Chemistry C-2407
Course Information

Name: Intensive General Chemistry

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Website Address for course:
http://www.columbia.edu/itc/chemistry/chem-c2407/

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More Course Information

Required Recitations: M, 3-5, 6-8; Tu, 3-5; W, 4-6; F, 10-12, 2-4

[Sign up for one only!]

These are held in the Chemistry Computer Room

Room 211 Havemeyer

Telephone Registration: Course # C2409

Teaching Assistants: Jennifer Inghrim (jai2002@columbia.edu, mail box #3133, Havemeyer Hall) (854-4964);
Office Hour: Wednesdays 10:00-11:00, Room 343 Havemeye
and Sean Moran (sdm2007@columbia.edu, mail box 3139, Havemeyer Hall) (854 8468);
Office Hour: Tuesdays 2:00-3:00, Room 343 Havemeyer

First Required Recitation: Tomorrow, Wednesday, September 3, 2003--Bring a blank, unformatted floppy disk!

A Little Observation

Consider 1 mole of water molecules. H_2O has a molecular weight of 18 gm/mole.

So, 6.02×10^{23} molecules weigh 18 gm

But, 18 gm of liquid water occupies 18 ml volume (18 cm^3)

Liquid water is pretty incompressible. So we guess that the water molecules in the liquid are literally in contact with each other. No significant space in between.

So the actual volume of one water molecule must be roughly 18 ml/6.02×10^{23}= 3×10^{-23} ml

Contrast this with the volume occupied by a water molecule in the gas phase. To find this number, treat water as an ideal gas at 300 K and use the ideal gas law to compute the volume:

pV=nRT with n=1 mole, p= 1 atm. and R=0.082 *l*-atm/mole-deg

V=(1)(.082)(300)/(1)= 24.6 liters

Or, the volume occupied per molecule is 24,600ml/6.023×10^{23}= 4.1×10^{-20} ml

Compare!

Thus the ratio of the volume occupied by an ideal gas molecule to its actual volume is 24600/18=1400 !!

This leads us to conclude that molecules in an ideal gas must be far apart, “rarely” bumping into each other. The volume of an actual molecule is tiny by comparison to the volume occupied at 1 atmosphere and 300K in the gas phase.

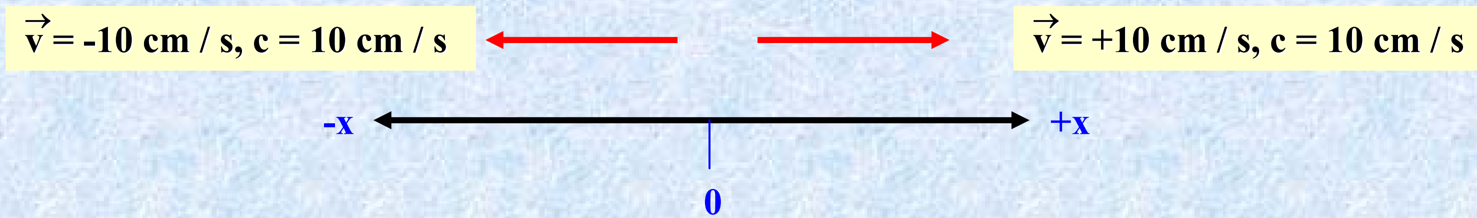
The picture we walk away with for the gaseous state of a molecule in an ideal gas is one of huge empty spaces between molecules with “rare” collisions.

This will allow us to develop a simple MODEL of the gaseous state which provides remarkable insight into the properties of molecules and matter.

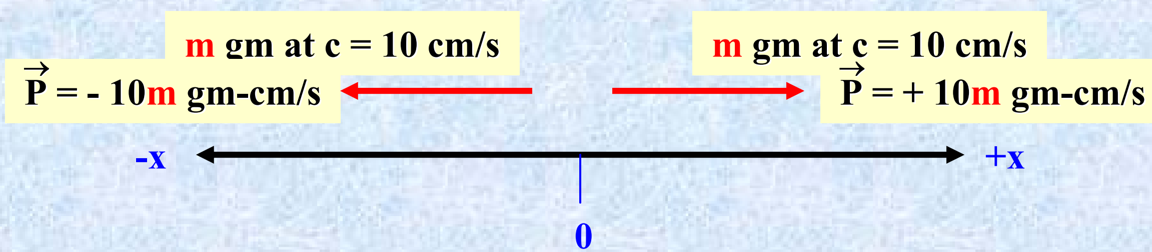
This MODEL is called the Kinetic Theory of Gases.

