GMU Teaching Demo: Atmospheric Escape

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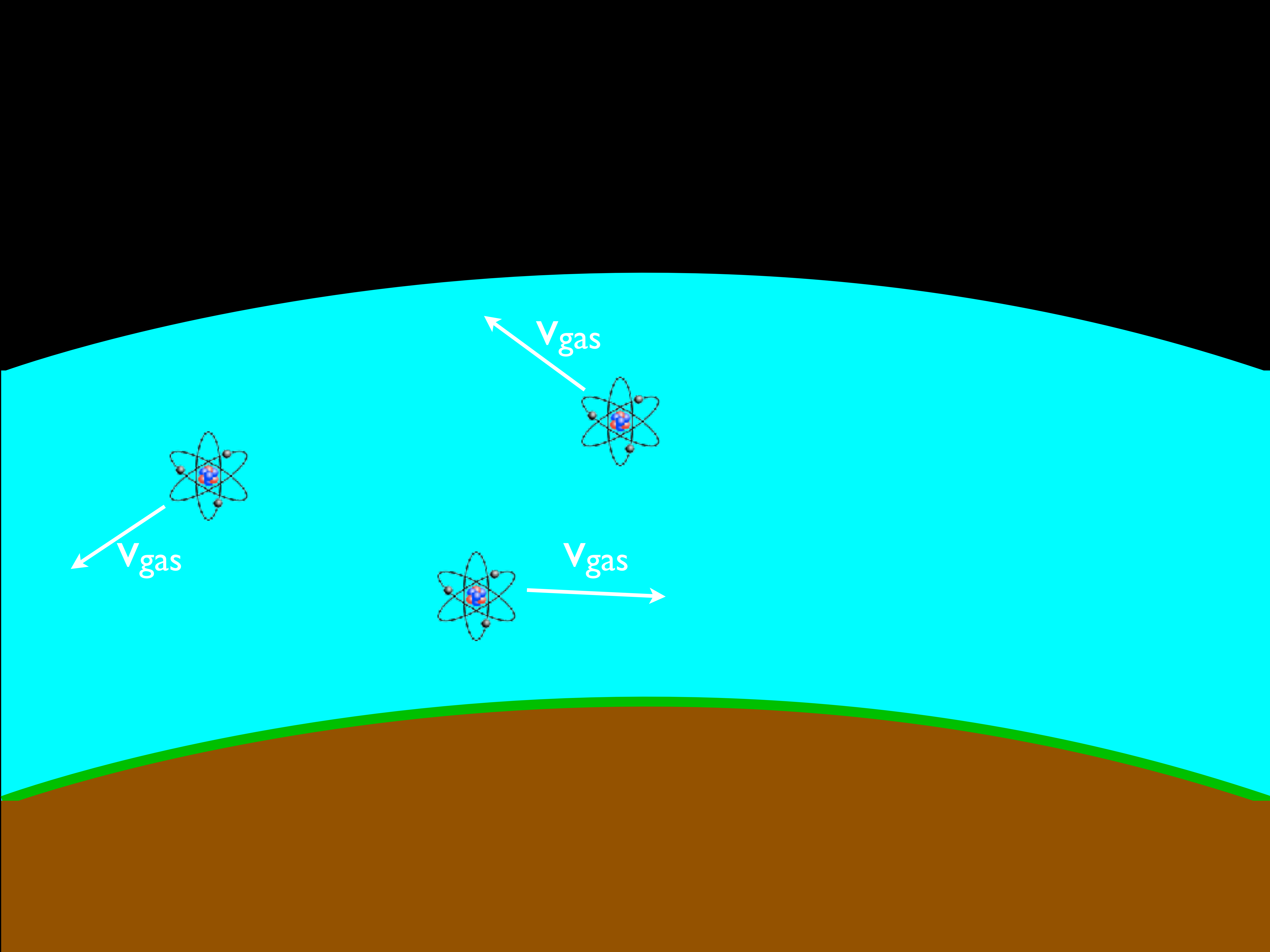
Mercury: N/A

