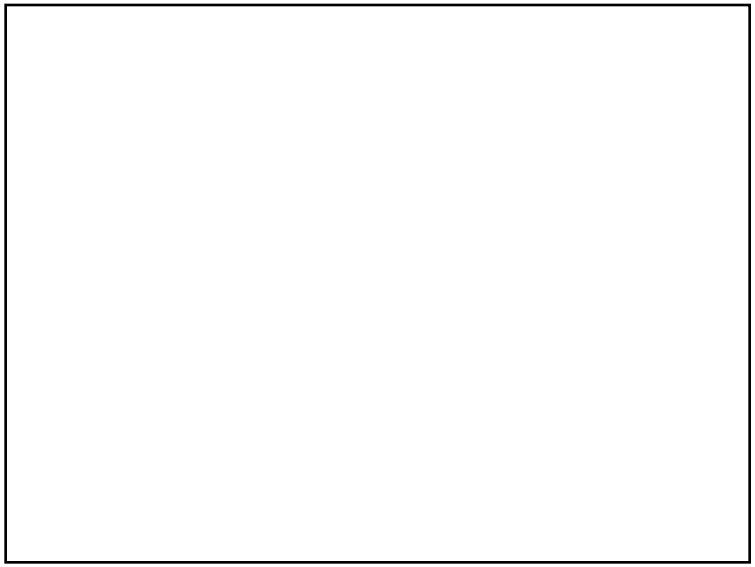
Physics 101: Lecture 25
Ideal Gas Law and Kinetic Theory

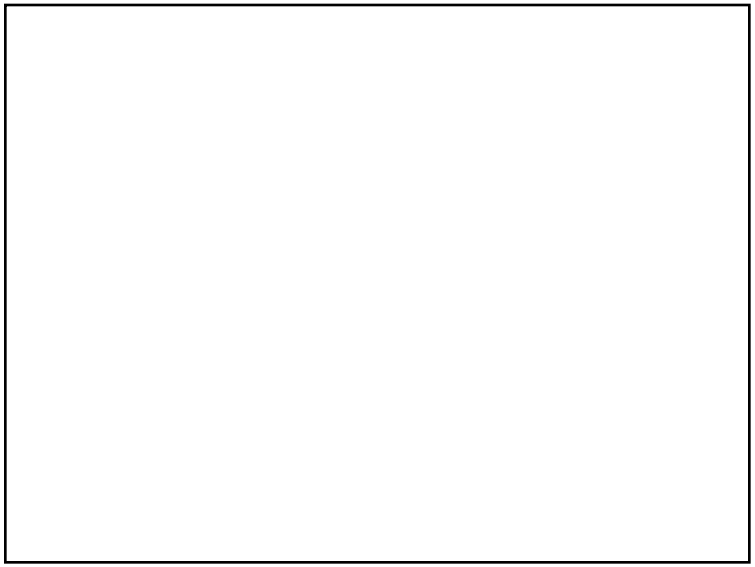
Molecular Picture of Gas

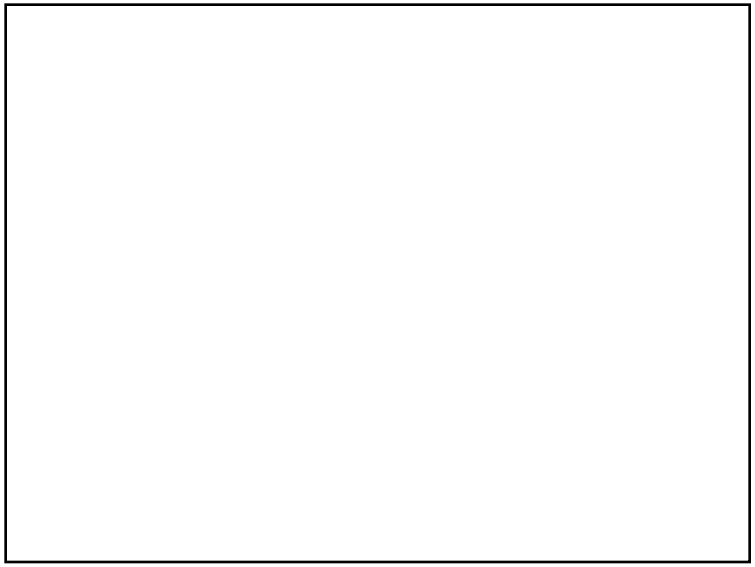
- Gas is made up of many individual molecules
- Number density is number of molecules/volume:
  - $N/V = \rho/m$
  - ρ is the mass density
  - m is the mass for one molecule
    - $1\ u = 1.66*10^{-27}\ kg = 1/12$ of a mass of C^{12}
- Number of moles: $n = N / N_A$
  - N_A = Avogadro's Number = $6.022x10^{23}\ mole^{-1}$
- Mass of 1 mole of "stuff" in grams = molecular mass in u
  - e.g., 1 mole of N_2 has mass of 2x14=28 grams

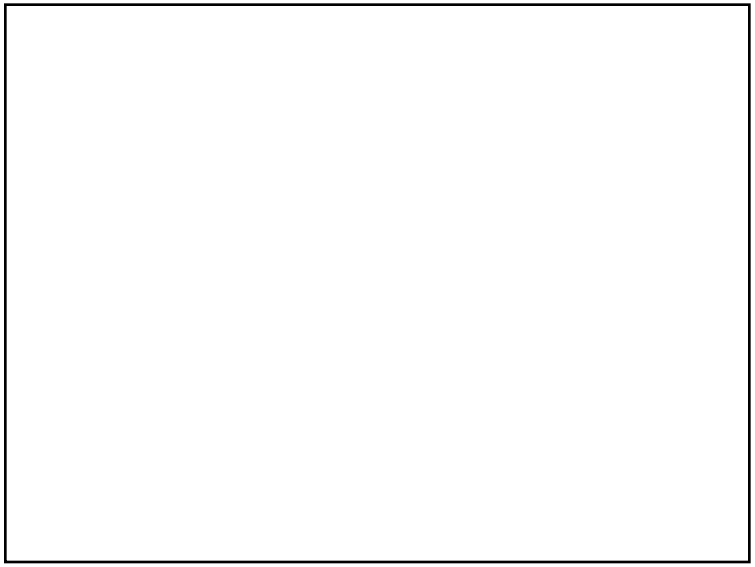
The Ideal Gas Law

- $P\,V = N\,k_B\,T$ or $P = (N/V)\,k_B\,T$
  - P = pressure in N/m^2 (or Pascals)
  - V = volume in m^3
  - N = number of molecules
  - T = absolute temperature in K
  - k_B = Boltzmann's constant = 1.38×10^{-23} J/K
  - Note: P V has units of N-m or J (energy!)
- $P\,V = n\,R\,T$ (get this by multiplying top eqn by N_A/N_A)
  - n = number of moles
  - R = ideal gas constant = $N_A k_B$ = 8.31 J/mol/K









Ideal Gas Law: Demos
pV = nRT

- When T is constant, PV is constant (Boyle's Law)
  - Boyle's law demo (Done earlier)
- When P is constant, V is proportional to T
  - Helium and oxygen in LN_2 (Balloon in LN_2)
- When V is constant, P is proportional to T
  - Explosion! (Cannon DEMO)

Summary

- Gas is made up of molecules
- Ideal Gas Law PV = n R T
  - P = pressure in N/m^2 (or Pascals)
  - V = volume in m^3
  - n = # moles
  - R = 8.31 J/ (K mole)
  - T = Temperature (K)