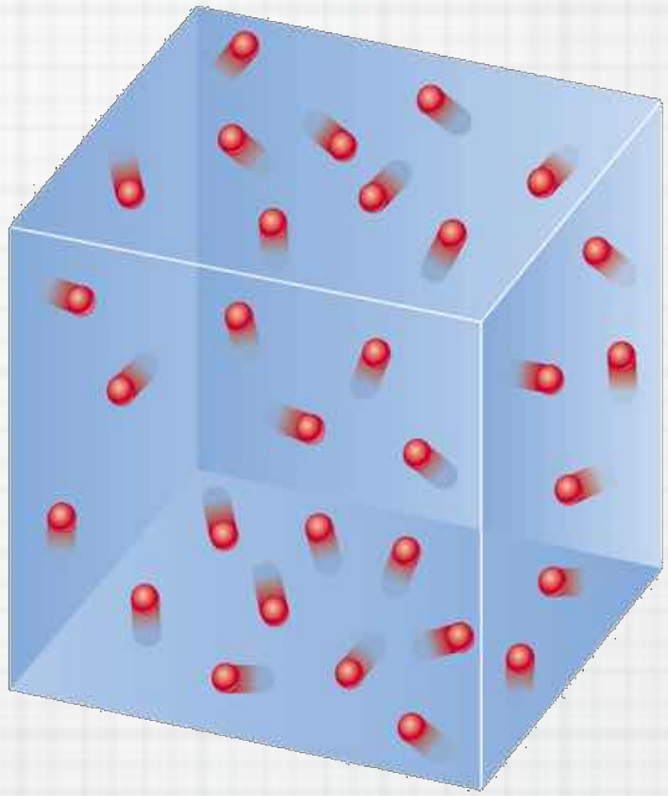
Kinetic Molecular Theory of Gases

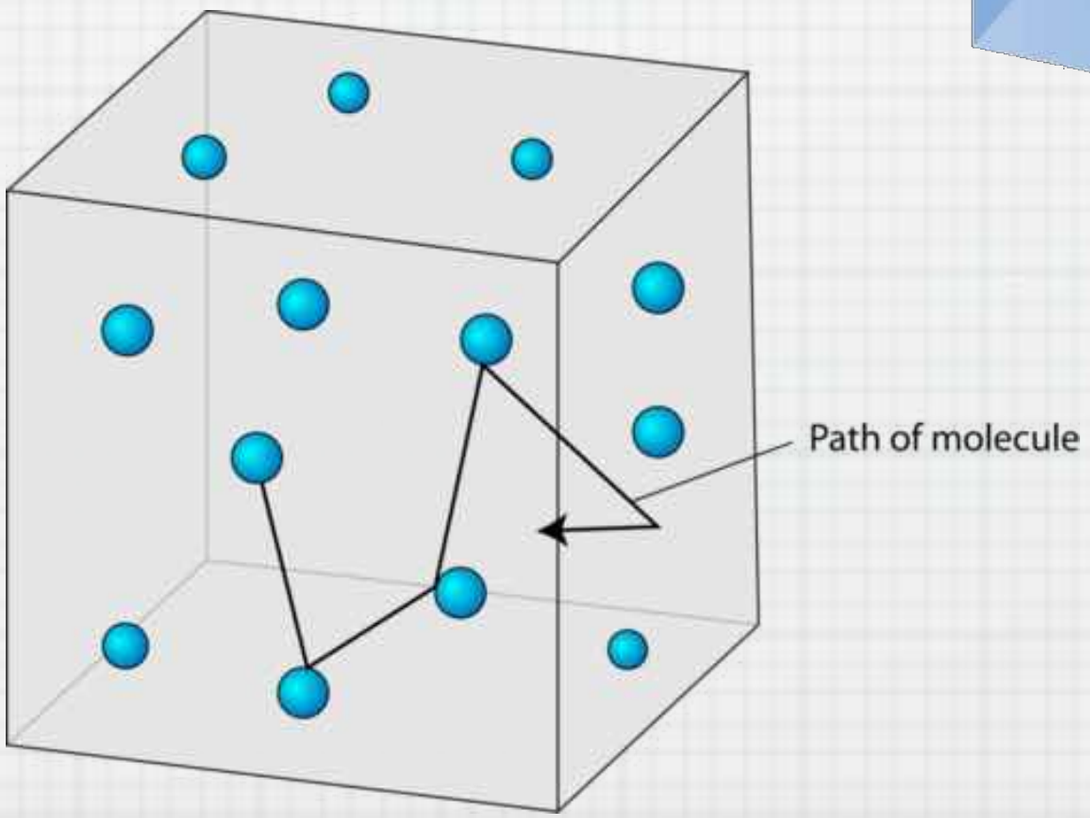
Chemistry 1

KMT of Gases

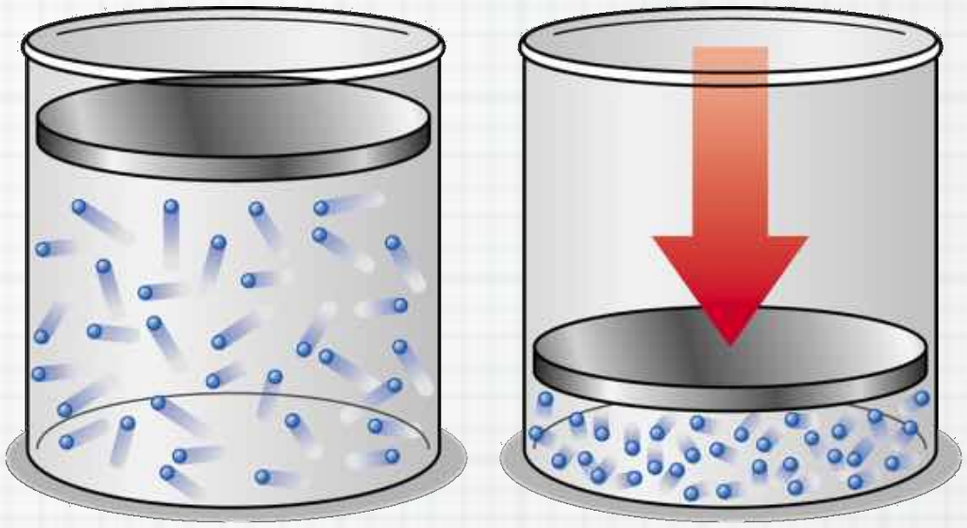
* Describes the behavior of gases based on their motion

1. Particles in constant, random, rapid movement
    * Responsible for mixing and diffusion (later)
