Gases

- All gases have several properties in common:
  - Relatively low density
  - Compressible
  - Expand to fill any container

Ideal Gases

- Gas Law:
  \[ PV = nRT \]
- Originally based on empirical observations
- Can also be derived mathematically from the kinetic theory of gases
Pressure

- Dimensions of force/area
- SI unit is N/m$^2$, or Pascal
- Other more common units:
  - atmospheres:
    - 1 atm = 101,325 Pa
  - torr (mm Hg):
    - 760 torr = 1 atm
  - lbs/in$^2$:
    - 14.7 psi = 1 atm

Gas Constant - R

- Proportionality constant, found by experiment
- In SI units:
  - $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
- Other units:
  - $R = 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
  - $= 62.36 \text{ L torr mol}^{-1} \text{ K}^{-1}$

Units

- Consistent units are ALWAYS required!
- Use any convenient units for $P$, $V$
- Then choose $R$ so that units all match
Estimate number of gas molecules in a typical balloon.

Temperature

\[ V = \frac{nRT}{P} \]

- If \( T \to 0 \), then \( V \to 0 \)
- MUST use absolute \( T \) (Kelvin, NOT °C)
  
  \[
  \begin{align*}
  0^\circ \text{C} & = 273.15 \text{ K} \\
  0 \text{ K} & = -459.7^\circ \text{ F}
  \end{align*}
  \]

What makes a gas “ideal?”

- In most simple terms, an ideal gas obeys the ideal gas law.
- But why? Can we predict when a gas might NOT obey the law?

Molecular viewpoint
Properties of an Ideal Gas

- Huge # of molecules
- Point masses, no volume
- No forces between molecules
- Constant, chaotic motion
- Elastic collisions

Gas Law = Limiting Case

- Any gas will behave ideally in the limits of
- LOW PRESSURE
- HIGH TEMPERATURE
- Explain this in terms of previous properties?

Applicability of Ideal Gas Law

- OK for most gases at ordinary T, P
- MUST fail at some point, since solids and liquids exist.
- Deviations at high P, low T.
Using Gas Law

- Change in conditions
  - “Before” and “after” eq’s, collect constant terms.

Example

- A bulb is filled with 760 torr of CH$_4$ at 25°C
- The bulb may burst if the pressure exceeds 2 atm
- If the bulb is heated, at what temperature would the pressure reach 2 atm?