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Important Formulas in Liquid-Liquid Extraction

Calculators! Examples! Conversions!

List of 23 Important Formulas in Liquid-Liquid Extraction

Important Formulas in Liquid-Liquid Extraction

1) Distribution Coefficient of Carrier Liquid from Activity Coefficients

Open Calculator

fx $$K_{CarrierLiq} = \frac{\Upsilon a_R}{\Upsilon a_E}$$

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

2) Distribution Coefficient of Carrier Liquid from Mass Fraction

Open Calculator

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

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

3) Distribution Coefficient of Solute from Activity Coefficient

Open Calculator

fx $$K_{Solute} = \frac{\Upsilon c_R}{\Upsilon c_E}$$

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

4) Distribution Coefficient of Solute from Mass Fractions

Open Calculator

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

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

5) Extraction Factor at Feed Point Slope of Equilibrium Curve

Open Calculator

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

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

6) Extraction Factor at Mean Slope of Equilibrium Curve

Open Calculator

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

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

7) Extraction Factor based on Raffinate Point Slope

Open Calculator

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

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

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

Open Calculator

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

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

9) Feed Solute Concentration for Single Ideal Stage Extraction

Open Calculator

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

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

10) Geometric Mean of Equilibrium Line Slope

Open Calculator

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

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

11) Mass Ratio of Solute in Extract Phase

Open Calculator

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

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

12) Mass Ratio of Solute in Raffinate Phase

Open Calculator

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

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

13) Mass Ratio of Solvent in Extract Phase

Open Calculator

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

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

14) Mass Ratio of Solvent in Raffinate Phase

Open Calculator

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

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

15) Number of Extraction Stages by Kremser Equation

Open Calculator

fx
$$N = \frac{\log 10\left(\left(\frac{z_C - \left(\frac{y_S}{K_{Solute}}\right)}{\left(x_C - \frac{y_S}{K_{Solute}}\right)}\right) \cdot \left(1 - \left(\frac{1}{\varepsilon}\right)\right) + \left(\frac{1}{\varepsilon}\right)\right)}{\log 10(\varepsilon)}$$

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

16) Number of Ideal Equilibrium Extraction Stages

Open Calculator

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

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

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

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

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

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

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

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

Open Calculator

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

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

21) Selectivity of Solute based on Distribution Coefficients

Open Calculator

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

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

22) Selectvity of Solute based on Activity Coefficients

Open Calculator

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

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

23) Selectvity of Solute based on Mole Fractions

Open Calculator

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

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
- 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
- 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

Constants, Functions, Measurements used

- Function: **log10**, log10(Number)
  Common logarithm function (base 10)
- Function: **sqrt**, sqrt(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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