Kinetic Theory Preliminaries

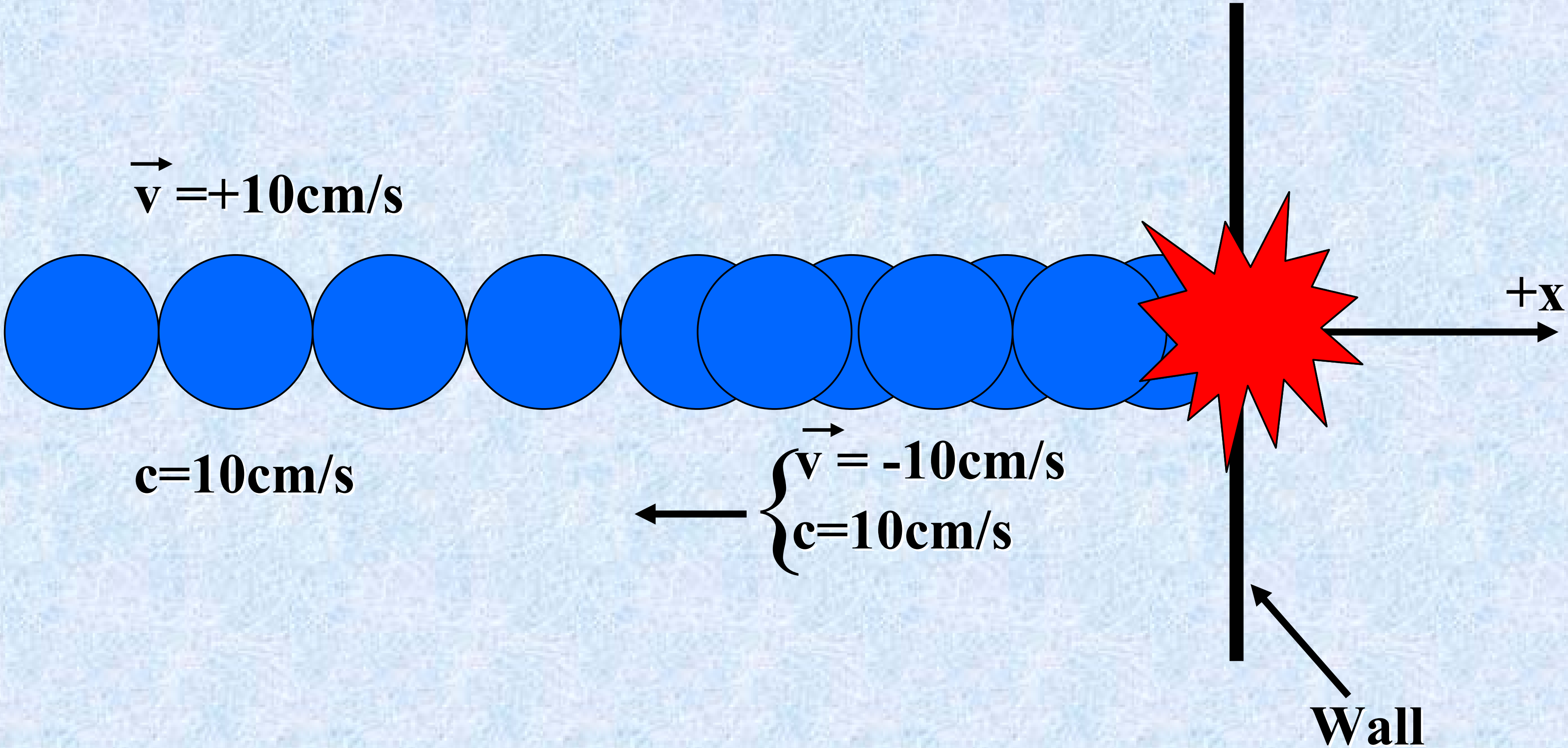
1) Particle velocity $\vec{v}$ includes both the speed (c) of a particle (cm/s) and its direction. In one dimension:

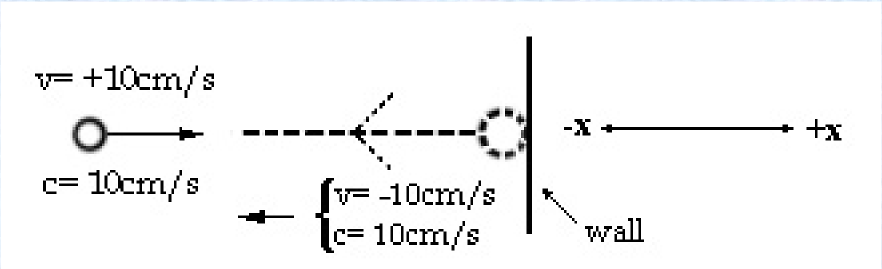


2) Particle Momentum is $\vec{P} = m\vec{v}$ (not mc). In one dimension:



