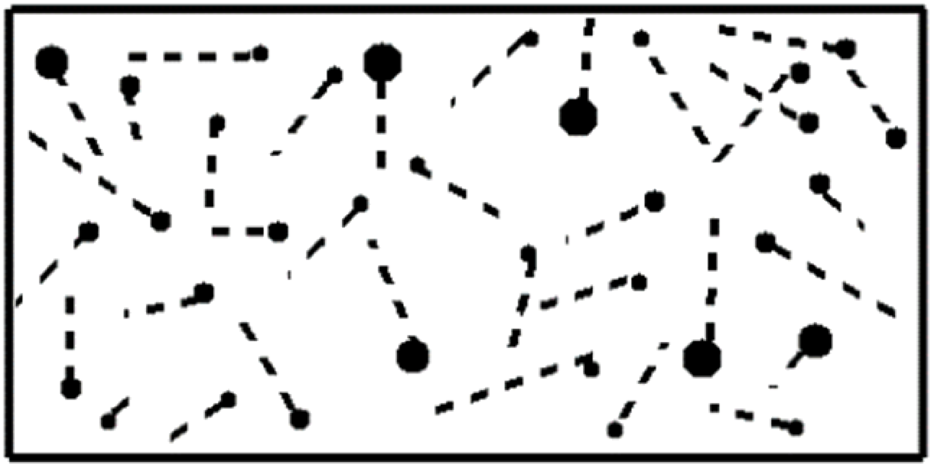
FlexiPrep

Kinetic Theory of Gases: Details of Kinetic Theory of Gases, Assumptions of Kinetic Theory (For CBSE, ICSE, IAS, NET, NRA 2022)



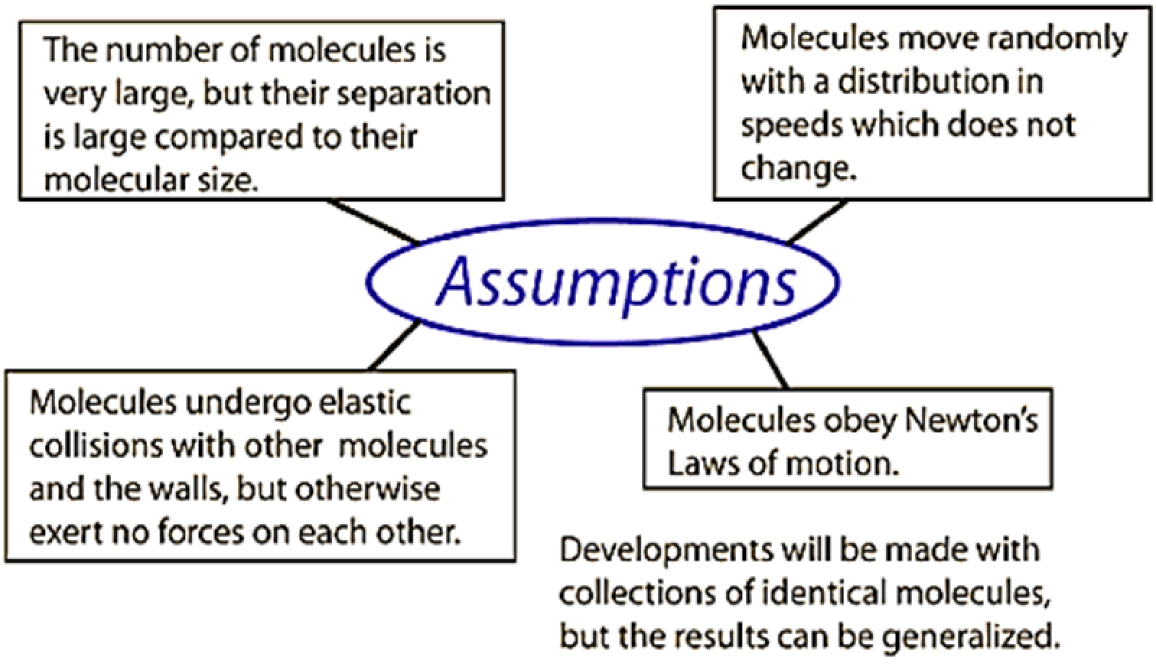
- Gases can be studied by considering the small-scale action of individual molecules or by considering the large-scale action of the gas.
- One can directly measure, or sense, the large-scale action of the gas. But to study the action of the molecules, one must use a theoretical model.
- This model, called the kinetic theory of gases, assumes that the molecules are very small relative to the distance between molecules.
- Kinetic theory of gases relates the macroscopic property of the gas, like – Temperature, Pressure, Volume to the microscopic property of the gas, like – speed, momentum, position.
- The molecules are in constant, random motion and frequently collide with each other and with the walls of any container.
- In this model, the atoms and molecules are continually in random motion, constantly colliding one another as shown in the figure and the walls of the container within which the gas is enclosed.
- It is this motion that results in physical properties such as heat and pressure.

Details of Kinetic Theory of Gases

- The British scientist James Clerk Maxwell and the Austrian physicist Ludwig Boltzmann, in the 19^{th} century, led in establishing the theory, which became one of the most important concepts in science.
- In this model the gases are made up of many molecules and they are flying in a random direction with a certain speed.
- By knowing their speed or position, one can figure out the macroscopic properties. In other words, by knowing the value of velocity or internal energy of gas molecules, one should be able to figure out the temperature or pressure.

- Such a model describes a perfect gas and is a reasonable approximation to a real gas, particularly in the limit of extreme dilution and high temperature. Such a simplified description, however, is not sufficiently precise to account for the behavior of gases at high densities.

Assumptions of Kinetic Theory



Derivation of Kinetic Theory of Gases

- Consider a cubic box of length l filled with the gas molecule of mass m , moving along the x-axis with velocity v_x Therefore its momentum is mv_x .
- The gas molecules collide the walls. At wall 1 , it collides and the gains momentum mv_x .
- Similarly, the molecules collide wall 2 , reversing the momentum i.e.. , $-\mathrm{mv}_x$
- Thus, the change in the momentum is given by

  $$\Delta p = \mathrm{mv}_x - (-\mathrm{mv}_x) = 2\,\mathrm{mv}_x --(1)$$

- After the collision, the molecule travels a distance of $2l$ before colliding again with wall 1 .
- Thus, the time taken is given by

  $$\text{Time} = \frac{2l}{v_x} \cdots (2)$$

- These continuous collisions carry a force, given by

$$\text{force} = \frac{\Delta P}{\Delta T} \cdots (3)$$

- Thus, substituting the values from equation (1) and (2) , we get
- The continuous collisions also exert pressure on the wall given by and as we know that the gas is made of N number of molecules and move in all possible directions. Thus, the pressure exerted on wall 1 by the collision of N number of gas molecules is given by-

The Equation of Force and Pressure