Molecular kinetic theory model

Derivation of kinetic theory equation

1. Initial momentum of a gas particle is mv
   Momentum after contact with the container wall is -mv

   Δmomentum = 2mv

2. Time between collisions: $v = \frac{s}{t} = \frac{2l_1}{t}$

   Time between collisions, $t = \frac{2l_1}{v}$

3. Newton's second law:

$$F = \frac{\Delta mv}{\Delta t} = 2mv \times \frac{v}{2l_1} = \frac{mv^2}{l_1}$$

4. Pressure:

$$p = \frac{F}{A} = \frac{mv^2}{l_1} \times \frac{1}{l_2 l_3} = \frac{mv^2}{l_1 l_2 l_3} = \frac{mv^2}{V}$$

5. However, there are **many** gas particles:

$$p = \frac{mv_1^2}{V} + \frac{mv_2^2}{V} + \frac{mv_3^2}{V} \ldots + \frac{mv_n^2}{V}$$

$$p = \frac{m}{V}(v_1^2 + v_2^2 + v_3^2 \ldots + v_n^2)$$

   Need to use an average:

   average v, $(c_{RMS})^2 = \frac{v_1^2 + v_2^2 + v_3^2 \ldots v_n^2}{n}$

$$n(c_{RMS})^2 = v_1^2 + v_2^2 + v_3^2 \ldots v_n^2$$

   ∴ overall: $p = \frac{mn(c_{RMS})^2}{V}$

6. However, particles do not just move in one plane ∴ we are dealing with a component in one of three planes - a third of the total magnitude.

$$p = \frac{mn(c_{RMS})^2}{3V}$$

∴

7. $mn =$ total mass, M:

$$p = \frac{M(c_{RMS})^2}{3V}$$

$$p = \frac{M}{V}$$

$$\therefore p = \frac{1}{3}p(c_{RMS})^2$$

Molecules and kinetic energy

For an ideal gas its internal energy is due only to the kinetic energy of the molecules of the gas.

Kinetic energy of a molecule $= \frac{total\ E_k\ of\ all\ the\ molecules}{total\ number\ of\ molecules} = \frac{\frac{1}{2}m(c_1^2 + c_2^2 \ldots c_N^2)}{N} = \frac{1}{2}m(c_{RMS})^2$

The higher the temperature of a gas the greater the mean kinetic energy of a molecule of the gas.

for an ideal gas, mean E_k of a molecule $= \frac{3}{2}kT$

total E_k of n mol of ideal gas $= \frac{3}{2}nRT =$ (internal energy)