Venus: 96.5% **CO_2**, 3.5% **N_2**, other trace gases

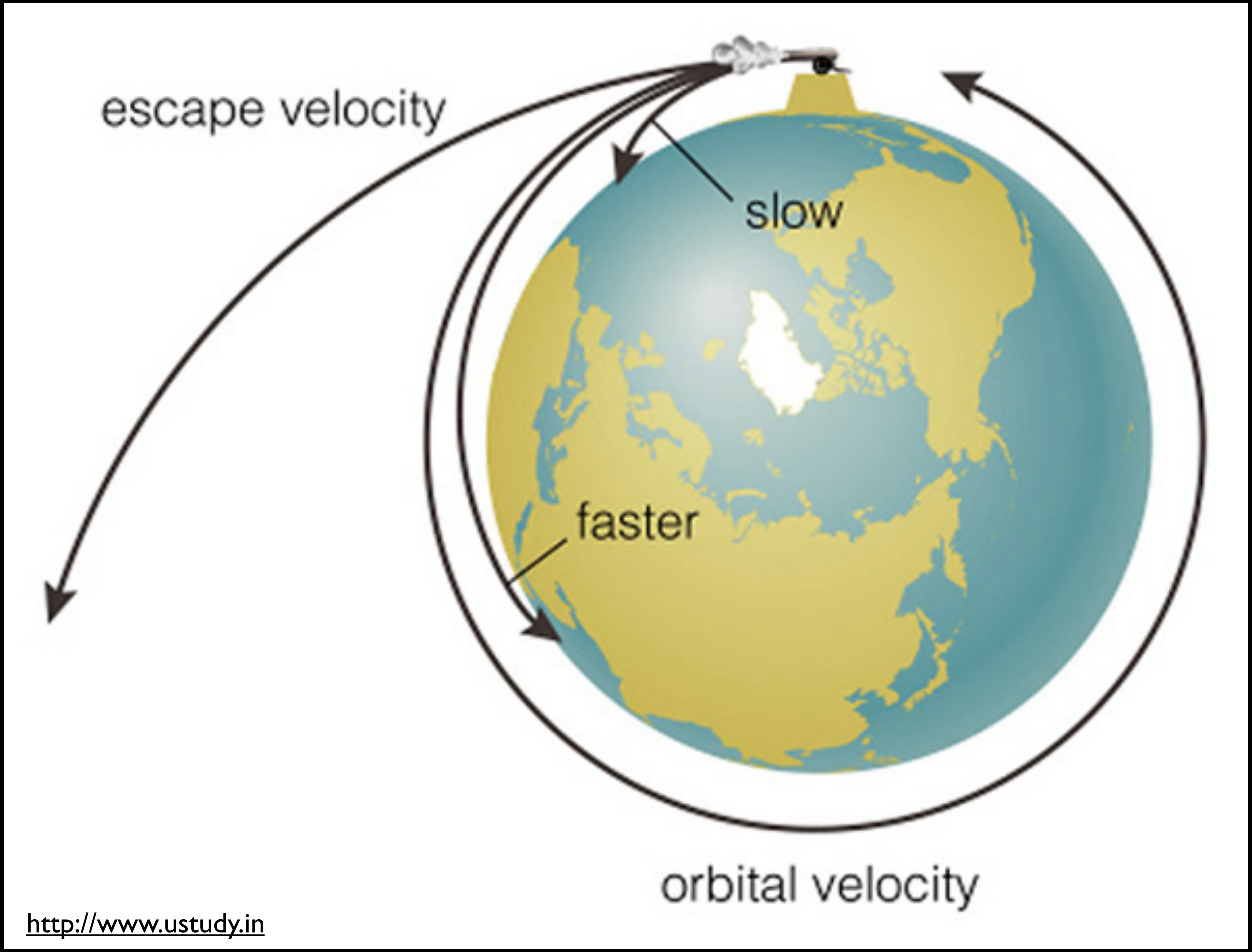
Earth: 78% **N_2**, 21% **O_2**, other trace gases

