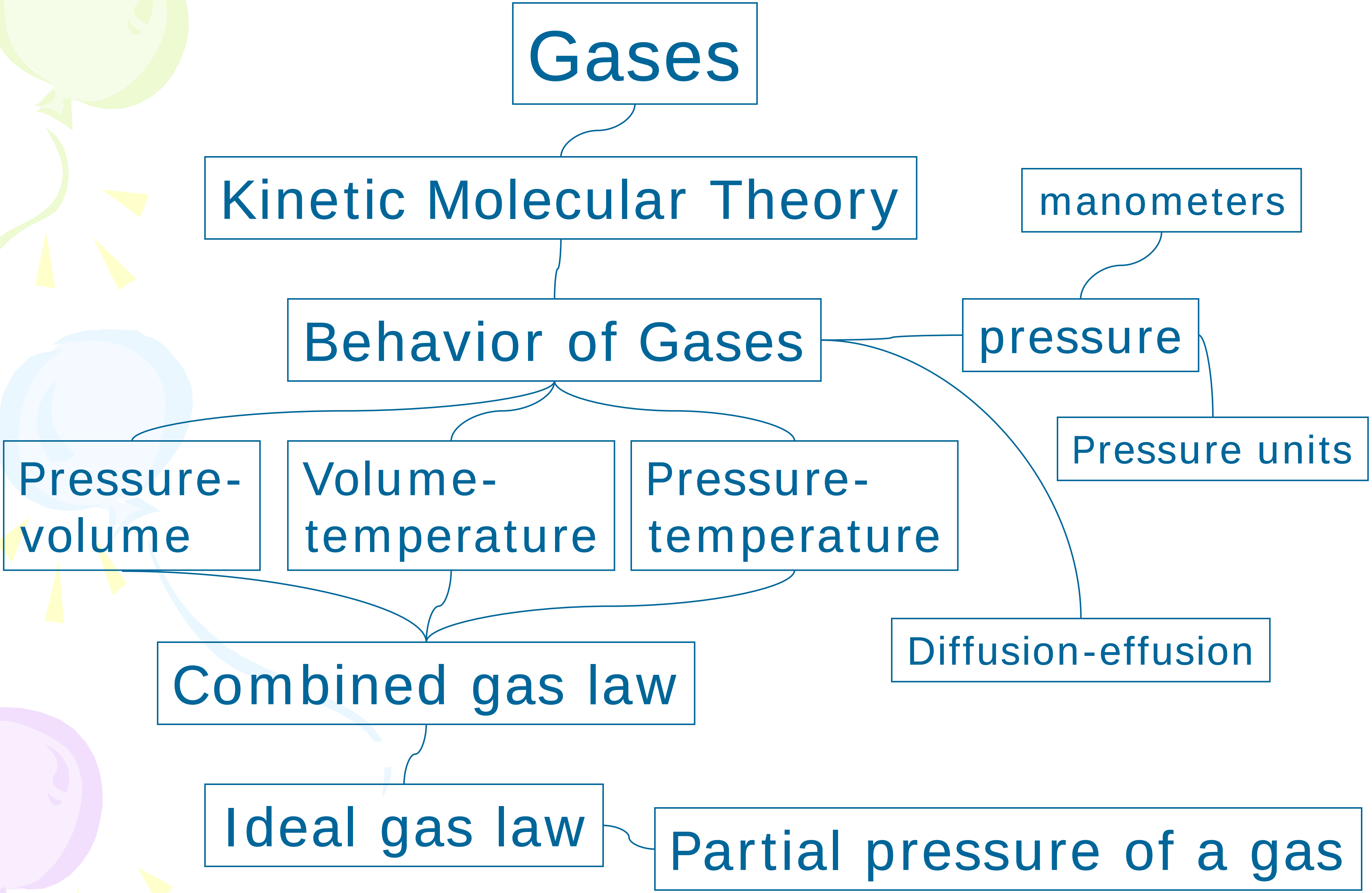
Gases

Bromfield Chemistry CP


Gases
Kinetic Molecular Theory
manometers
Behavior of Gases
pressure
Pressure units
Pressure-volume
Volume-temperature
Pressure-temperature
Diffusion-effusion
Combined gas law
Ideal gas law
Partial pressure of a gas

Properties of Gases

- Very low density
- Low freezing points
- Low boiling points
- Can diffuse (rapidly and spontaneously spread out and mix)

Properties of Gases

- Flow
- Expand to fill container
- Compressible

Kinetic Molecular Theory of Gases

- Particles move non-stop, in straight lines.
- Particles have negligible volume (treat as points)
- Particles have no attractions to each other (no repulsions, either).

