Important Formulas in Liquid-Liquid Extraction PDF

Formulas
Examples
with Units

List of 23
Important Formulas in Liquid-Liquid Extraction

1) Distribution Coefficient of Carrier Liquid from Activity Coefficients Formula

Evaluate Formula

Formula

$$K_{CarrierLiq} = \frac{Ya_R}{Ya_E}$$

Example

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

2) Distribution Coefficient of Carrier Liquid from Mass Fraction Formula

Evaluate Formula

Formula

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

Example

$$1.4978 = \frac{0.674}{0.45}$$

3) Distribution Coefficient of Solute from Activity Coefficient Formula

Evaluate Formula

Formula

$$K_{Solute} = \frac{Yc_R}{Yc_E}$$

Example

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

4) Distribution Coefficient of Solute from Mass Fractions Formula

Evaluate Formula

Formula

$$K_{Solute} = \frac{y_C}{x_C}$$

Example

$$2.7238 = \frac{0.3797}{0.1394}$$

5) Extraction Factor at Feed Point Slope of Equilibrium Curve Formula

Evaluate Formula

Formula

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

Example with Units

$$2.1988 = 3.721 \cdot \frac{65\,\text{kg/s}}{110\,\text{kg/s}}$$

6) Extraction Factor at Mean Slope of Equilibrium Curve Formula

Evaluate Formula

Formula

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

Example with Units

$$2.1994 = 3.722 \cdot \frac{65\,\text{kg/s}}{110\,\text{kg/s}}$$

7) Extraction Factor based on Raffinate Point Slope Formula

Evaluate Formula

Formula

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

Example with Units

$$2.2 = 3.723 \cdot \frac{65\,\text{kg/s}}{110\,\text{kg/s}}$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.5005 = \frac{0.0334}{\left(\frac{110\,\text{kg/s}}{110\,\text{kg/s} + \left(62\,\text{kg/s} \cdot 2.6\right)}\right)^3}$$

9) Feed Solute Concentration for Single Ideal Stage Extraction Formula

Evaluate Formula

Formula

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

Example with Units

$$0.5 = \frac{0.2028}{\frac{110\,\text{kg/s}}{110\,\text{kg/s} + \left(62\,\text{kg/s} \cdot 2.6\right)}}$$

10) Geometric Mean of Equilibrium Line Slope Formula

Evaluate Formula

Formula

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

Example

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

11) Mass Ratio of Solute in Extract Phase Formula

Evaluate Formula

Formula

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

Example

$$0.3603 = \frac{0.3797}{0.674 + 0.3797}$$

12) Mass Ratio of Solute in Raffinate Phase Formula

Evaluate Formula

Formula

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

Example

$$0.2365 = \frac{0.1394}{0.45 + 0.1394}$$

13) Mass Ratio of Solvent in Extract Phase Formula

Evaluate Formula

Formula

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

Example

$$0.4081 = \frac{0.43}{0.674 + 0.3797}$$

14) Mass Ratio of Solvent in Raffinate Phase Formula

Evaluate Formula

Formula

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

Example

$$0.9162 = \frac{0.54}{0.45 + 0.1394}$$

15) Number of Extraction Stages by Kremser Equation Formula

Evaluate Formula

Formula

$$N = \frac{\log10\left(\left(\frac{z_C - \left(\frac{y_s}{K_{Solute}}\right)}{\left(\frac{x_C - y_s}{K_{Solute}}\right)}\right) \cdot \left(1 - \left(\frac{1}{\varepsilon}\right)\right) + \left(\frac{1}{\varepsilon}\right)\right)}{\log10\left(\varepsilon\right)}$$

Example

$$2.6502 = \frac{\log10\left(\left(\frac{0.5 - \left(\frac{0.05}{2.6}\right)}{\left(\frac{0.1394 - 0.05}{2.6}\right)}\right) \cdot \left(1 - \left(\frac{1}{2.2}\right)\right) + \left(\frac{1}{2.2}\right)\right)}{\log10\left(2.2\right)}$$

16) Number of Ideal Equilibrium Extraction Stages Formula

Evaluate Formula

Formula

$$N = \frac{\log10\left(\frac{z_C}{X_N}\right)}{\log10\left(\left(\frac{K_{Solute} \cdot E'}{F'}\right) + 1\right)}$$

Example with Units

$$2.9988 = \frac{\log10\left(\frac{0.5}{0.0334}\right)}{\log10\left(\left(\frac{2.6 \cdot 62\,\text{kg/s}}{110\,\text{kg/s}}\right) + 1\right)}$$

17) Number of Stages for Extraction Factor equal to 1 Formula

Evaluate Formula

Formula

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

Example

$$3.0008 = \left(\frac{0.5 - \left(\frac{0.05}{2.6}\right)}{0.1394 - \left(\frac{0.05}{2.6}\right)}\right) - 1$$

18) Raffinate Phase Solute Concentration for N Number of Ideal Stage Extraction Formula

Evaluate Formula

Formula

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

Example with Units

$$0.0334 = \left(\left(\frac{110\,\text{kg/s}}{110\,\text{kg/s} + \left(62\,\text{kg/s} \cdot 2.6 \right)} \right)^3 \right) \cdot 0.5$$

19) Raffinate Phase Solute Concentration for Single Ideal Stage Extraction Formula

Evaluate Formula

Formula

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

Example with Units

$$0.2028 = \left(\frac{110\,\text{kg/s}}{110\,\text{kg/s} + \left(62\,\text{kg/s} \cdot 2.6 \right)} \right) \cdot 0.5$$

20) Recovery of Solute in Liquid-Liquid Extraction Formula

Evaluate Formula

Formula

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

Example with Units

$$0.8885 = 1 - \left(\frac{0.1394 \cdot 40\,\text{mol/s}}{0.5 \cdot 100\,\text{mol/s}} \right)$$

21) Selectivity of Solute based on Distribution Coefficients Formula

Evaluate Formula

Formula

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

Example

$$1.7333 = \frac{2.6}{1.5}$$

22) Selectvity of Solute based on Activity Coefficients Formula

Evaluate Formula

Formula

$$\beta_{C,A} = \frac{\frac{\gamma c_R}{\gamma c_E}}{\frac{\gamma a_R}{\gamma a_E}}$$

Example

$$1.7333 = \frac{\frac{4.16}{1.6}}{\frac{1.8}{1.2}}$$

23) Selectvity of Solute based on Mole Fractions Formula

Evaluate Formula

Formula

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

Example

$$1.8186 = \frac{\frac{0.3797}{0.674}}{\frac{0.1394}{0.45}}$$

Variables used in list of Important Formulas in Liquid-Liquid Extraction above

- **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
- X_1 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

Constants, Functions, Measurements used in list of Important Formulas in Liquid-Liquid Extraction above

- Functions: **log10**, log10(Number)
  The common logarithm, also known as the base-10 logarithm or the decimal logarithm, is a mathematical function that is the inverse of the exponential function.
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- 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

- z_C Mass Fraction of Solute in the Feed
- $\beta_{C, A}$ Selectivity
- ε Extraction Factor
- Ya_E Activity Coefficient of Carrier Liquid in Extract
- Ya_R Activity Coefficient of Carrier Liq in Raffinate
- Yc_E Activity Coefficient of Solute in Extract
- Yc_R Activity Coefficient of Solute in Raffinate

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