Mars: 95.9% **CO_2**, 2% **Ar**, 1.9% **N_2**, other trace gases

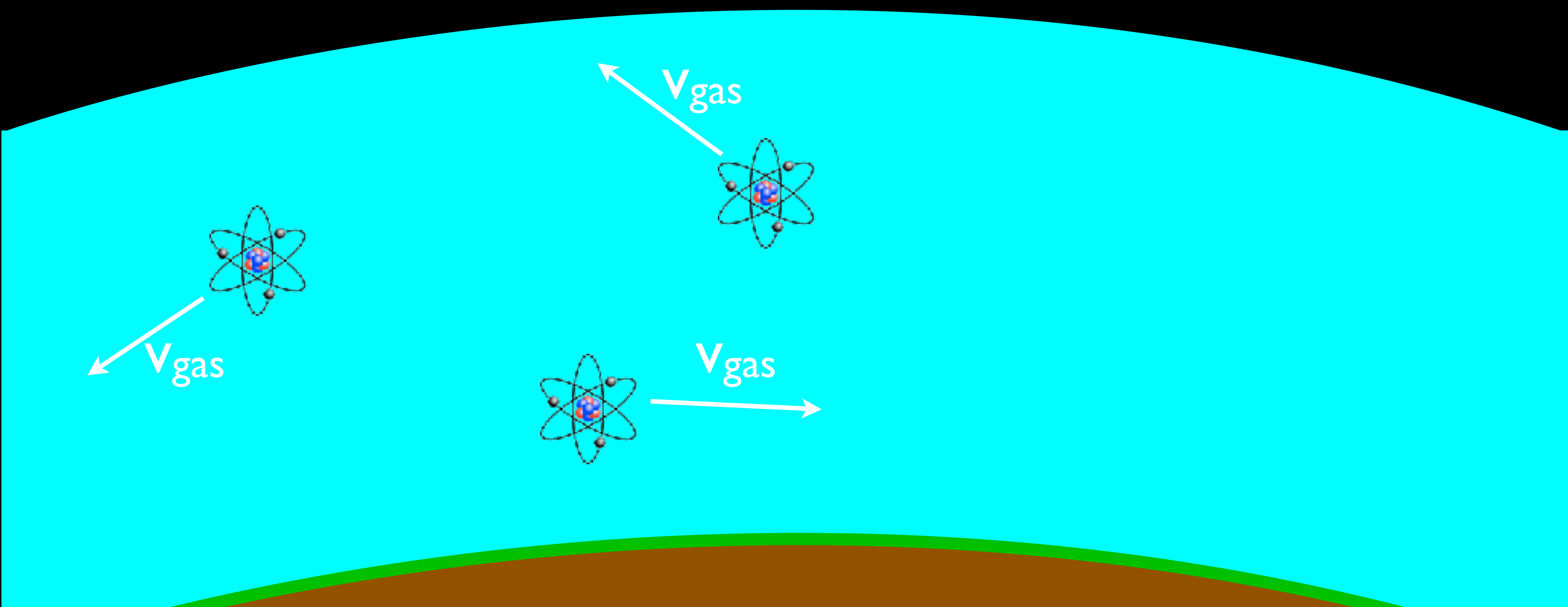
But H and He are the most common gases in the universe.
What's going on?



