21}\text{ J/molecule}}$$

8. Given that the rms speed of a helium atom at a certain temperature is 1 350 m/s, find by proportion the rms speed of an oxygen (O_2) molecule at this temperature. The molar mass of O_2 is 32.0 g/mol, and the molar mass of He is 4.00 g/mol.

P21.8 $v = \sqrt{\frac{3k_BT}{m}}$

$$\frac{v_O}{v_{He}} = \sqrt{\frac{M_{He}}{M_O}} = \sqrt{\frac{4.00}{32.0}} = \sqrt{\frac{1}{8.00}}$$

$$v_O = \frac{1\,350\text{ m/s}}{\sqrt{8.00}} = \boxed{477\text{ m/s}}$$

10. A 5.00-L vessel contains nitrogen gas at 27.0°C and 3.00 atm. Find (a) the total translational kinetic energy of the gas molecules and (b) the average kinetic energy per molecule.

P21.10 (a) $PV = nRT = \frac{Nmv^2}{3}$

The total translational kinetic energy is $\frac{Nmv^2}{2} = E_{trans}$:

$$E_{trans} = \frac{3}{2}PV = \frac{3}{2}\left(3.00\times 1.013\times 10^5\right)\left(5.00\times 10^{-3}\right) = \boxed{2.28\text{ kJ}}$$

(b) $\frac{mv^2}{2} = \frac{3k_BT}{2} = \frac{3RT}{2N_A} = \frac{3(8.314)(300)}{2\left(6.02\times 10^{23}\right)} = \boxed{6.21\times 10^{-21}\text{ J}}$