Announcements – 10/9/00

- ***Note:*** Additional readings and problems in Chapter 11!
- **Quiz Today**
- **Exam #2:** *Wed., 10/18, 7:00 pm*

  -contact me THIS WEEK if you need to schedule an alternate time
- ***Demo today!***

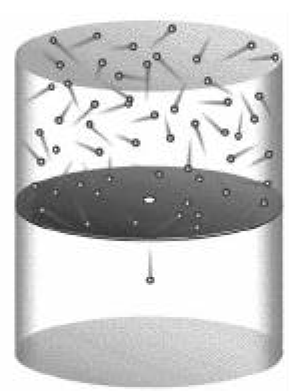
1

Graham's Law of Effusion

If gas molecules are allowed to enter a vacuum only through a small opening:

The rate at which they *effuse* through the opening will vary with the *square root* of their molar masses:

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$



So that's why those cheap helium-filled balloons don't last very long! 2

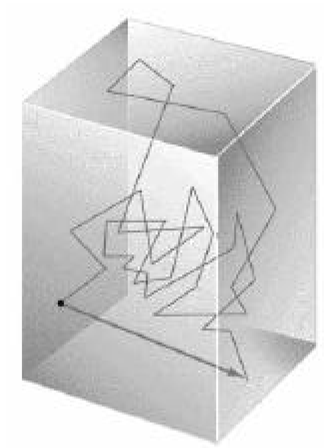
Diffusion

- *Diffusion* is the spread of a substance through space (or through another substance)

  -gas molecules travel in a straight line until they collide with something, after which, they *change direction*

  -the *distance* that they travel before they collide is called the **mean free path** *(mfp)*

  -*mfp varies with density:*
  nm @ atm pressure
  cm @ upper atmosphere



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What about individual gas particles?

- We can also express the *average kinetic energy* per particle in terms of temperature. For 1 mol:

$$\langle \varepsilon_k \rangle = \frac{\textit{Total Kinetic Energy}}{\text{\# particles}} = \frac{E_k}{N_0} = \frac{3/2\,RT}{N_0}$$

$$\boxed{\langle \varepsilon_k \rangle = 3/2\; k_B T}$$

k_B: Boltzmann's Constant (= 1.38066×10^{-23} J/K)

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Maxwell-Boltzmann Statistics

- Allows us to characterize the behavior of *individual particles* by statistical analysis of the *aggregate*
- The speed distribution for a gas at thermal equilibrium:

$$F(v) = Kv^2 e^{-mv^2/2k_bT}$$

where: $K = 4\pi(m/2\pi k_b T)^{3/2}$ - constant at fixed temp

There are two opposing trends:

$F(v) \propto v^2$ (incr) AND $F(v) \propto e^{-v^2}$ (decr)

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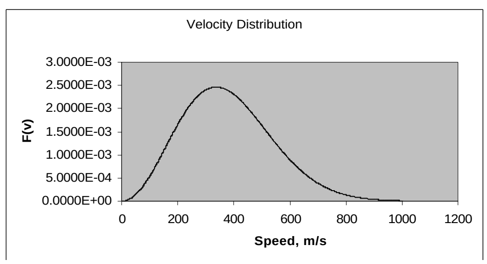
Maxwell-Boltzmann Speed Distribution