v_{gas}
v_{gas}
v_{gas}



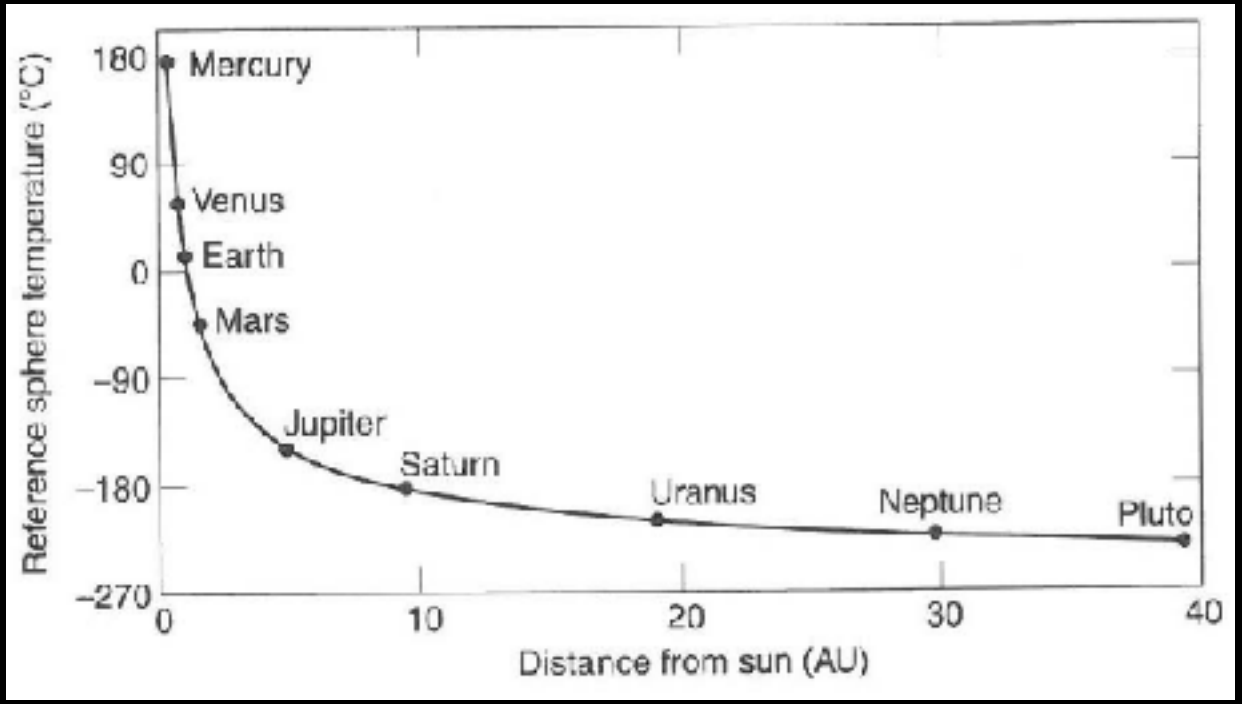
$$v_{esc} = \sqrt{(2GM / r)}$$

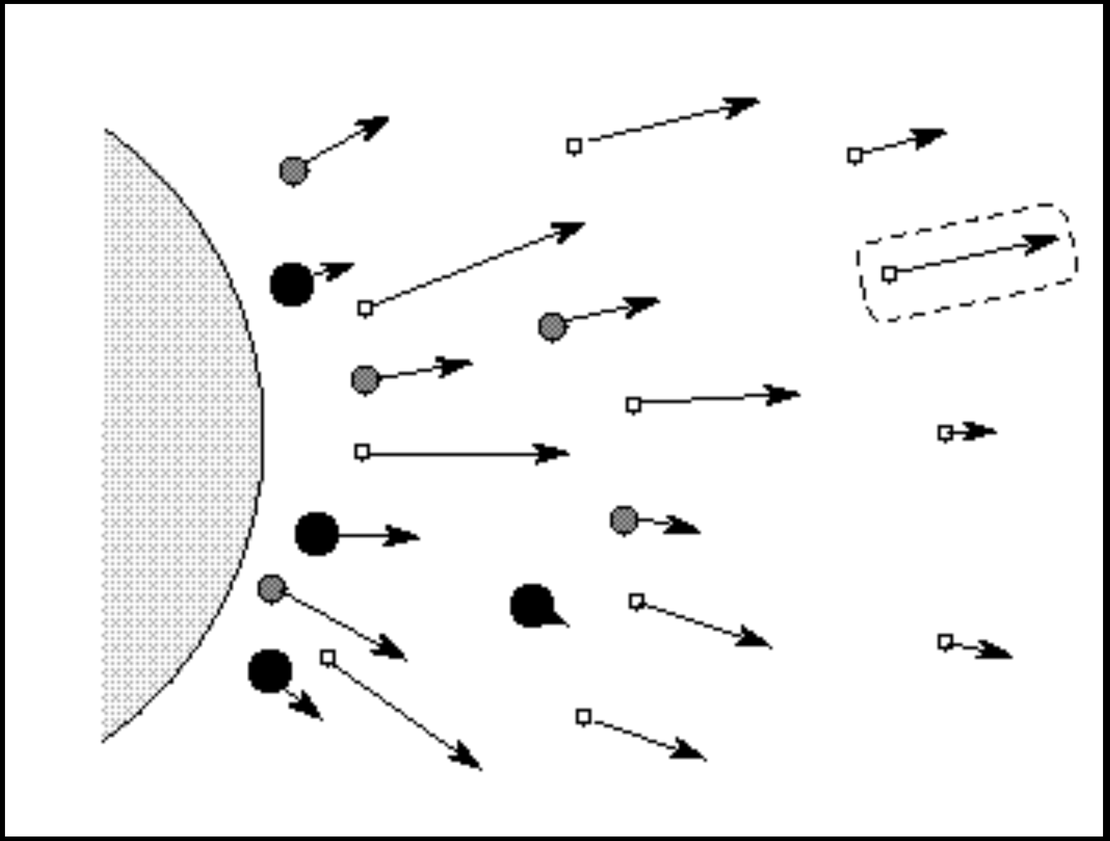


If $v_{gas} < v_{esc}$, the molecules are bound to planet

If $v_{gas} > v_{esc}$, the molecules are lost to space

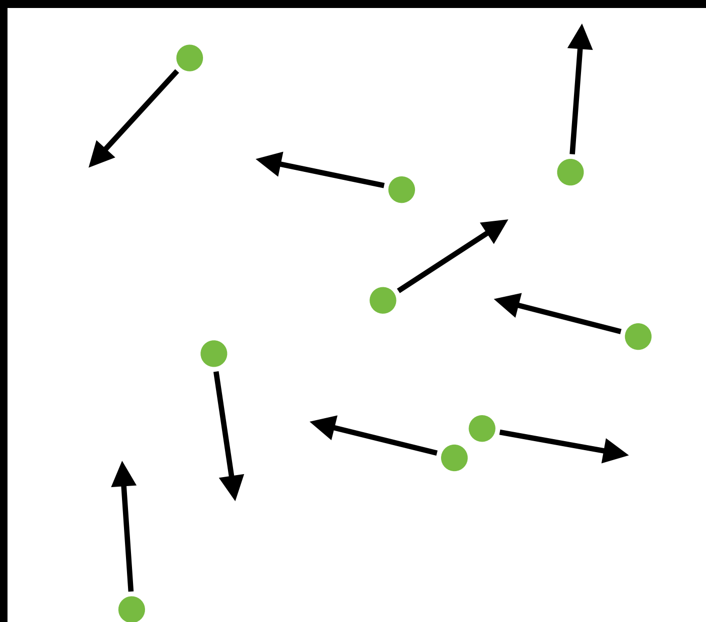
- A gas's temperature dictates the molecules' kinetic energy
- Kinetic energy dictates how fast a gas molecule can move
- If two gases are at the same temperature, their molecules have the same kinetic energy