Kinetic Molecular Theory of Gases

- Collisions between particles are “elastic” (no gain or loss of energy)

Why science teachers are not asked to monitor recess.

Kinetic Molecular Theory of Gases

- Collisions between particles are “elastic” (no gain or loss of energy)
- Particles exert pressure on the container by colliding with the container walls.

Video

- Trying to breathe on Mt. Everest

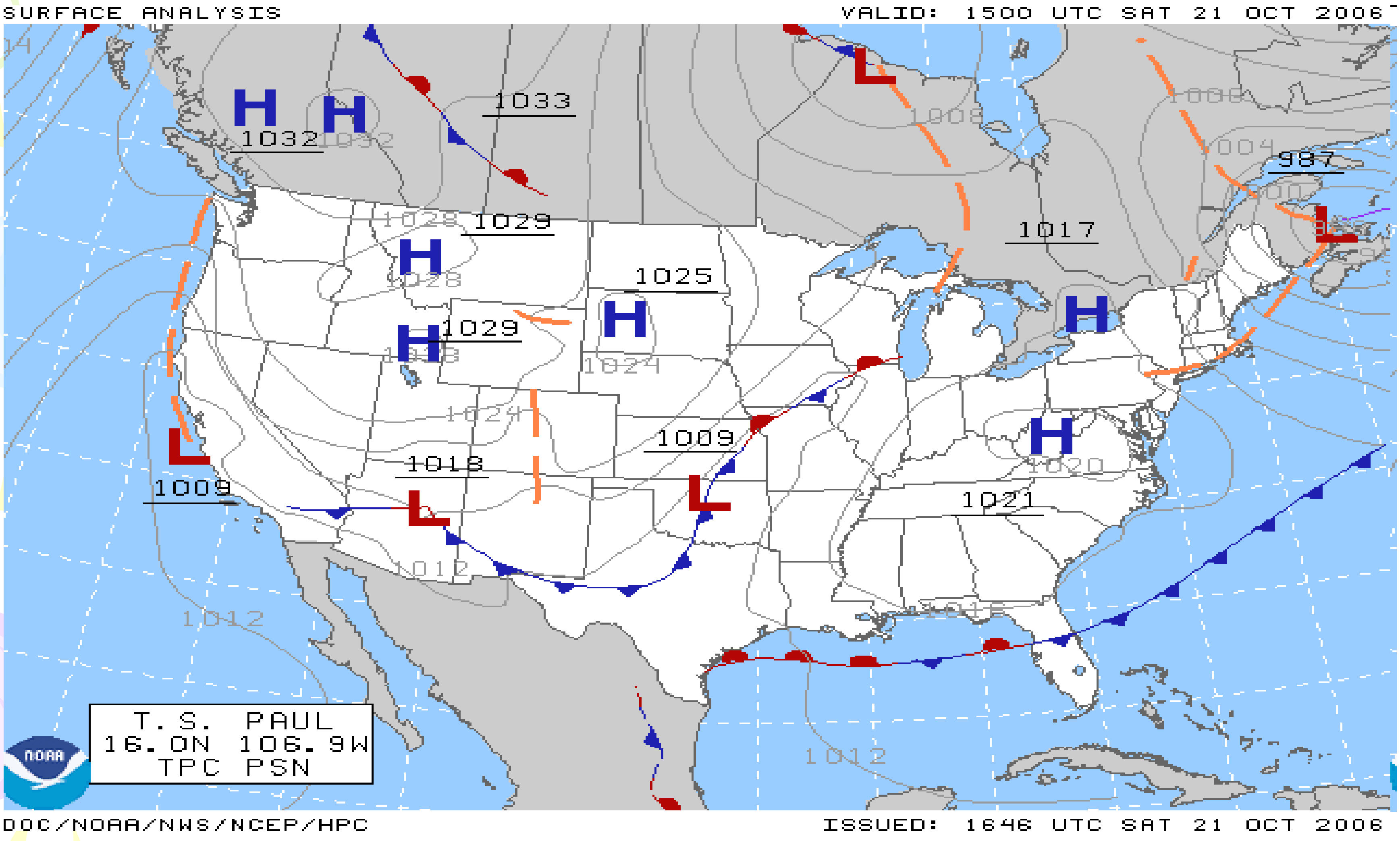
Pressure

- Pressure = force/area

photo by the_Moog

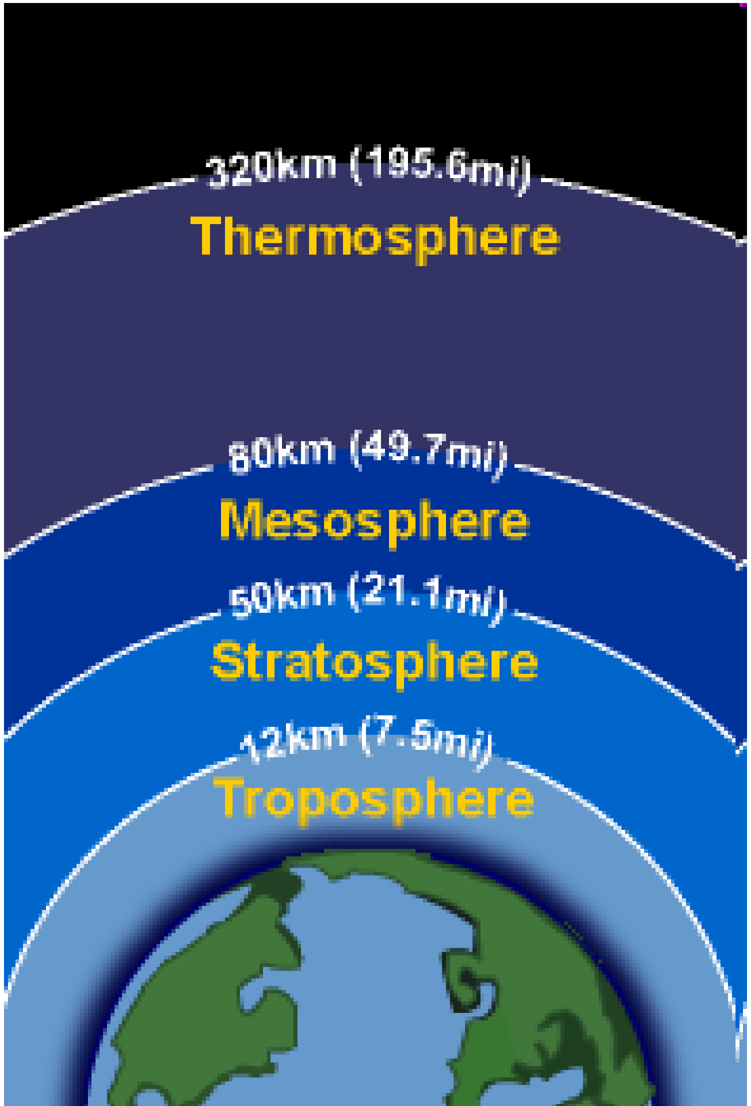
photo by RonAlmog

Weather Maps



Pressure

- Atmospheric pressure
  - Because air molecules collide with objects



Barometer

- Animation of a water barometer

- Torricelli-1643
- Air molecules collide with liquid mercury in open dish
- This holds the column up!

