CEN 207 Physical Chemistry

Text book:

Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, 11th Edition, Oxford University Press.

Reference books

. Physical Chemistry, Robert J. Silbey, Robert A. Alberty, Moungi G. Bawendi

. Physical Chemistry, Ira N. Levine

B. The kinetic model

In the kinetic theory of gases (which is sometimes called the kinetic-molecular theory, KMT) it is assumed that the only contribution to the energy of the gas is from the kinetic energies of the molecules.

The model assumptions:

i. The gas consists of molecules of mass **m** ceaseless random motion obeying the laws of classical mechanics.

ii. The size of the molecules is negligible, in the sense that their diameters are much smaller than the average distance travelled between collisions; they are "point-like".

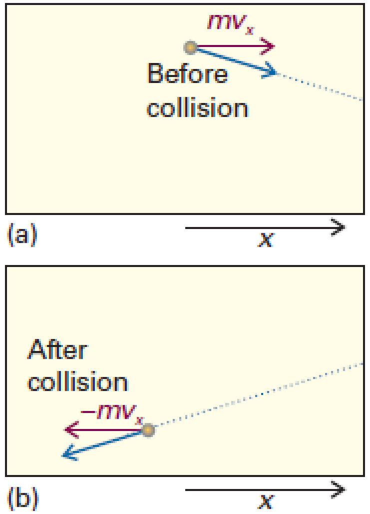
iii. The molecules interact only through brief elastical collisions. (An elastical collision is a collision in which the total translational kinetic energy of the molecules is conserved).

B. The kinetic model

Pressure and molecular speeds: using the kinetic model to derive an expression for the pressure of a gas.

The calculation of the change in momentum:

m : particle mass;
v_x: a component of velocity is parallel to the x-axis
Linear momentum: mv_x (before collision)
Linear momentum: $-mv_x$ (after collision)
The x-component of momentum therefore changes by $\underline{2mv_x}$ (y and z components are unchanged. Many molecules collide with the wall in an interval Δt (for total change of momentum x the number of molecules)



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B. The kinetic model

distance ($v_x\Delta t$) along with the x-axis to strike the wall.

A: the area of the wall

V: the volume ($A*v_x\Delta t$) all the particles reach the wall (if they are travelling towars it)

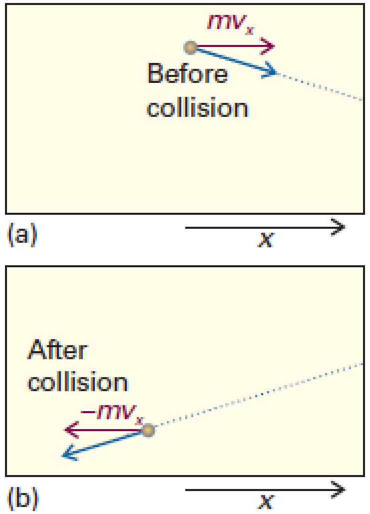
The number density of particles: nN_A/V

n: the total amount of molecules,

N_A: Avogadro's constant

V: the container of volume

It follows that the number of molecules in the volume ($A*v_x\Delta t$) is (nN_A/V) x ($A*v_x\Delta t$)



B. The kinetic model

The total momentum change:

$$Momentum\ change = \frac{nN_A A v_x \Delta t}{2V} * 2mv_x = \frac{n\overbrace{mN_A}^{M} A v_x^2 \Delta t}{V} = \frac{nMAv_x^2 \Delta t}{V}$$

Calculate the force

Momentum change is divided by the interval Δt during which it occurs, is

$$Rate\ of\ change\ of\ momentum = \frac{nMAv_x^2}{V}$$

Rate of change of momentum = Force (according to Newton's second law of motion).

Calculate the pressure

$$Pressure = \frac{nM\langle v_x^2 \rangle}{V}\ \ ;\ \langle v_x^2 \rangle = \frac{1}{3}\langle v^2 \rangle$$

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$v_{rms} = \langle v^2 \rangle^{1/2}$ Root- mean- square speed (definition)

So it can be written for the pressure as

$$\langle v_x^2 \rangle = \frac{1}{3}\langle v^2 \rangle = \frac{1}{3} v_{rms}^2$$

to give

$pV = \frac{1}{3} nMv_{rms}^2$

Relation between pressure and volume [KMT]

pV= constant (at constant temperature) which is the content of Boyle's law. The right-hand side of the equation is equal to **nRT** (pV=nRT).