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Important Formulas in Liquid-Liquid Extraction

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List of 23 Important Formulas in Liquid-Liquid Extraction

Important Formulas in Liquid-Liquid Extraction

1) Distribution Coefficient of Carrier Liquid from Activity Coefficients

$$\text{fx } K_{\text{CarrierLiq}} = \frac{\gamma_{aR}}{\gamma_{aE}}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$\text{ex } 1.5 = \frac{1.8}{1.2}$$

2) Distribution Coefficient of Carrier Liquid from Mass Fraction

$$\text{fx } K_{\text{CarrierLiq}} = \frac{y_A}{x_A}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$\text{ex } 1.497778 = \frac{0.674}{0.45}$$


3) Distribution Coefficient of Solute from Activity Coefficient

$$\text{fx } K_{\text{Solute}} = \frac{\gamma_{cR}}{\gamma_{cE}}$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d_img.jpg\)](#)

$$\text{ex } 2.6 = \frac{4.16}{1.6}$$



4) Distribution Coefficient of Solute from Mass Fractions 

$$fx \quad K_{\text{Solute}} = \frac{y_C}{x_C}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)


$$ex \quad 2.723816 = \frac{0.3797}{0.1394}$$

5) Extraction Factor at Feed Point Slope of Equilibrium Curve 

$$fx \quad \varepsilon = m_F \cdot \frac{S'}{F'}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)


$$ex \quad 2.198773 = 3.721 \cdot \frac{65\text{kg/s}}{110\text{kg/s}}$$

6) Extraction Factor at Mean Slope of Equilibrium Curve 

$$fx \quad \varepsilon = m \cdot \frac{S'}{F'}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 2.199364 = 3.722 \cdot \frac{65\text{kg/s}}{110\text{kg/s}}$$

7) Extraction Factor based on Raffinate Point Slope 

$$fx \quad \varepsilon = m_R \cdot \frac{S'}{F'}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$ex \quad 2.199955 = 3.723 \cdot \frac{65\text{kg/s}}{110\text{kg/s}}$$




8) Feed Solute Concentration for N-number of Ideal Stage Extraction 

$$fx \quad z_C = \frac{X_N}{\left(\frac{F'}{F' + (E' \cdot K_{\text{Solute}})}\right)^N}$$

Open Calculator 

$$ex \quad 0.500538 = \frac{0.0334}{\left(\frac{110\text{kg/s}}{110\text{kg/s} + (62\text{kg/s} \cdot 2.6)}\right)^3}$$

9) Feed Solute Concentration for Single Ideal Stage Extraction 

$$fx \quad z_C = \frac{X_1}{\frac{F'}{F' + (E' \cdot K_{\text{Solute}})}}$$

Open Calculator 

$$ex \quad 0.499994 = \frac{0.2028}{\frac{110\text{kg/s}}{110\text{kg/s} + (62\text{kg/s} \cdot 2.6)}}$$

10) Geometric Mean of Equilibrium Line Slope 

$$fx \quad m = \sqrt{m_F \cdot m_R}$$

Open Calculator 

$$ex \quad 3.722 = \sqrt{3.721 \cdot 3.723}$$

11) Mass Ratio of Solute in Extract Phase 

$$fx \quad Y = \frac{y_C}{y_A + y_C}$$

Open Calculator 

$$ex \quad 0.360349 = \frac{0.3797}{0.674 + 0.3797}$$



12) Mass Ratio of Solute in Raffinate Phase

$$\text{fx } X = \frac{x_C}{x_A + x_C}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 0.236512 = \frac{0.1394}{0.45 + 0.1394}$$

13) Mass Ratio of Solvent in Extract Phase

$$\text{fx } Z = \frac{y_B}{y_A + y_C}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 0.408086 = \frac{0.43}{0.674 + 0.3797}$$

14) Mass Ratio of Solvent in Raffinate Phase

$$\text{fx } z = \frac{x_B}{x_A + x_C}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$\text{ex } 0.916186 = \frac{0.54}{0.45 + 0.1394}$$



15) Number of Extraction Stages by Kremser Equation 

fx

Open Calculator 

$$N = \frac{\log_{10} \left(\left(\frac{z_C - \left(\frac{y_s}{K_{\text{Solute}}} \right)}{\left(\frac{x_C - y_s}{K_{\text{Solute}}} \right)} \right) \cdot \left(1 - \left(\frac{1}{\epsilon} \right) \right) + \left(\frac{1}{\epsilon} \right) \right)}{\log_{10}(\epsilon)}$$

$$\text{ex } 2.650155 = \frac{\log_{10} \left(\left(\frac{0.5 - \left(\frac{0.05}{2.6} \right)}{\left(\frac{0.1394 - 0.05}{2.6} \right)} \right) \cdot \left(1 - \left(\frac{1}{2.2} \right) \right) + \left(\frac{1}{2.2} \right) \right)}{\log_{10}(2.2)}$$

16) Number of Ideal Equilibrium Extraction Stages 

fx

Open Calculator 

$$N = \frac{\log_{10} \left(\frac{z_C}{X_N} \right)}{\log_{10} \left(\left(\frac{K_{\text{Solute}} \cdot E'}{F'} \right) + 1 \right)}$$


$$\text{ex } 2.998807 = \frac{\log_{10} \left(\frac{0.5}{0.0334} \right)}{\log_{10} \left(\left(\frac{2.6 \cdot 62 \text{kg/s}}{110 \text{kg/s}} \right) + 1 \right)}$$