Barometer

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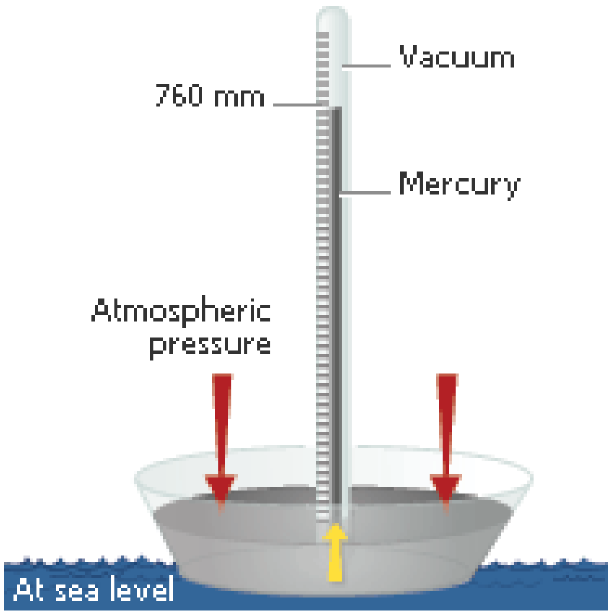
- Air molecules collide with liquid mercury in open dish
- This holds the column up!
- Column height is an indirect measure of atmospheric pressure



Pressure

- Pressure = force/area
- Atmospheric pressure
  - Because air molecules collide with objects

- More collisions → greater pressure

Pressure Units

- Atmosphere

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Pressure Units

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- Pounds per square inch (psi)
- mm Hg
- Torr
- Pascal (Pa) or kilopascal (kPa)

Pressure Units

1 atm = 14.7 psi = 760 mm Hg

1 atm = 760 torr = 101.3 kPa

Temperature and Kinetic Energy

- Kinetic energy
  - Energy due to motion

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- KE = ½ (mass)$(velocity)^2$

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- Temperature is a measure of kinetic energy.
  - Temperature measures how quickly the particles are moving. (Heat IS NOT the same as temperature!)
  - If temperature increases, kinetic energy increases.
    - Which has greater kinetic energy: a 25 g sample of water at 25^{o}C or a 25 g sample of water at -15^{o}C?

Why use the Kelvin scale?

- In the Kelvin scale, there is an absolute correlation between temperature and kinetic energy.

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Why use the Kelvin scale?

- In the Kelvin scale, there is an absolute correlation between temperature and kinetic energy.
  - As temperature in Kelvin increases, kinetic energy increases.
- Absolute zero: All molecular motion ceases. There is no kinetic energy.

0 K

Kelvin-Celsius Conversions

- $K = {}^{o}C + 273.15$

- ${}^{o}C = K - 273.15$

Kelvin-Celsius conversions

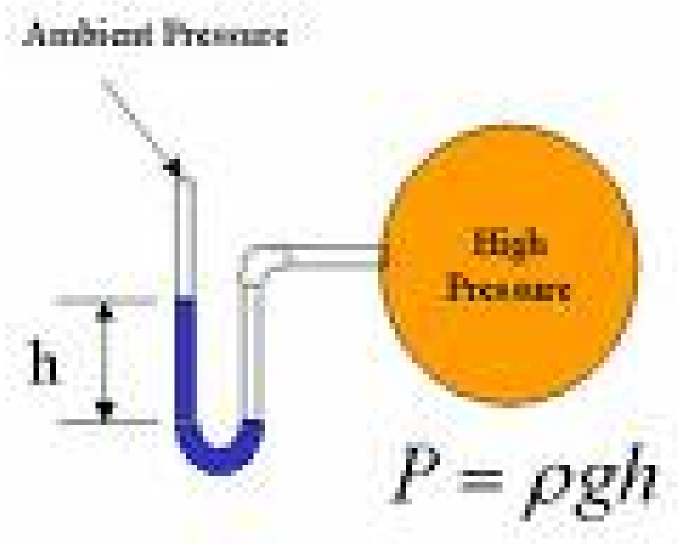
- The temperature of liquid nitrogen is -196^{o}C. What is this temperature in Kelvin?

Kelvin-Celsius conversions

- Convert 872 Kelvin to Celsius temperature.