    * Move in a straight line until collide with another particle or container

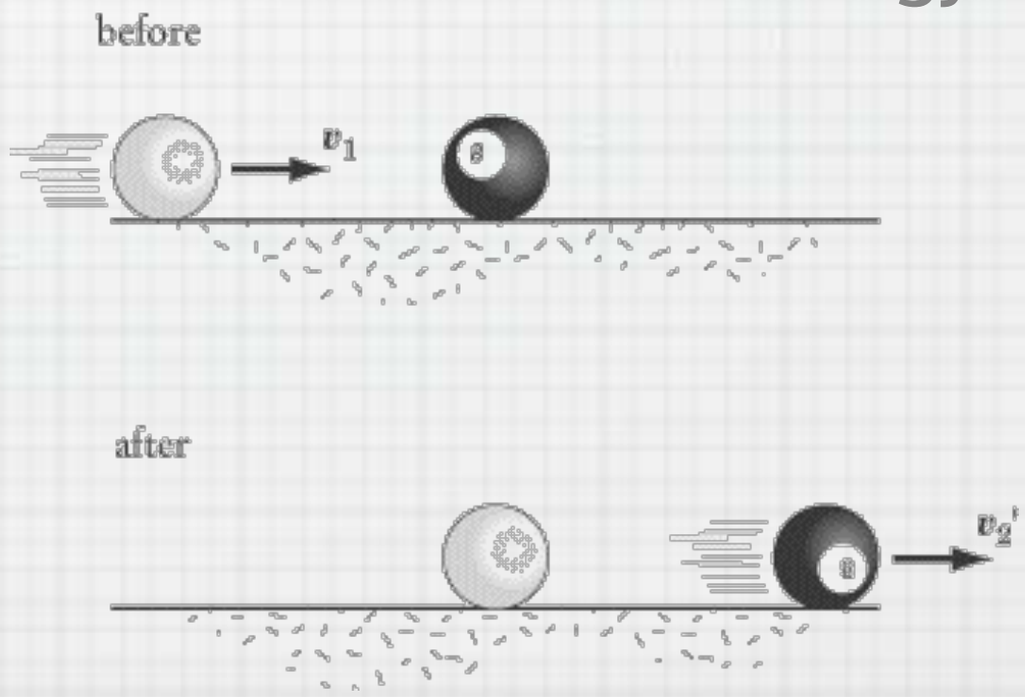




2. Particles small compared to distance between them
   - Volume of each particle negligible (nearly zero)
   - Compressible: as container volume decreases, density increases (image)
   - Particles rarely interact (collide)



