Ideal Gas Law

Lecture Notes (Math 142-1)

December 3, 2015

1 Diffusion

- Box with a small hole in it; how quickly does gas escape?
- KE proportional to T
- $KE = \frac{1}{2}m\overline{v}^2$
- $\overline{v} = \sqrt{\frac{2KE}{m}}$
- How quickly does a particle with velocity $\overline{v}$ escape?
  - Assume probability of $0 < p < 1$ for escaping each time it hits the wall with the hole
  - $\Delta t = \frac{2L}{\overline{v}}$ between wall hits
  - Probability of escaping after i failed attempts is $p(1-p)^i$
  - $E[t] = \sum_{i=0}^{\infty} i\Delta t p(1-p)^i = \frac{1-p}{p}\Delta t = \frac{1-p}{p}\frac{L\sqrt{2m}}{\sqrt{KE}}$
- This suggests that the rate of diffusion is proportional to $\frac{\sqrt{T}}{\sqrt{m}}$
- This can be used in principle to determine the relative masses of gas particles

2 Subtlety is required

- Setup
  - Box, separated in two
  - Right side empty
  - Left side contains gas
- Case I
  - Divider is slowly moved back allowing gas to occupy full box
  - Gas gets cooler
- Case II
  - Divider is punctured to allow gas to occupy full box
  - Divider can then be removed
  - Gas stays same temperature
- Why the difference?
  - In case I, but not case II, we got energy by moving the wall
  - In case II, the system is far from equilibrium