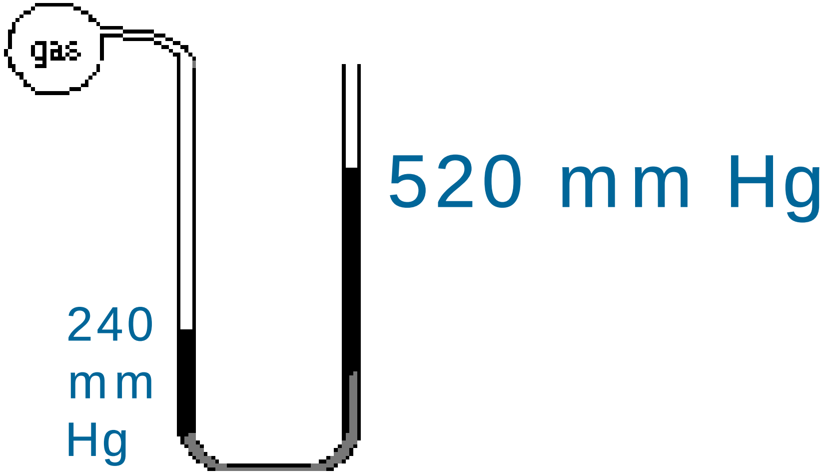
Manometer

- Two types: open and closed
- Use to measure the pressure exerted by a confined gas



Reading Manometers

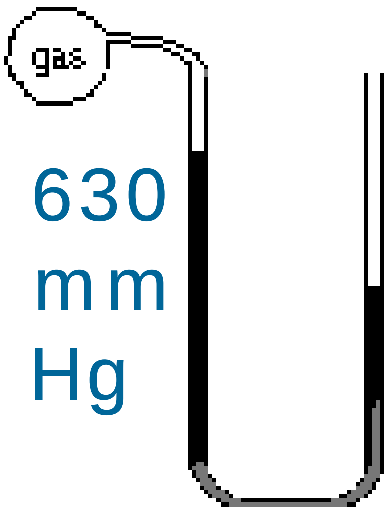
- Open manometer



P_{atm} = 750 mm Hg

Reading Manometers

- Open manometer



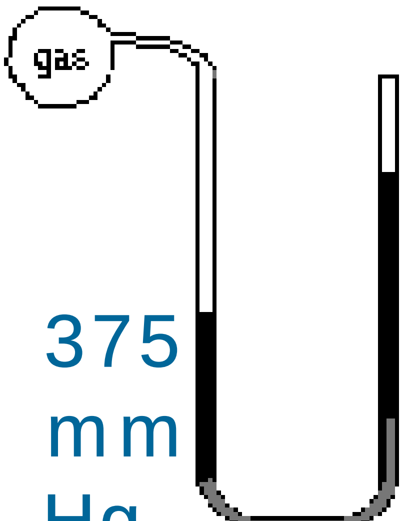
630 mm Hg

450 mm Hg

P_{atm} = 755 mm Hg

Reading Manometers

- Closed manometer



625 mm Hg

375 mm Hg

Ideal vs. Real Gases

- Ideal gas: completely obeys all statements of kinetic molecular theory

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- Ideal gas: completely obeys all statements of kinetic molecular theory
- Real gas: when one or more statements of KMT don't apply
  - Real molecules do have volume, and there are attractions between molecules

When to expect ideal behavior?

- Gases are most likely to exhibit ideal behavior at…
  - High temperatures
  - Low pressures

When to expect ideal behavior?

- Gases are most likely to exhibit real (i.e., non-ideal) behavior at…
  - Low temperatures
  - High pressures

Diffusion and Effusion

- Diffusion
  - The gradual mixing of 2 gases due to random spontaneous motion
- Effusion
  - When molecules of a confined gas escape through a tiny opening in a container

Graham's Law

- Thomas Graham (1805-1869)
- Do all gases diffuse at the same rate?
  - Graham's law discusses this quantitatively.
  - Technically, this law only applies to gases effusing into a vacuum or into each other.

Graham's Law

- Conceptual:
  - At the same temperature, molecules with a smaller gfm travel at a faster speed than molecules with a larger gfm.
    - As gfm ↑, v ↓

- Consider H_2 vs. Cl_2

Which would diffuse at the greater velocity?