Lab. 5: Diffusion

Diffusion defined as a movement and transport of (gas or liquid or solid) molecule in limited direction in which eventuate increases in molecule number at this direction. Is the process by which molecules spread from areas of high concentration, to areas of low concentration. When the molecules are even throughout a space - it is called Equilibrium. Molecules are in a constant state of motion. If, for example, NaCl is dissolved in water so that the NaCl molecules have a completely even and random distribution throughout the water, then there will be no net movement of NaCl in any direction. If however, the NaCl concentration is initially higher in one part of the water than another, diffusion will occur so that there is a net movement of NaCl from the area of high concentration to an area of lower concentration.

Factor which affect on diffusion rate:

1. R $\propto$ 1/**f**riction -------------- **Diffusion rate** (r) change conversely with friction force.
2. R $\propto$ C ---------------------- **Diffusion rate** (r) change correspondently with friction force.

3. **Diffusion rate** (r) depend on area which pass distributed material through it, also depend on distance modest between two regions, and this relationship discussed by flick's first law.

S/t = Da C1 – C2 /x   S= distributed matter quantity by mole , t = time in seconds

S/t = number of material mole distributed by time = diffusion rate

Da= diffusion

C1 = high concentration mole/litter C2 = low concentration mole/litter

X= distance between C1, C2

C1 – C2 /x are concentration gradient.

4. **Diffusion rate** (r) $\propto$ 1/atom size or 1/molecular weight (molecule and atomic weight).

5. In the case of gas present the graham law used. Also known as **Graham's law of diffusion** was formulated by Scottish physical chemist, Thomas Graham. Graham found experimentally that the rate of effusion of a gas is inversely proportional to the square root of the mass of its particles. This formula can be written as:

$$\frac{\mathrm{Rate}_1}{\mathrm{Rate}_2} = \sqrt{\frac{M_2}{M_1}}$$

Where:

Rate$_1$ is the rate of effusion of the first gas.

Rate$_2$ is the rate of effusion for the second gas.

M_1 is the molar mass of gas 1

M_2 is the molar mass of gas 2.

Example:

Let gas 1 be H_2 and gas 2 be O_2.

$$\frac{\text{Rate } H_2}{\text{Rate } O_2} = \frac{\sqrt{32}}{\sqrt{2}} = \frac{\sqrt{16}}{\sqrt{1}} = \frac{4}{1}$$

Therefore, hydrogen molecules effuse four times as fast as those of oxygen.

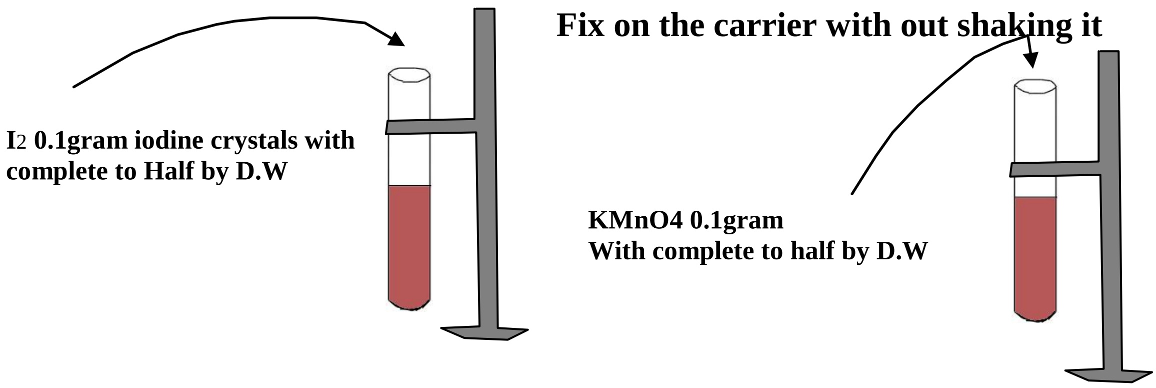
6. R $\propto$ temp --------- **Diffusion rate** (r) change conversely with temperature. (Causes of increases of movement force)
7. R $\propto$ 1/C ------------- **Diffusion rate** (r) change correspondently with concentration of solvent.
8. R $\propto$ change correspondently with solubility of distributed material in distribution media.

Importance of diffusion for plants

The plant body composed of a series element, these elements enters the plant body as (positive and negative) ion form, or as atoms and molecule form, some of them by the vegetative part through the pores, and chunk of cuticle example (O2 ,CO2 , SO2), and some of them such as water and positive and negative ions of mineral diffuse through the root hair from the soil solution then transporting to other parts of plant body, the plant loss some of them through vegetative organ such leaves to the external environment, for example (water loss) through vegetative as liquid form or water vapor, and also O2, CO2….atc.

