Hello everyone. Myself doctor Sachin B. Kakodkar, Assistant Professor from Parvatibai Chowgule College of Arts and Science, Autonomous. Today I'll be covering Bachelor of Science, second year, Chemistry Semester 3 paper CHC 103 that is Physical Chemistry and Organic Chemistry. I'll be taking up the Unit one that is Solutions, module number 3, under which I'll be covering Ideal solutions and Raoult's Law.

The outline of the topic is Raoult's Law, Derivation of Raoult's Law, and ideal solutions and their characteristics.

The Learning Outcomes of this topic is that after learning the topic, the student will be able to understand Raoult's Law, derive Raoult's Law and explain the characteristics of ideal solutions.

## Raoult's Law

The vapor pressure of a component in solution at a given temperature is equal to the product of mole fraction of that component in solution multiplied by the vapor pressure of that component in pure state. So if $x_i$ the more fraction of that component and $p^o$ is the vapor pressure in pure state, then the pressure is given as $x_i$ multiplied by $p^o$.

For a binary solution,

Vapour pressure of the solvent in solution is equal to the product of mole fraction of solvent in solution and vapour pressure of pure solvent.

Similar equation can be written for a solute if it is volatile.

Now when we add another volatile solute to solvent, there is no contribution from the salute to the total vapor pressure. So vapour pressure of such solutions is given as mole fraction of solvent in solution multiplied by vapour pressure of pure solvent.

## Lowering of Vapour Pressure: Raoult's Law

The vapour pressure of a pure solvent is decreased when a non-volatile solute is dissolved in it. If **p** is the vapour pressure of the solvent and **$p_s$** that of the solution, the lowering of vapour pressure is **p minus $p_s$**. This lowering of vapour pressure relative to the vapour pressure of the pure solvent is termed the Relative lowering of Vapour pressure. Relative Lowering of Vapour Pressure is equal to p minus $p_s$ divided by p.

Raoult in the year 1886 gave an empirical relation connecting the relative lowering of vapour pressure and the concentration of the solute in solution. This is referred to as the Raoult's Law which states that 'the relative lowering of the vapour pressure of a dilute solution is equal to the mole fraction of the solute present in dilute solution'.

**Mathematical expression of Raoult’s Law:**

p minus $p_s$ divided by p is equal to n divided by n plus N. where small n stands for the number of moles of solute and capital N stands for the number of moles of solvent.

Now coming to the derivation of Raoult’s Law, we know that vapor pressure of pure solvent is due to number of molecules evaporating from its surface. So when a non-volatile solute is added to the solvent to make the solution, the solute molecules on the surface block a fraction of the surface. Hence there is no evaporation. This results in lowering of vapour pressure. Thus the vapour pressure of the solution is determined by the number of molecules of solvent present at any time on the surface, which is proportional to the mole fraction of solvent.

If you look at this diagram, in the case of pure solvent, there are more number of molecules escaping from the surface, whereas in the solution with anon-volatile solute, the solute molecules on the surface block a fraction of solvent molecules. That's why there are less number of molecules evaporating from the surface. The vapor pressure of solution is less than the vapour pressure of pure solvent.

So $p_s$ will be proportional to N divided by N plus n, which is the mole fraction of the solvent, where capital N stands for moles of solute whereas small n stands for moles of solute. So we introduce a proportionality factor k. In case of pure solvent small n is equal to zero. Therefore, p is equal to k. Thus the vapor pressure of solvent (p) is equal to proportionality factor k. Now coming to $p_{s,}$ when we substitute this in equation for $p_s$, we find that, p minus $p_s$ divided by $p_s$ is equal to n divided by n plus N, which is the Raoult’s Law that is relative lowering of vapor pressure is equal to the mole fraction of solute.

**Ideal solutions**

These are solutions which obey Raoult’s law at every range of concentration and at all temperatures. They are obtained by mixing two ideal components, that is solute and a solvent having similar size and structure. So if you mix two liquids A and B, then solution will experience three different kinds of intermolecular forces of attraction inside it. There is A-A, B-B and A-B. Now ideal solution will be one in which the intermolecular forces of attraction between A-A, B-B and A-b are nearly equal.

So coming to characteristics of ideal solutions:

They follow Raoult’s Law at every range of concentration and temperatures.

Enthalpy of mixing of two components is equal to zero, that is, Delta H mixing is equal to zero.

Volume of mixing is equal to zero, that is, Delta V mixing is equal to zero.

And most importantly the solute-solute interaction and solvent-solvent interaction is almost similar to that of solute-solvent interaction.

### Examples of ideal solutions

n-hexane and n-heptane

Bromoethane and Chloroethane

Benzene and Toluene

$CCl_4$ and $SiCl_4$

Chlorobenzene and Bromobenzene

Ethyl Bromide and Ethyl Iodide

n-Butyl Chloride and n-Butyl Bromide

The references that I have quoted is

A. Bahl, B. S. Bahl and G. D. Tuli, Essentials of Physical Chemistry, S. Chand Publications, 26th edition 2009

https://www.toppr.com/guides/chemistry/solutions/ideal-and-non-ideal-solutions/

Thank you.