- If one gas has less massive molecules, then its atoms must be moving faster than the other gas's molecules



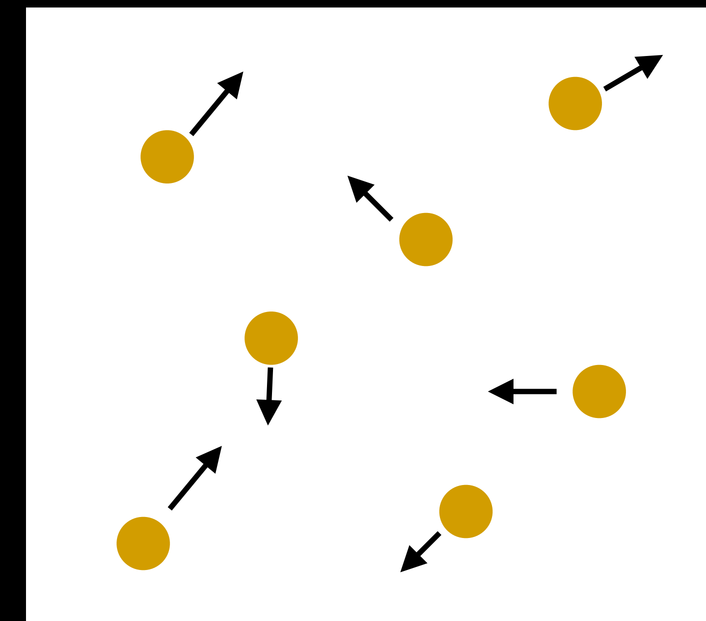


- Think about getting hit with a bowling ball vs a wiffle ball
- The bowling ball doesn't have to move as fast to deliver the same energy as the wiffle ball
- If there are two gases at the same temperature, the one with the more massive atoms/molecules will have smaller velocities