17) Number of Stages for Extraction Factor equal to 1 [Open Calculator](#) 


$$\text{fx } N = \left(\frac{z_C - \left(\frac{y_s}{K_{\text{Solute}}} \right)}{x_C - \left(\frac{y_s}{K_{\text{Solute}}} \right)} \right) - 1$$

$$\text{ex } 3.000768 = \left(\frac{0.5 - \left(\frac{0.05}{2.6} \right)}{0.1394 - \left(\frac{0.05}{2.6} \right)} \right) - 1$$

18) Raffinate Phase Solute Concentration for N Number of Ideal Stage Extraction [Open Calculator](#) 

$$\text{fx } X_N = \left(\left(\frac{F'}{F' + (E' \cdot K_{\text{Solute}})} \right)^N \right) \cdot z_C$$

$$\text{ex } 0.033364 = \left(\left(\frac{110\text{kg/s}}{110\text{kg/s} + (62\text{kg/s} \cdot 2.6)} \right)^3 \right) \cdot 0.5$$

19) Raffinate Phase Solute Concentration for Single Ideal Stage Extraction [Open Calculator](#) 

$$\text{fx } X_1 = \left(\frac{F'}{F' + (E' \cdot K_{\text{Solute}})} \right) \cdot z_C$$

$$\text{ex } 0.202802 = \left(\frac{110\text{kg/s}}{110\text{kg/s} + (62\text{kg/s} \cdot 2.6)} \right) \cdot 0.5$$



20) Recovery of Solute in Liquid-Liquid Extraction

$$fx \quad R_{\text{solute}} = 1 - \left(\frac{x_C \cdot R}{z_C \cdot F} \right)$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$ex \quad 0.88848 = 1 - \left(\frac{0.1394 \cdot 40 \text{mol/s}}{0.5 \cdot 100 \text{mol/s}} \right)$$

21) Selectivity of Solute based on Distribution Coefficients

$$fx \quad \beta_{C, A} = \frac{K_{\text{Solute}}}{K_{\text{CarrierLiq}}}$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$ex \quad 1.733333 = \frac{2.6}{1.5}$$

22) Selectivity of Solute based on Activity Coefficients

$$fx \quad \beta_{C, A} = \frac{\frac{\gamma_{CR}}{\gamma_{CE}}}{\frac{\gamma_{aR}}{\gamma_{aE}}}$$

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

$$ex \quad 1.733333 = \frac{\frac{4.16}{1.6}}{\frac{1.8}{1.2}}$$



23) Selectivity of Solute based on Mole Fractions

[Open Calculator !\[\]\(666e09182d4cd268646ea700ea60dcdf_img.jpg\)](#)

$$\text{fx } \beta_{C, A} = \frac{\frac{y_C}{y_A}}{\frac{x_C}{x_A}}$$

$$\text{ex } 1.818572 = \frac{\frac{0.3797}{0.674}}{\frac{0.1394}{0.45}}$$



Variables Used



- **E'** Solute Free Extract Phase Flowrate in LLE (*Kilogram per Second*)
- **F** Feed Flowrate in Liquid-Liquid Extraction (*Mole per Second*)
- **F'** Solute Free Feed Flowrate in Extraction (*Kilogram per Second*)
- **K_{CarrierLiq}** Distribution Coefficient of Carrier Liquid
- **K_{Solute}** Distribution Coefficient of Solute
- **m** Mean Slope of Equilibrium Curve
- **m_F** Feed Point Slope of Equilibrium Curve
- **m_R** Raffinate Point Slope of Equilibrium Curve
- **N** Number of Equilibrium Extraction Stages
- **R** Raffinate Phase Flowrate in LLE (*Mole per Second*)
- **R_{solute}** Recovery of Solute in Liquid-Liquid Extraction
- **S'** Solute Free Solvent Flowrate in Extraction (*Kilogram per Second*)
- **X** Mass Ratio of Solute in Raffinate Phase
- **X₁** Single Stage Mass Fraction of Solute in Raffinate
- **x_A** Mass Fraction of Carrier Liquid in the Raffinate
- **x_B** Mass Fraction of Solvent in the Raffinate
- **x_C** Mass Fraction of Solute in the Raffinate
- **X_N** N Stages Mass Fraction of Solute in Raffinate
- **Y** Mass Ratio of Solute in Extract Phase
- **y_A** Mass Fraction of Carrier Liquid in the Extract
- **y_B** Mass Fraction of Solvent in the Extract
- **y_C** Mass Fraction of Solute in the Extract



- y_S Mass Fraction of Solute in the Solvent
- z Mass Ratio of Solvent in Raffinate Phase
- Z Mass Ratio of Solvent in Extract Phase
- z_C Mass Fraction of Solute in the Feed
- $\beta_{C, A}$ Selectivity
- ϵ Extraction Factor
- Y_{aE} Activity Coefficient of Carrier Liquid in Extract
- Y_{aR} Activity Coefficient of Carrier Liq in Raffinate
- Y_{cE} Activity Coefficient of Solute in Extract
- Y_{cR} Activity Coefficient of Solute in Raffinate



Constants, Functions, Measurements used

- **Function:** **log10**, $\log_{10}(\text{Number})$
Common logarithm function (base 10)
- **Function:** **sqrt**, $\sqrt{\text{Number}}$
Square root function
- **Measurement:** **Mass Flow Rate** in Kilogram per Second (kg/s)
Mass Flow Rate Unit Conversion 
- **Measurement:** **Molar Flow Rate** in Mole per Second (mol/s)
Molar Flow Rate Unit Conversion 



Check other formula lists

- **Distribution Coefficient, Selectivity & Mass Ratio Formulas** 
- **Equilibrium Stage Calculations for Immiscible (Pure) Solvent &**
- **Carrier Liquid Formulas** 
- **Important Formulas in Liquid-Liquid Extraction** 
- **Kremser's Equation for Liquid-Liquid Extraction Formulas** 

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