Example: **Argon**

T_1 = 273.15 K

v_{rms}= 413.0 m/s

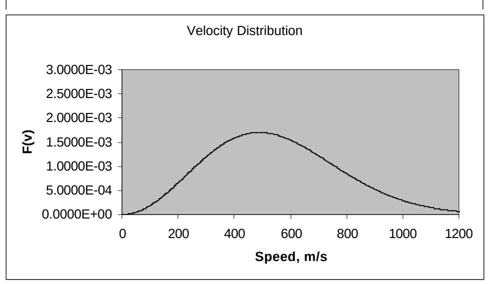
v_{mp} = 337.2 m/s



T_2 = 573.15 K

v_{rms}= 598.2 m/s

v_{mp} = 488.4 m/s



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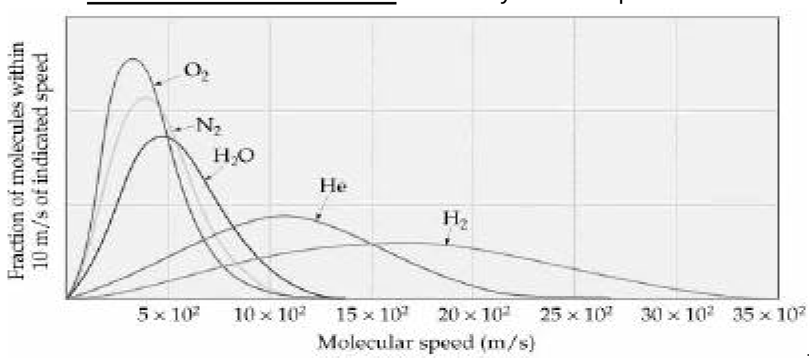
Maxwell-Boltzmann: Effect of Gas Composition

- Avg Kinetic Energy is *independent of gas composition* ® depends **only** on <u>temperature</u>
  - -since the ***mass*** of the gas molecules varies with composition, the **<u>velocities of the molecules</u>** must vary with composition:



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NON-Ideal Gases: The *Real* Thing

- If a gas acts *ideally*:

$$\frac{PV}{RT} = 1 \quad \textbf{for 1 mol gas}$$

- A plot of $\frac{PV}{RT}$ versus P should yield a straight line at a constant value of 1.00

Let's take a look, shall we?

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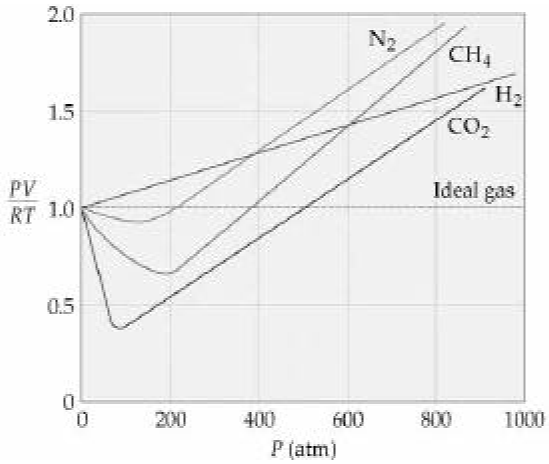
Real Gas Behavior

- No deviations until P>20 atm
- *Negative Deviations* at intermediate pressures
  - Due to lower than *ideal* volumes
  - *Molecular* ***attractions***
- *Positive Deviations* at high pressures
  - Due to higher than *ideal* volumes
  - *Molecular* ***repulsions***



At constant temperature (300 K)

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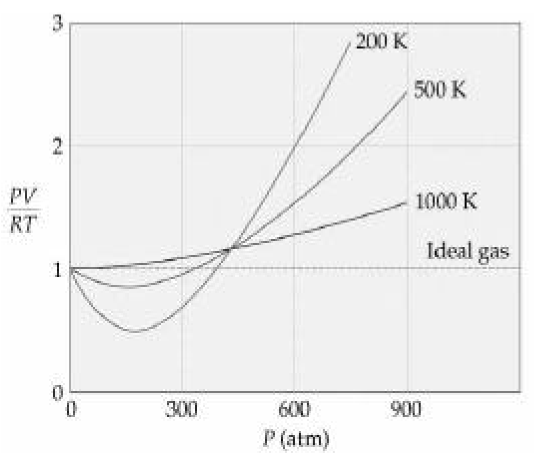
Effect of Temperature



-*negative deviations* are more significant at lower temps

-due to decreased molecular motion, allowing more significant intermolecular interactions

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