3) Change in Momentum for an elastic collision: An elastic collision is one where <u>speed</u> is the same before and after the collision:


$\vec{v}$ =+10cm/s
c=10cm/s
$\vec{v}$ = -10cm/s
c=10cm/s
+x
Wall



$\vec{P}_{initial}$ = +10m(gm-cm/s) = $m\vec{v}$ = mc

$\vec{P}_{final}$ = -10m(gm-cm/s) = $m\vec{v}$ = -mc

$\Delta\vec{P} = \vec{P}_f - \vec{P}_i$ = -mc - (mc) = -2mc [Δ is the symbol for "change"]

4) Conservation of Momentum: what particle loses, wall must gain

$\Delta\vec{P}_{wall}$ = +2mc

$\Delta\vec{P}_w + \Delta\vec{P}_m = 0$

5) Acceleration **a** is Δ (velocity) / Δ (time).
$\vec{a}$ like $\vec{v}$ has direction.

$\vec{a} = \Delta\vec{v} / \Delta t$ ($\vec{a} = d\vec{v} / dt$)

6) Force = $\vec{F} = m\vec{a}$

$\vec{F} = m\vec{a} = m\Delta\vec{v} / \Delta t = \Delta\vec{P} / \Delta t$

Force is change in momentum with time:

$\vec{F} = d\vec{P} / dt$

Kinetic Theory of Gases

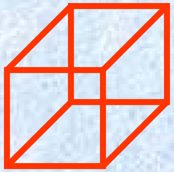
Assumptions

1) Particles are point mass atoms (volume = 0)

2) No attractive forces between atoms. Behave independently except for brief moments of collision.

Model System

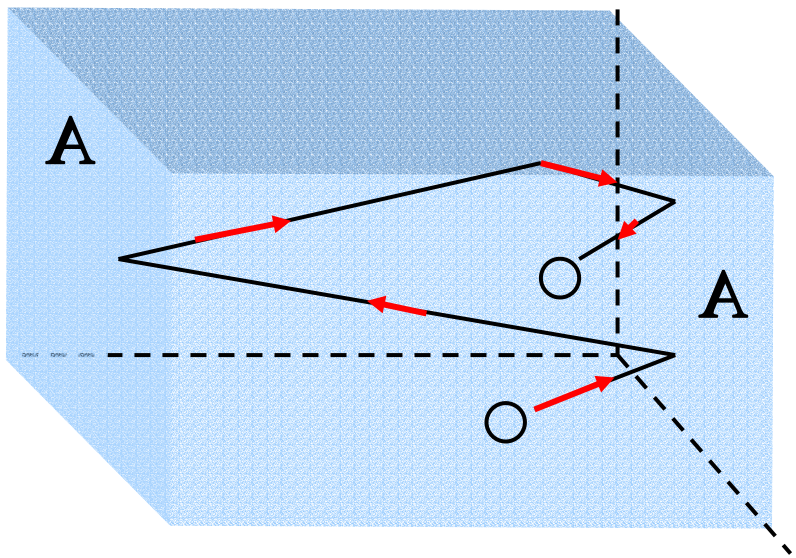
A box of volume V with N atoms of mass m all moving with the same speed c.



V, N, m, c

We wish to calculate the pressure exerted by the gas on the walls of the box:

Typical Path for a gas atom or molecule in a box.



Force of atom impinging on wall creates pressure that we can measure [$pV = nRT$].

Pressure ≡ Force / unit area

Thus, we need to find force exerted by atoms on the the wall of the box.

$\vec{F} = m\vec{a} = m(\Delta\vec{v})/\Delta t$

$(\Delta\vec{P})/\Delta t$=(Change in momentum) / (change in time)

Let's try to calculate the force exerted by the gas on a segment of the box wall having area A.

To do this we will make one more simplifying assumption:

We assume that all atoms move either along the x, y, or z axes but not at any angle to these axes! (This is a silly assumption and, as we shall see later, causes some errors that we must correct.)

Vectors and Vector Components: The Movie

Z

QuickTime™ and a
Video decompressor
are needed to see this picture.

Y

X