Important Formulas in Solid-Liquid Extraction PDF

Formulas
Examples
with Units

List of 31
Important Formulas in Solid-Liquid Extraction

1) Area of Contact for Batch Leaching Operation Formula

Evaluate Formula

Formula

$$A = \left(- \frac{V_{Leaching}}{K_L \cdot t} \right) \cdot \ln\left(\left(\frac{C_S - C}{C_S} \right) \right)$$

Example with Units

$$0.1663\,m^2 = \left(- \frac{2.48\,m^3}{0.0147\,mol/s*m^2 \cdot 600\,s} \right) \cdot \ln\left(\left(\frac{56\,kg/m^3 - 25\,kg/m^3}{56\,kg/m^3} \right) \right)$$

2) Beta Value based on Ratio of Solvent Formula

Evaluate Formula

Formula

$$\beta = \frac{b}{a}$$

Example with Units

$$2.8571 = \frac{30\,kg}{10.5\,kg}$$

3) Concentration of Solute in Bulk Solution at Time t for Batch Leaching Formula

Evaluate Formula

Formula

$$C = C_S \cdot \left(1 - \exp\left(\frac{-K_L \cdot A \cdot t}{V_{Leaching}} \right) \right)$$

Example with Units

$$23.6162\,kg/m^3 = 56\,kg/m^3 \cdot \left(1 - \exp\left(\frac{-0.0147\,mol/s*m^2 \cdot 0.154\,m^2 \cdot 600\,s}{2.48\,m^3} \right) \right)$$

4) Fraction of Solute as Ratio of Solute Formula

Evaluate Formula

Formula

$$\theta_N = \frac{S_{N(Wash)}}{S_{Solute}}$$

Example with Units

$$0.001 = \frac{0.01\,kg}{10\,kg}$$

5) Fraction of Solute remaining based on Solvent Decanted Formula

Evaluate Formula

Formula

$$\theta_N = \left(\frac{1}{\left(1 + \left(\frac{b}{a}\right)\right)^{N_{Washing}}} \right)$$

Example with Units

$$0.0012 = \left(\frac{1}{\left(1 + \left(\frac{30\,\text{kg}}{10.5\,\text{kg}}\right)\right)^{5}} \right)$$

6) Fractional Solute Discharge based on Ratio of Overflow to Underflow Formula

Evaluate Formula

Formula

$$f = \frac{R - 1}{\left(R^{N+1}\right) - 1}$$

Example

$$0.1883 = \frac{1.35 - 1}{\left(1.35^{2.5+1}\right) - 1}$$

7) Fractional Solute Discharge based on Recovery of Solute Formula

Evaluate Formula

Formula

$$f = 1 - \text{Recovery}$$

Example

$$0.2 = 1 - 0.8$$

8) Fractional Solute Discharge Ratio based on Solute Underflow Formula

Evaluate Formula

Formula

$$f = \frac{S_N}{S_0}$$

Example with Units

$$0.203 = \frac{2\,\text{kg/s}}{9.85\,\text{kg/s}}$$

9) Number of Equilibirum Leaching Stages based on Fractional Solute Discharge Formula

Evaluate Formula

Formula

$$N = \frac{\log10\left(1 + \frac{R - 1}{f}\right)}{\log10\left(R\right)} - 1$$

Example

$$2.3708 = \frac{\log10\left(1 + \frac{1.35 - 1}{0.2}\right)}{\log10\left(1.35\right)} - 1$$

10) Number of Equilibrium Leaching Stages based on Recovery of Solute Formula

Evaluate Formula

Formula

$$N = \frac{\log10\left(1 + \frac{R - 1}{1 - \text{Recovery}}\right)}{\log10\left(R\right)} - 1$$

Example

$$2.3708 = \frac{\log10\left(1 + \frac{1.35 - 1}{1 - 0.8}\right)}{\log10\left(1.35\right)} - 1$$

11) Number of Stages based on Original Weight of Solute Formula

Evaluate Formula

Formula

$$N_{Washing} = \left(\frac{\ln\left(\frac{S_{Solute}}{S_{N(Wash)}}\right)}{\ln\left(1 + \beta\right)} \right)$$

Example with Units

$$4.9829 = \left(\frac{\ln\left(\frac{10\,\text{kg}}{0.01\,\text{kg}}\right)}{\ln\left(1 + 3\right)} \right)$$