H_2 at 30°C

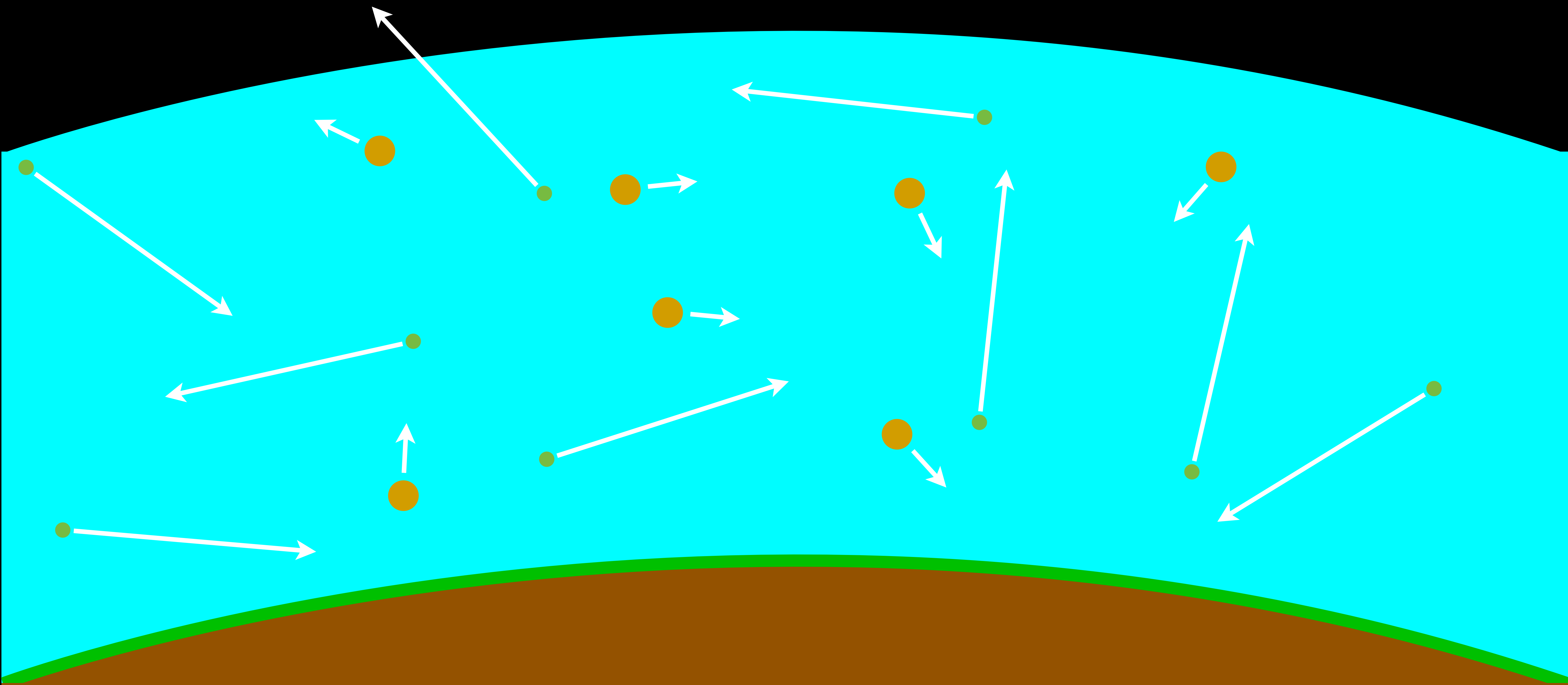


CO_2 at 30°C



- At a given temperature, less massive molecules move faster

- Gases made of massive atoms/molecules are easier for a planet's gravity to hold on to



H or He can be lost to space, while CO_2 or something else massive remains bound

Atmospheric Escape

To sum up, 3 things affect whether a planet retains an atmosphere:

1. Mass of molecules
2. Escape velocity (mass) of planet
3. Temperature of planet (distance from Sun)

Think-Pair-Share

Which planet is most likely to retain its atmosphere?

A. A planet orbiting at 0.2 AU with a mass of 0.3 M_{Earth}

B. A planet orbiting at 1.5 AU with a mass of 1.5 M_{Earth}

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B. A planet orbiting at 1.5 AU with a mass of 1.5 M_{Earth}

Think-Pair-Share

Which gas is most likely to be retained by this planet?

A. Hydrogen

B. Helium

C. Carbon dioxide

Think-Pair-Share

Which gas is most likely to be retained by this planet?

A. Hydrogen

B. Helium

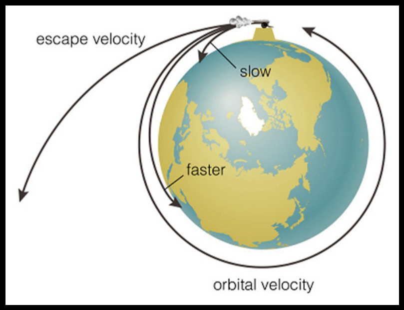
C. Carbon dioxide

Atmospheric Escape

To sum up, 3 things affect whether a planet retains an atmosphere:

1. Mass of molecules- *more massive molecules move more slowly*

2. Escape velocity (mass) of planet- *the more massive a planet, the faster you have to move to escape grav. pull*



3. Temperature of planet (distance from Sun)- *hot temperatures means gas is moving faster*