Diffusion of solid material

The diffusion rate of solid material depends on their solubility in the medium which present in it. (Speed of distribution increase by increasing the solubility of solid material in media and in reverse case is true.). Also, it depends on the size and mass of the particles themselves. (Small particle size diffusion is faster, and in reverse case it is true).
We can able to use I_2 and KMnO4 0.1 gram to show this:



Note the diffusion of this two matter. Color change after some time 10- 20 – 30 -40 minute. Which of chemical faster diffused why?
$KMnO_4$ faster diffused than I_2 because:

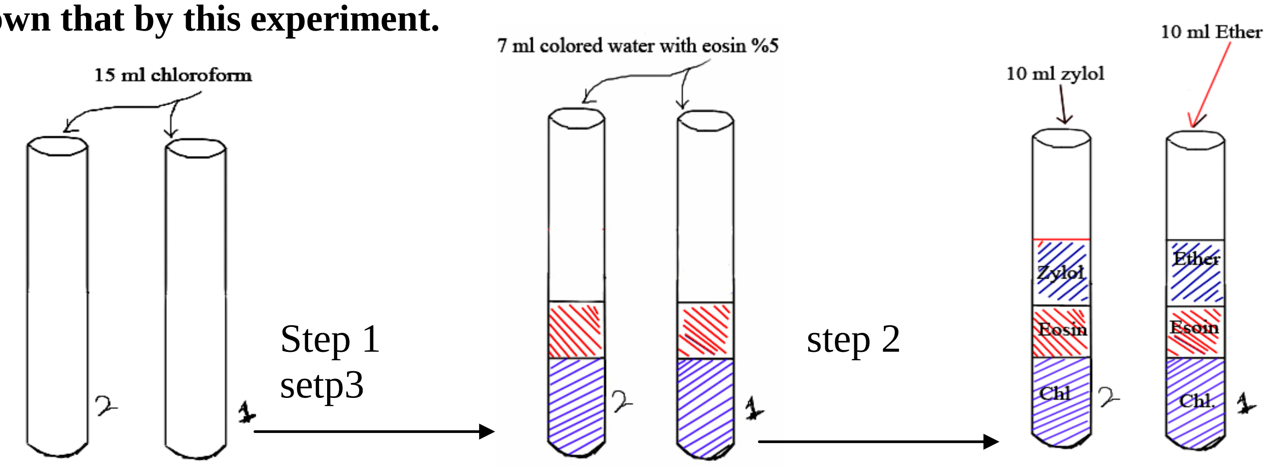
1. Solubility of it more than I_2 in water (distribution media)
2. Size of its particle less than I_2 Particle.
3. Molecular Weight of it less than I_2.

I_2 = 2*127=254 $KMnO_4$=39+55+16*4=158

Liquid diffusion

The diffusion average of liquid organic material such as ether, zylol and chloroform depends on their solubility range in water membrane (distribution media) which is disuniting them. Whatever the increases of organic material solubility, and its mixing with water higher, the diffusion average are increases. (In reverse cases are true).

Shown that by this experiment.



- Close the lip of test tube and put it on carrier, leave it to the next week, and symbol it between colored water layer (upper and bottom).
- Notice the colored water layer in test tube 1 in which the level was increased but in tube 2 decreased. In **tube 1** the ether diffuses through water layer faster than chloroform so cause to increase of solution volume under water layer and exert increases of water level. In tube **2** chloroform diffuse faster than zylol, so cause to decreases of chloroform volume after that causes to decreases of water level.
- So we concluded that ether diffuse faster than other three materials in water, followed by chloroform and zylol. Solubility of ether in water> chloroform> zylol.

Gases diffusion

Difference type of gases diffuses by different equation either under same atmosphere factors. Diffusion rate of different gases change reversal with its density square. Density of gases means the weight of state volume of gases toward to the same volume in hydrogen gases or it is the ratio between the molecular weight of gases and molecular weight of hydrogen.

White ring

Effects of molecular weight on the rate of diffusion

Soak a cotton plug with HCl and another with NH4OH. Both plugs will be inserted simultaneously into opposite ends of a large glass tube and the ends will be capped with rubber stoppers. Note the time of insertion.

Ammonium hydroxide (NH4OH) dissociates into ammonia (NH3, a gas) and water. Ammonia diffuses toward the opposite end of the tube. At the same time, hydrochloric acid vapors (HCl) diffuse toward the ammonia. When the two gases meet, they react to form a white ring (ammonium chloride) around the glass tubing. Record the time at which the white ring is first seen. The overall reaction is:

$NH_4OH + HCl$ --------> $NH_4Cl + H_2O$

Measure the distance to the white ring from the front edge of each of the cotton plugs (d1 and d2). Which gas traveled faster? And why?
The diffusion rate (*r*) of a molecule is inversely related to the square root of its molecular weight (*MW*),

$$r = \frac{1}{\sqrt{MW}}$$

and the ratio of the distances traveled by NH3 (*d*1) and HCl (*d*2) should be close to the ratio of the diffusion rates:

$$\frac{r_1 = 1/\sqrt{MW_1}}{r_2 = 1/\sqrt{MW_2}} = \frac{r_1}{r_2} \propto \frac{d_1}{d_2}$$

Calculate the ratio of diffusion rates from the molecular weights. The molecular weight of ammonia gas (NH3) is 17; the molecular weight of hydrogen chloride gas (HCl) is 36.