3. Particles don't attract/repel: don't exert a force on other particles
   - Only interact in elastic collisions: no loss in kinetic energy (like billiard balls)

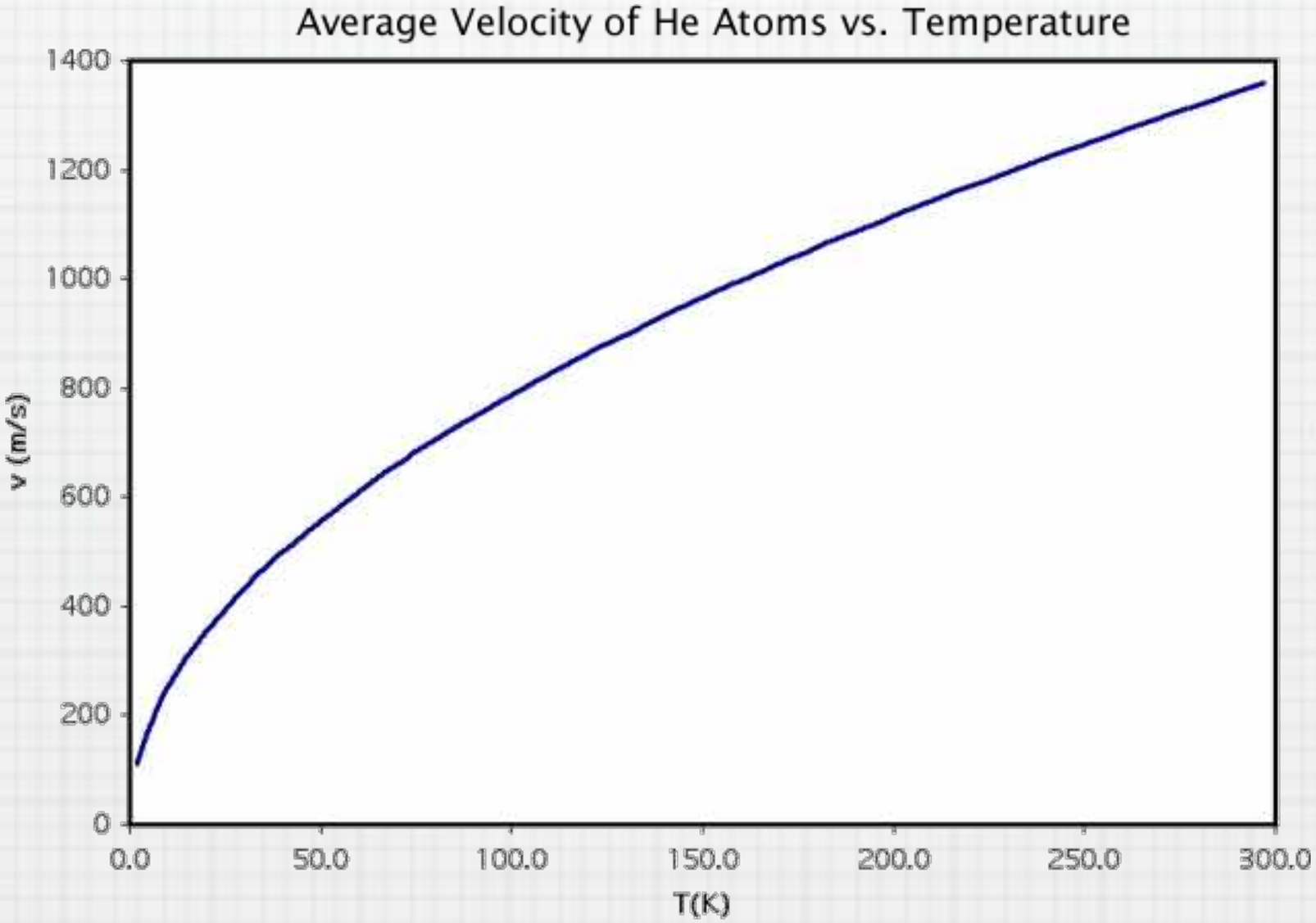


4. Temperature measures average kinetic energy: $T \propto KE_{avg}$

