Kinetic Theory and the First Law of Thermodynamics

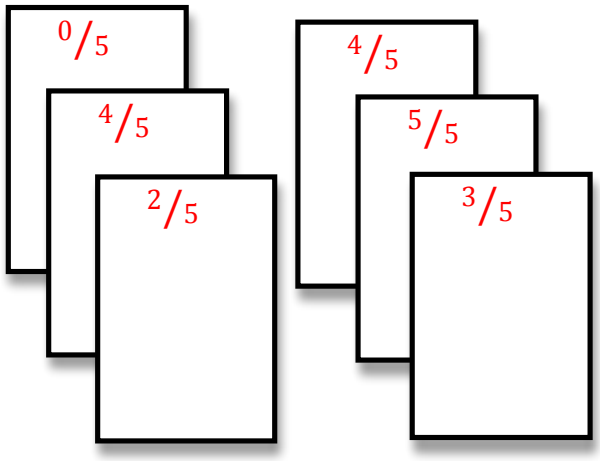
Pre-Class Questions

Problem Set (due next time)
Ch 15 - 23, 24, 37, 46

Lecture Outline

1. Kinetic Theory
2. The First Law of Thermodynamics

Root Mean Square



At the right are six homework papers from last night.

1. Find the average score.

2. Square each score and find the average of the squares.

3. Take the square root of the average of the squares.

4. Is it larger or smaller than the regular average?

Example 1: Estimate the rms speed of the molecules in this room by assuming they are all nitrogen with a molecular mass of 28g/mol.

Rank the total internal energies of the ideal gases below that contain different number of molecules (N) at various temperatures (T) and pressures (P). Note: The volumes are not given.

A

P= 2 atm
T= 200 K
N= 15,000

B

P= 2 atm
T= 150 K
N= 10,000

C

P= 2 atm
T= 250 K
N= 20,000

D

P= 2 atm
T= 300 K
N= 15,000

E

P= 2 atm
T= 150 K
N= 12,500

F

P= 1 atm
T= 150 K
N= 12,500

G

P= 1 atm
T= 300 K
N= 15,000

H

P= 3 atm
T= 200 K
N= 25,000

Greatest 1____ 2____ 3____ 4____ 5____ 6____ 7____ 8____ Least

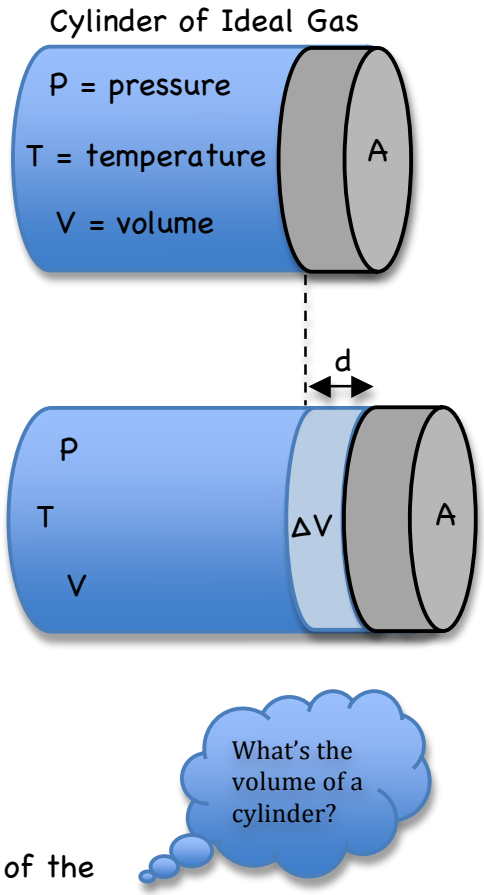
Or, all these gases the same total internal energy. _____

Or, it is not possible to rank the total internal energies for these gases. _____

Please carefully explain your reasoning.

What A Smart-Gas!

At the right is a cylinder of ideal gas with pressure P, temperature T, volume V, and cross-sectional area, A.



Remember $P = F/A$?

1. Find the force on the gray movable plug at the right (called a "piston") in terms of P, T, V, and A.

Work is force times distance, right?

2. If the gas exerts this force on the piston causing it to move to the right a short distance, d, Find the work done by the gas.

What's the volume of a cylinder?

3. Write the increase in volume, ΔV, in terms of the area, A and distance, d.

4. Finally, rewrite the work done by the gas using ΔV.

Example 2: 1.0mol of ideal gas initially has a pressure of 100kPa and a volume of 20L. It expands to 22L while the pressure stays constant. Find (a)the initial temperature of the gas, (b)the final temperature of the gas, (c)the change in internal energy of the gas, (d)the work done by the gas, and (e)the heat added to the gas. (f) Draw the pV diagram.

Lecture 38 - Summary

The Definition of Temperature is $\frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$

where k is Boltzman's Constant k = 1.38×10^{-23} J/K.

First Law of Thermodynamics: $Q = \Delta U + W$

Internal Energy of an Ideal Gas is $U = \frac{3}{2}NkT$

The work done by an ideal gas at constant pressure $W = P\Delta V$.