Solutions:

Nernst Distribution Law Application in solvent Extraction.

In this dissolved solute in one solvent is extracted with the help of another solvent. When a solution containing the solute is shaken with another immiscible solvent the solute distributes between 2 solutions. From second solvent, the solute can be separated by distillation, evaporation etc.

Let m_0 be mass of solute present in volume V_1 of solvent 1.

Let V_2 volume of solvent 2 is added each time till entire solvent 2 is exhausted

If solvent 2 is added 'n' times then

Total volume of solvent 2 used for extraction $= nV_2$

If 'm_1' is mass of solute which remains unextracted in the solvent 1 after the addition of first lot of V_2 of the solvent 2

$$\frac{C_1}{C_2} = \frac{m_1/V_1}{(m - m_1)/V_2} = K_d$$

$$\frac{m_1}{V_1} = Kd\left(\frac{m - m_1}{V_2}\right)$$

$$= \frac{Kd}{V_2} m - \frac{Kd\, m_1}{V_2}$$

$$\frac{m_1}{V_1} + \frac{Kd}{V_2} m_1 = \frac{Kd\, m}{V_2}$$

$$m_1\left(\frac{1}{V_1} + \frac{Kd}{V_2}\right) = \frac{Kd\, m}{V_2}$$

$$\frac{m_n}{m} = \left(\frac{K_d V_1}{K_d V_1 + V_2}\right)^n \quad \text{---(6)}$$

If extraction is carried out in a single stage by adding whole of the solvent in one lot

$$\frac{m'}{m} = \frac{K_d V_1}{K_d V_1 + V_2} \quad \text{---(7)}$$

To Compare whether multistage extraction is effective or single stage extraction

eq (6). Taking inverse

$$\frac{m}{m_n} = \left(\frac{K_d V_1 + V_2}{K_d V_1}\right)^n$$

$$= \left(1 + \frac{V_2}{K_d V_1}\right)^n$$

$$\frac{m}{m_n} = 1 + \frac{nV_2}{K_d V_1} + n(n-1)\left(\frac{V_2}{K_d V_1}\right)^2 + n(n-1)(n-2)\left(\frac{V_2}{K_d V_1}\right)^3 \quad \text{---(8)}$$

Inverse of eq (7)

$$\frac{m}{m'} = \frac{K_d V_1 + nV_2}{K_d V_1} = 1 + \frac{nV_2}{K_d V_1} \quad \text{---(9)}$$

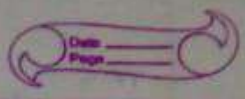
Substitute (9) in (8)

$$\frac{m}{m_n} = \frac{m}{m'} + n(n-1)\left(\frac{V_2}{K_d V_1}\right)^2 + \cdots$$

$$\frac{m}{m_n} > \frac{m}{m'} \quad \text{or} \quad m_n < m'$$

$\Rightarrow \frac{1}{m_n} > \frac{1}{m'}$ Amount of solute remaining unextracted in ten in multistage extraction

$$m_1\left(\frac{V_2 + V_1 K_d}{V_1 V_2}\right) = \frac{K_d m}{V_2}$$



$$m_1 = \frac{m K_d V_1}{(V_2 + V_2 K_d)} = \frac{K_d V_1 m}{(K_d V_1 + V_2)} \quad \text{---(1)}$$

If m_2 is mass of solute unextracted after addition of second lot

$$\frac{C_1'}{C_2'} = \frac{m_2/V_1}{(m_1 - m_2)/V_2} = K_d$$

$$\frac{m_2}{V_1} = K_d\left(\frac{m_1 - m_2}{V_2}\right)$$

$$\frac{m_2}{V_1} = \frac{K_d}{V_2} m_1 - \frac{m_2}{V_2} K_d$$

$$m_2\left(\frac{1}{V_1} + \frac{K_d}{V_2}\right) = \frac{K_d}{V_2} m_1$$

$$m_2\left(\frac{V_2 + V_1 K_d}{V_1 V_2}\right) = \frac{K_d}{V_2} m_1$$

$$m_2 = \left(\frac{V_1 K_d}{V_1 K_d + V_2}\right) m_1 \quad \text{---(2)}$$

Subs. value of m_1.

$$m_2 = \left(\frac{K_d V_1}{K_d V_1 + V_2}\right)^2 m \quad \text{---(3)}$$

Similarly if m_3 mass is left

$$m_3 = \left(\frac{K_d V_1}{K_d V_1 + V_2}\right)^3 m \quad \text{---(4)}$$

If n times then

$$m_n = \left(\frac{K_d V_1}{K_d V_1 + V_2}\right)^n m \quad \text{---(5)}$$

i.e. amount of extracted solute is larger in multistage extraction than single stage extraction. Hence M.S.E is more effective than single stage extraction.

But 100% of extraction of solute is never possible. However large no. of extractions may be done because, Something will always be left behind in the solution acc. distribution law.

K_d = ratio of solute in the solvent in which it is already present to that of extracting solvent