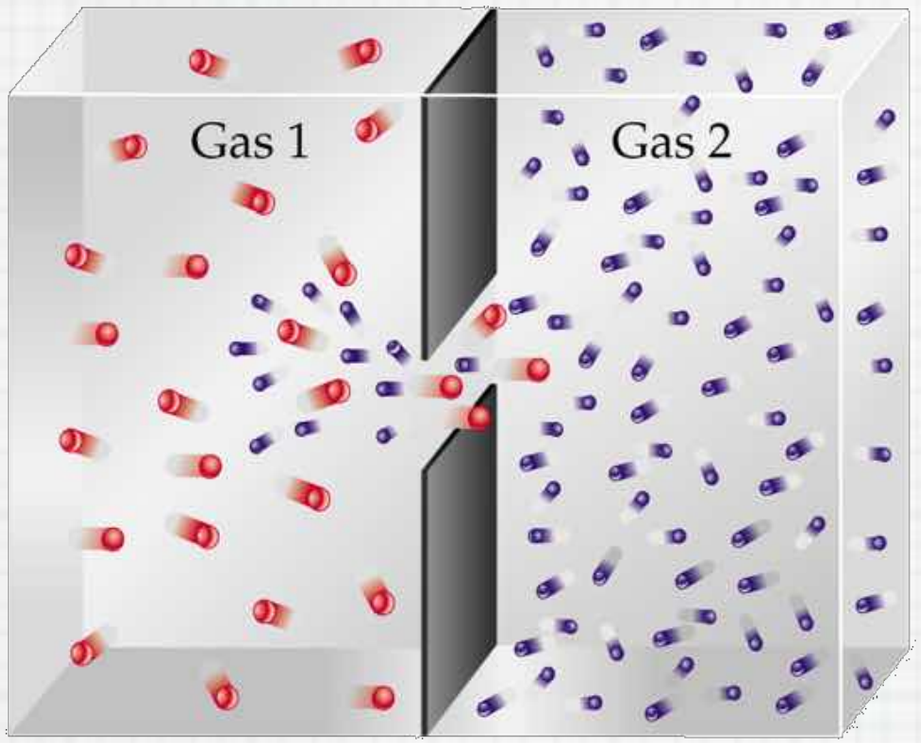
* Kinetic energy due to motion of particles:

$$KE_{avg} = \tfrac{1}{2}m(v_{avg})^2$$

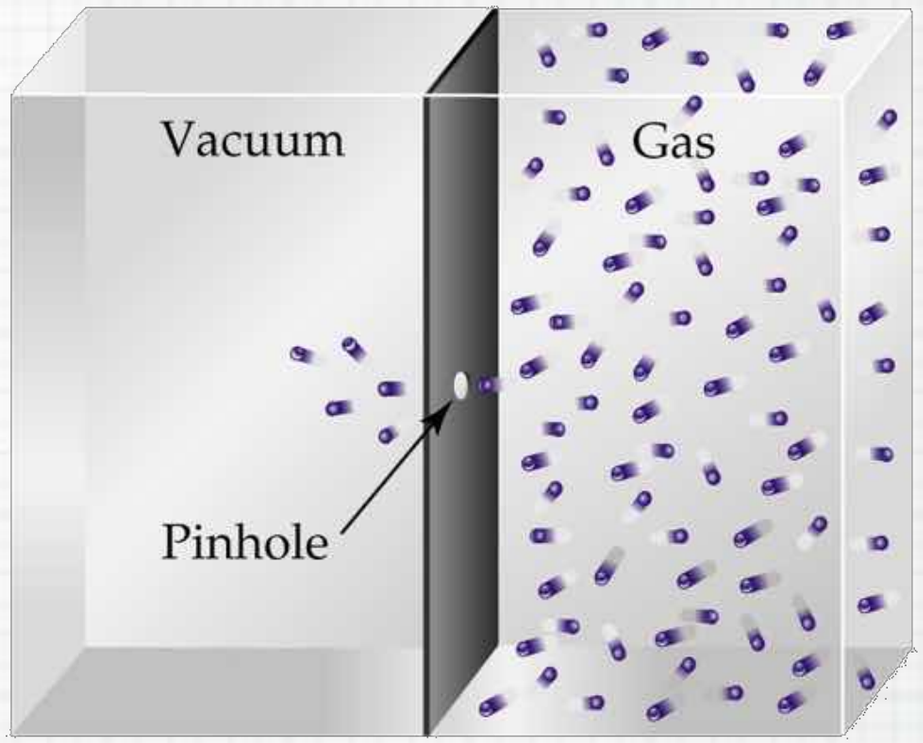
* motion = energy
* As T increases, KE increases, average velocity increases:



