The pressure exerted by a gas arises from the gas particles colliding and rebounding off a surface in contact with the gas. What would happen if some benevolent, omnipotent, but ultimately just curious being replaced each and every particle in a gas with two new particles, both moving at the same speed as the original particle but each having only half the original mass? What would happen to the pressure? To the temperature? Discuss this in terms of physical concepts and not just citing equations.

What determines pressure? What determines temperature?

If there are two times as many particles with all half the mass, this is essentially going to be the same amount of total mass from all the particles. This means that the pressure and the temperature are going to stay the same.

The pressure would be twice as high because there would be twice the amount of particles rebounding off the surface. The mass of these particles does not affect the pressure because they do not affect the speed or amount of rebounding, which is a main factor in determining pressure. The temperature will remain the same because the total mass remains the same as well as the velocity. Kinetic energy of a gas is related to the temperature of the gas. In this case, the kinetic energy remains the same so the temperature must remain the same.

What is temperature fundamentally? Average energy per degree of freedom!

Doubling the number of particles would double the pressure of the system because there is twice as many particles hitting the walls of the container. However, since the masses are halved the impact against the wall will be halved and thus the pressure is halved. The end result is the pressure remains the same. Since the average speed of the particles remain the same the temperature would not change. This makes sense because any more kinetic energy in the system would raise the whole average kinetic energy and the speed of the particles. And raising kinetic energy would increase temperature.

A quick calculation shows that the average speed of an oxygen molecule at room temperature is about 500 m/s (zoom!). Use that to estimate the average speed of an odd hydrogen molecule wandering through the room, explaining your chain of logic along the way. The mass of the oxygen molecule is about 16 times that of the hydrogen molecule.

What determines temperature?

Because the particles are at room temperature, it can be assumed that the particles also have equal average kinetic energies per particle REGARDLESS of their masses. Therefore, I am assuming that the hydrogen particles are moving at the same speed as the oxygen molecules.

Answer: kinetic energy per particle, so mass must be taken into account

Assuming that the kinetic energy is equal in this case due to room temperature, the hydrogen molecule must be faster than the oxygen molecule to make up for the lower mass. If we wanted to get an estimate we could use K=1/2(m)(v^2) to make a rough estimate. Since the KE is around the same, we can say the oxygen has a KE of 16amu(500m/s)^2. Since oxygen weighs 16 times more than hydrogen, the hydrogen needs to be around 4 times as fast (because velocity affects KE exponentially while mass affects it linearly). Therefore, hydrogen would have a speed of around 2000 m/s.

The hydrogen atom would move faster than oxygen. Using the equation for kinetic energy E = 1/2mv^2 and since their average kinetic energies would be the same at rt (dp - don't abbreviate!) you can set both their kinetic energies equal to each other

    (1/2)16mv^2 = (1/2)mv^2   (left for oxygen and right for hydrogen)

multiply by 2 to get rid of the halves

divide by m

    16v^2=v^2

sqrt to get 4v

so the average speed of the hydrogen molecule would be 4 times that of the oxygen molecule

For two gases of different composition in thermal equilibrium, what do their particles share in common?
a. Average translational speed
b. Average translational energy per molecule
c. Average total energy per molecule
d. Molar heat capacity
e. All of the above
f. None of the above