States of Matter & Ionic Equilibria

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Kinetic Molecular Theory of Gases

The Kinetic Molecular Theory of Gases is based on following Postulates:

- A gas consists of a large number of minute particles called molecules. The molecules are so small that their actual volume is negligible as compared to the total volume (space) occupied by them.
- The molecules are in state of constant motion in all possible directions colliding in a random manner with one another and with the walls of vessel.
- The molecular collisions are perfectly elastic so that there is no net loss of energy when gas molecules collide with one another or against the walls of the vessel.

- The kinetic energy may be transferred from one molecules with another but it is not converted into any other form of energy such as heat.
- There are no attractive forces between molecules or between molecules or between molecules and the wall of container. The molecules move completely independent of each other.
- The pressure of gas is due to the bombardment of molecules in the containing vessel.
- The laws of classical mechanics are applicable for motion of gaseous state molecules.

Pressure of an ideal gas

The postulates of Kinetic Theory are applicable for the derivation of pressure of a gas. Lets consider N molecules of a gas each having mass **m**, enclosed in a cubical vessel of volume **V,** each side of cube being **l.** The motion of these molecules at any instant is considered to be totally random.

Velocity of one molecule of gas is **c**. The volume can be resolved into three components *u, v, w* along the three axes *x, y, z.* Since the volume components are perpendicular to the wall of container. Therefore,

$$c^2 = x^2 + y^2 + z^2$$

Consider the motion of molecules along x-axis to be elastic and the walls remain stationary, on rebounding, on the sign component of velocity changes. The resulting changes of momentum in the x-direction (Δp_x) is given by,

$$\Delta p_x = m\,\{u - (-u)\} = 2mu$$

Immediately, after the collision, the molecule takes time equal to l/u to collide with the opposite wall (and time equal to 2l/u to strike against the same wall). Hence, the frequency of collision on the two opposite walls is given by u/l and the change in momentum is given by

$$\frac{\Delta p_x}{\Delta p_y} = \frac{2mu}{l}.u = \frac{2mu^2}{l}$$

The total change in momentum is given by (single molecule per unit time arising from collisions on all six walls):

$$\frac{\Delta p}{\Delta t} = \frac{2mu^2}{l} + \frac{2mv^2}{l} + \frac{2mw^2}{l} = \frac{2m}{l}(u^2 + v^2 + w^2) = \frac{2mc^2}{l}$$

The total change in momentum of a single molecule per unit time arising from collisions on all the six walls is as given above.

However, the total change in momentum per unit time for all the N molecules of container is obtained by summing the contributions of all the molecules. Thus,

$$\frac{\Delta y}{\Delta x} = \sum_{i=1}^{N} \frac{2m{c_i}^2}{l} = \frac{2m}{l} \sum_{i=1}^{N} c_i^2$$