Diffusion & Effusion



(a) Diffusion



(b) Effusion

(a) Diffusion is movement of one material through another

* Smell of fresh cookies moving through house

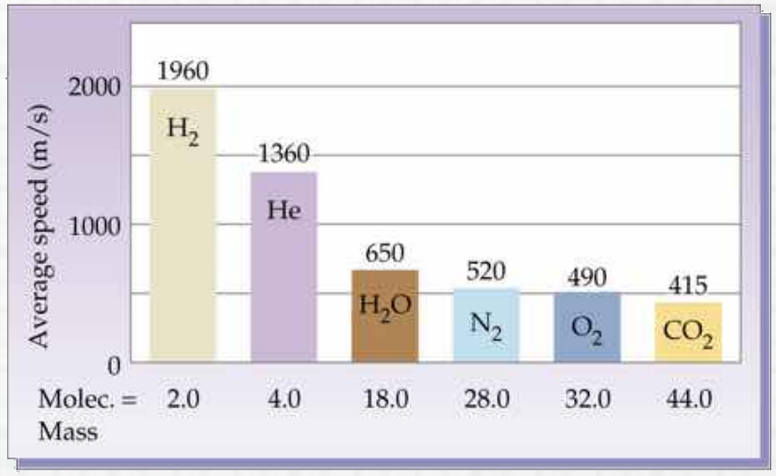
(b) Effusion is gas escaping through a small opening

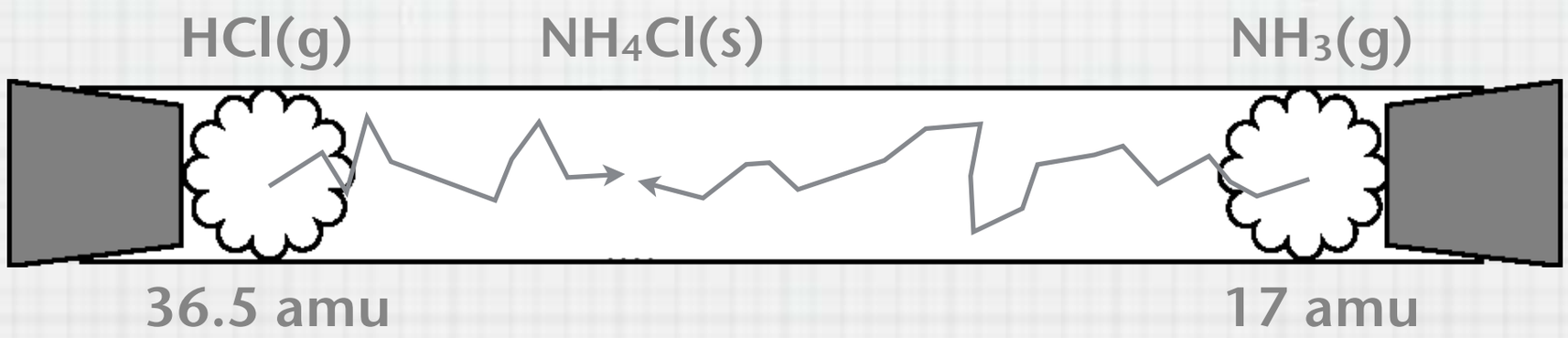
* Escape of He from balloon
* More control over variables, used by scientists to compare masses of two gases (Graham's Law)

Factors Affecting Rate

- Rate (velocity) depends on Temperature & Mass: $v_{avg} = \sqrt{\frac{3RT}{MM}}$
  - Rate is directly proportional to $\sqrt{T}$: as T ↑, KE ↑ and v_{avg} ↑
  - Rate is inversely proportional to $\sqrt{MM}$: as mass ↓, KE stays the same and v_{avg} ↑
    - HCl(g) & NH_3(g) diffuse and form NH_4Cl: Closer to HCl source since NH_3 moves faster

TABLE 9.5 Average Speeds (m/s) of Some Molecules at 25°C





Talking Like a Duck…

- Why does helium make your voice sound funny?
  - Mass He = 4 amu, ~7× less than mass of air (~29 amu)
  - What should happen to v_{avg}?
    - He Video: https://youtu.be/v6z-ziQHa2E (next in playlist)
    - As mass ↓, v_{avg} and resonant frequency ↑
- What would happen if we use "anti He"?
  - What is mass of SF_6? How much more massive is it than air?
    - 146 amu, about 5× more massive than air
  - As mass ↑, v_{avg} and resonant frequency ↓
  - SF_6 video: https://youtu.be/HIXEzj08MwE (after He video in playlist)