

Chem11 The Kinetic Theory of Gases :

Notes/W.S. - 15

General Characteristics of Gases.

- 1) **Expansion** : Gases expand to fill the container they are in. They have no shape.
- 2) **Compressibility** : Gases can be compressed.
- 3) **Pressure** : All gases exert pressure.
- 4) **Low density** : All gases have a low density.
- 5) **Diffusion** : Two or more gases will mix rapidly and uniformly when placed in contact with each other.
- 6) **Ideal Gas Law** : In general, gases obey the ideal gas law ;
 $PV = nRT$.

The Kinetic Molecular Theory

This theory came about in an attempt to explain the above characteristics of gases. The theory states that particles of a gas act like billiard balls moving on a billiard table. The following assumptions are made :

- 1) Gases are composed of small particles (atoms or molecules) that are far apart in relation to their size.
- 2) There is no attractive force between the particles.
- 3) The particles are in constant, rapid, straight line motion until colliding with each other or the walls of the container. A force is exerted when the particles collide with the walls of the container. This force (per unit area) is the **pressure** of the gas.
- 4) There is no energy lost in collisions. That is, the collisions are "elastic".
- 5) The Kelvin **temperature** of the gas is proportional to the average kinetic energy of the particles. Particles move faster when the gas is heated.

The above theory works well unless the temperature is very low and/or the pressure is very high. Also, in reality, gas particles do exert small attractive forces on each other and so can become liquids at low temperatures.

Problems :

- 1) Give six characteristics of gases.
- 2) State the five main points of the Kinetic Theory of Gases.
- 3)a) The Kelvin temperature is proportional to the average _____ of the particles of the gas.
b) The pressure of a gas arises from the _____ of the particles of the gas with the walls of the container.
- 4) Use the K.M.T. to explain the following, in your own words.
 - i) Gases have a low density when compared to liquids and solids.
 - ii) Gases can be compressed.
 - iii) Perfume from a perfume bottle can be smelled from a distance quite soon after the bottle is opened.
 - iv) If we increase the volume of a container of gas, but keep the number of moles constant, the pressure decreases. Assume T is constant.
 - v) If the number of particles in a container increases, the pressure increases. (assume T and V are constant)
 - vi) If we have a container of gas (constant volume), the pressure increases if we heat the gas.
- 5) Suppose we have a container with one mole of NH_3 at 0.0°C and 1.0 atm. of pressure. The average molecular speed is 6.3×10^4 cm/s. The number of collisions per second for each molecule is about 1.0×10^9 .
 - a) Find the average distance a molecule travels between collisions.
 - b) If the volume of a molecule in the above question is 3.3×10^{-23} cm^3 , show that the percentage of empty space in the container is about 99.9%. (One mole of any gas occupies 22.4 L)

Answers : 1) see text, 2) see text, 3)a) kinetic energy, b) collisions, 4)i) molecules are far apart, ii) same as i), gases are mostly empty space, iii) gases diffuse and mix rapidly, iv) molecules will move at the

same speed but there will be less collisions per unit time with the container walls because the container is larger, v) there will be more collisions per unit time with the walls of the container, vi) particles move faster so there are more collisions with the container walls per unit time. 5)a) 6.3×10^{-5} cm, b) The total volume of gas = 22.4 L = 22,400 cm³. The total volume of molecules = $6.02 \times 10^{23} \times 3.3 \times 10^{-23}$ = 20. cm³. This volume is less than 0.1 % of the total volume.