# Planetary Atmospheres and Escape of Gas

### Part 1: Atmospheric Gas

Gas particles in this box move randomly; the arrows show the direction and size of particle movements. The combined motion of the particles colliding with each other (and the box) is felt as the **pressure** of the gas.

1. What happens to the particle movements as you increase the temperature of the gas?

2. What effect will that temperature increase have on the pressure of the gas?

3. If you now increase the volume of the box (decreasing the density of particles), what effect will that have on the pressure of the gas?

Now suppose you have a significant amount of gas surrounding a planet (an atmosphere). Notice that in this case there is no “box” or container keeping the particles confined.



4. What keeps the gas particles from flying away into space?

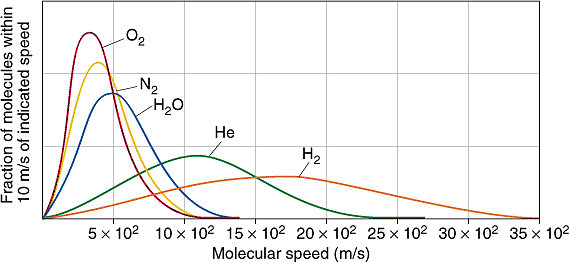
5. What keeps all of the gas particles from collapsing to the surface of the planet?

6. Suppose you raise the temperature at the surface of the planet. What effect will that have on the motions of particles in that planet’s atmosphere?

7. Given your answer to Question 6, and the fact that there is no “container” for the atmosphere, what do you think will be the overall consequence of raising the temperature on the atmosphere of the planet?

### Part 2: Particle Speeds and Escape Velocity in an Atmosphere

We have established that at higher temperatures, gas particles (atoms and molecules) in an atmosphere will move at higher speeds. The speeds that the particles will reach also partly depend on the **mass** of the particles.

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*Figure 1: The chart above shows the distribution of speeds of some atmospheric atoms and molecules at a constant temperature of 298.15 K (25° C). (Source: Chemistry LibreTexts,* [*https://chem.libretexts.org/*](https://chem.libretexts.org/)*, UC Davis Chemistry Chemistry 107A)*

Notice that in Figure 1, each particle has a peak at the “most probable speed” for a given atom or molecule. We can calculate this most probable speed mathematically, using the formula, . In this formula, *k* is Boltzmann’s constant, *k*=1.38x10-23 m2 kg s-2 K-1, *T* is the temperature in Kelvin, and *mparticle* is the mass per particle (atom or molecule) in kg.

8. Using the graph and the formula given above, what kind of particles will reach the highest most-probable speeds?

9. Is there a point at which the speed of the particle will be higher than the forces that hold the molecules around the planet? What is our name for that speed?

10. Notice that even if the peak speed is not very high, there is a wide range of particle speeds above the most probable speed. Do you think some of these fast-moving particles might be able to escape from the planet? Why or why not?

In general, if the most probable speed is at least 20% of the escape velocity, fast-moving particles will have a chance to “leak away” from a planet’s atmosphere over the lifetime of the planet to date.

11. Based on Figure 1, and assuming a constant planetary temperature, which gases are most likely to “leak away” from a planet’s atmosphere over its lifetime?

12. How will the escape velocity of a planet with a higher mass be different from the escape velocity of a planet with a lower mass? (Hint: Think about how mass affects the force of gravity.)

13. What does your answer to question 12 tell you about which planets are more likely to lose gases from their atmospheres over time?