Nernst Distribution law:-

A solute having same molecular state in two immiscible or slightly miscible liquids distributes itself between the two adjacent layers in such a way that at constant temperature its ratio of the concentration of the solute in two layers is constant and is independent of amount of solute and the liquids.

If c_1 & c_2 are the concentration of solute in the layers-1 & 2 respectively then at constant temperature -

$$\frac{c_1}{c_2} = \text{constant.}$$

$$\text{i.e. } \frac{c_1}{c_2} = K$$

Where, K is called distribution coefficient or partition coefficient.

When the two liquids are saturated with the solutes then c_1 & c_2 become equal to the solubilities S_1 & S_2 of the two solutes in the two layers.

Hence,

$$K = S_1/S_2 = c_1/c_2.$$

* Thermodynamic derivation of distribution law:-

Distribution law may be derived thermodynamically by means of the rule that chemical potential of any substance remains the same in two phase in equilibria.

Let μ_1 & μ_2 are the chemical potential of solute in the layers 1 & 2 respectively then,

In the layer-1, $\mu_1 = \mu_1^\circ + RT \ln a_1$

& In the layer-2, $\mu_2 = \mu_2^\circ + RT \ln a_2$

Where, a_1 and a_2 are the activity of the solute in the layers 1 & 2 and μ_1° and μ_2° are their standard chemical potential respectively.

Since, two phases are in equilibrium. so,

$$\mu_1 = \mu_2$$

$$\therefore \quad \mu_1^\circ + RT \ln a_1 = \mu_2^\circ + RT \ln a_2$$

or $$RT \ln a_1 - RT \ln a_2 = \mu_2^\circ - \mu_1^\circ$$

or $$RT \left(\ln \frac{a_1}{a_2} \right) = \mu_2^\circ - \mu_1^\circ$$

or $$\ln \frac{a_1}{a_2} = \frac{\mu_2^\circ - \mu_1^\circ}{RT}$$

or $$\frac{a_1}{a_2} = \exp \left(\frac{\mu_2^\circ - \mu_1^\circ}{RT} \right)$$

At a given temperature —

$$\exp \left(\frac{\mu_2^\circ - \mu_1^\circ}{RT} \right) = \text{constant.}$$

$$\therefore \quad \frac{a_1}{a_2} = \text{Constant.}$$

Since, $a = f \cdot C$

Where,

C = Concentration f = activity coefficient.

$$a_1 = f_1 \cdot c_1$$

& $$a_2 = f_2 \cdot c_2$$

$$\therefore \frac{f_1 c_1}{f_2 c_2} = \text{Constant}$$

for dilute solution

$$f_1 = f_2 = \cdots\cdots = 1.$$

$$\therefore \boxed{\frac{c_1}{c_2} = \text{Constant.}}$$

which is Nernst Distribution law.

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