Physics 260 Homework Solution 8

Chapter 21

1 PSE6 21.P.001

Newton's second law says force is mass times acceleration. Since there are N hailstones present, the total average force is

$$\overline{F} = Nm\overline{a}$$

The average acceleration is the change in velocity over a time interval Δt. Hailstones strike the window at an angle θ at speed v. Speed can be decomposed into x and y components. Only the x component is considered here, $v_x = v \sin\theta$. Since the collision is elastic, the final speed of the hailstones should have the same magnitude as the initial speed but in the opposite direction. Therefore

$$\overline{F} = Nm\frac{\Delta v}{\Delta t} = Nm\frac{2v_x}{\Delta t}$$

And the average pressure is $P = \overline{F}/A$.

2 PSE6 21.P.003

To find the force exerted by the gas on one of the walls of the container, one needs to know what the pressure on one of the walls is first. Using the expression $PV = Nk_BT$, the pressure can be found. The area we are considering in this problem is just on side of the container. $F = PA$.

3 PSE6 21.P.004

Equation 21.2 says $P = \frac{2N}{3V}(\frac{1}{2}m\overline{v^2})$. So the average translational kinetic energy is

$$\overline{K} = \frac{1}{2}m\overline{v^2} = \frac{3PV}{2N}$$

4 PSE6 21.P.007

a. Assuming the balloon is a sphere, the volume can be found. Using the equation of ideal gas law, get $N = \frac{PV}{k_B T}$.

b.

$$\overline{K} = \frac{3}{2} k_B T$$

c.

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

where M is the molar mass of helium in Kg/molecule.

5 PSE6 21.P.013

a. Hydrogen gas is diatomic, so $C_P = \frac{7}{2}R$ and $Q = nC_P \Delta T$.

b.

$$\Delta E_{int} = nC_V \Delta T$$

c.

$$W = \Delta E_{int} - Q$$

6 PSE6 21.P.015

a & b. In a constant-volume process, $W = 0$. Hence, $\Delta E_{int} = Q$. c.

$$Q = nC_V(T_f - T_i)$$

7 PSE6 21.P.024

a. Since it is an adiabatic process, $PV^\gamma =$ constant. We then have

$$P_i V_i^\gamma = P_f V_f^\gamma$$

$$\frac{V_i}{V_f} = \left(\frac{P_i}{P_f}\right)^\gamma$$

b. From ideal gas law we have

$$\frac{P_i V_i}{T_i} = \frac{P_f V_f}{T_f}$$

$$\frac{T_i}{T_f} = \frac{P_i V_i}{P_f V_f}$$

c. $Q = 0$ since it is an adiabatic process. Hence, $W = \Delta E_{int} = nC_V \Delta T$.

8 PSE6 21.P.037

a.

$$v_{av} = \frac{\Sigma n_i v_i}{N}$$

b.

$$\overline{v^2} = \frac{\Sigma n_i v_i^2}{N}$$

and

$$v_{rms} = \sqrt{\overline{v^2}}$$

c. The most probable speed is the speed at which the most number of particles would have. It is the fourth one.

9 PSE6 21.P.041

The solutions to part (a) and (b) are the same. Use the expression $\overline{v} = \sqrt{\frac{8k_BT}{\pi m}}$ and solve for T.

10 PSE6 21.QQ.001

The average translational kinetic energy per molecule in container A and B are the same because it only depends on temperature and both containers have the same temperature.

11 PSE6 21.QQ.002

The internal energy in container B is twice that for container A because from previous question we know that each molecule has the same average translational kinetic energy, but the number of molecules in B is twice that of A.

12 PSE6 21.QQx.002

In the first experiment, where the wall is suddenly pulled away, there is no work done on the system($W = 0$). Also we know there is no heat transfer ($Q = 0$). So the total internal energy stays the same, which means the temperature stays same ($\Delta E_{int} = nC_V\Delta T = Q + W = 0$, so $\Delta T = 0$). In the second experiment, the piston is slowly moved to the right. There is work done on the system(negative work). Again, $Q = 0$. So the change in internal energy equals the work done on the system. And it is also negative. Since $DeltaE_{int} = n * C_V\Delta T$, change in temperature is negative, which means the final temperature is smaller than the initial temperature. Since both systems start out with the same initial temperature and temperature does not change in the first experiment, the final temperature of the second experiment should be smaller than the final temperature of the first experiment.

13 PSE6 21.QQ.005

E_{int} stays the same because path $f \rightarrow f'$ is isothermal and the temperature does not change. The internal energy of a system is function of temperature only.

14 PSE6 21.QQ.003

They are the same. The rms speed depends on the type of molecule and the temperature it is at.