12) Number of Stages based on Solvent Decanted Formula

Evaluate Formula

Formula

$$N_{Washing} = \left(\frac{\ln\left(\frac{1}{\theta_N}\right)}{\ln\left(1+\left(\frac{b}{a}\right)\right)} \right)$$

Example with Units

$$5.1171 = \left(\frac{\ln\left(\frac{1}{0.001}\right)}{\ln\left(1+\left(\frac{30\,\text{kg}}{10.5\,\text{kg}}\right)\right)} \right)$$

13) Original Weight of Solute based on Number of Stages and Amount of Solvent Decanted Formula

Evaluate Formula

Formula

$$S_{Solute} = S_{N(Wash)} \cdot \left(\left(1+\left(\frac{b}{a}\right)\right)^{N_{Washing}} \right)$$

Example with Units

$$8.5375\,\text{kg} = 0.01\,\text{kg} \cdot \left(\left(1+\left(\frac{30\,\text{kg}}{10.5\,\text{kg}}\right)\right)^{5} \right)$$

14) Ratio of Solute Discharged in Underflow to Overflow Formula

Evaluate Formula

Formula

$$R = \frac{L}{S}$$

Example with Units

$$1.3333 = \frac{0.5\,\text{kg/s}}{0.375\,\text{kg/s}}$$

15) Ratio of Solution Discharged in Overflow to Underflow Formula

Evaluate Formula

Formula

$$R = \frac{V}{W}$$

Example with Units

$$1.3467 = \frac{1.01\,\text{kg/s}}{0.75\,\text{kg/s}}$$

16) Ratio of Solvent Discharged in Underflow to Overflow Formula

Evaluate Formula

Formula

$$R = \frac{V - L}{W - S}$$

Example with Units

$$1.36 = \frac{1.01\,\text{kg/s} - 0.5\,\text{kg/s}}{0.75\,\text{kg/s} - 0.375\,\text{kg/s}}$$

17) Recovery of Solute based on Fractional Solute Discharge Formula

Evaluate Formula

Formula

$$\text{Recovery} = 1 - f$$

Example

$$0.8 = 1 - 0.2$$

18) Recovery of Solute based on Solute Underflow Formula

Evaluate Formula

Formula

$$\text{Recovery} = 1 - \left(\frac{S_N}{S_0}\right)$$

Example with Units

$$0.797 = 1 - \left(\frac{2\,\text{kg/s}}{9.85\,\text{kg/s}}\right)$$

19) Solute Discharged in Overflow based on Ratio of Overflow to Underflow and Solution Discharged Formula

Evaluate Formula

Formula

$$L = V - R \cdot (W - S)$$

Example with Units

$$0.5037\,\text{kg/s} = 1.01\,\text{kg/s} - 1.35 \cdot (0.75\,\text{kg/s} - 0.375\,\text{kg/s})$$

20) Solute Discharged in Underflow based on Ratio of Overflow to Underflow and Solution Discharged Formula

Evaluate Formula

Formula

$$S = W - \left(\frac{V - L}{R}\right)$$

Example with Units

$$0.3722\,\text{kg/s} = 0.75\,\text{kg/s} - \left(\frac{1.01\,\text{kg/s} - 0.5\,\text{kg/s}}{1.35}\right)$$

21) Solute Underflow Entering Column based on Ratio of Overflow to Underflow Formula

Evaluate Formula

Formula

$$S_0 = \frac{S_N \cdot \left(\left(R^{N+1}\right) - 1\right)}{R - 1}$$

Example with Units

$$10.6211\,\text{kg/s} = \frac{2\,\text{kg/s} \cdot \left(\left(1.35^{2.5+1}\right) - 1\right)}{1.35 - 1}$$

22) Solute Underflow Entering Column based on Recovery of Solute Formula

Evaluate Formula

Formula

$$S_0 = \frac{S_N}{1 - \text{Recovery}}$$

Example with Units

$$10\,\text{kg/s} = \frac{2\,\text{kg/s}}{1 - 0.8}$$

23) Solute Underflow Leaving Column based on Ratio of Overflow to Underflow Formula

Evaluate Formula

Formula

$$S_N = \frac{S_0 \cdot (R - 1)}{\left(R^{N+1}\right) - 1}$$

Example with Units

$$1.8548\,\text{kg/s} = \frac{9.85\,\text{kg/s} \cdot (1.35 - 1)}{\left(1.35^{2.5+1}\right) - 1}$$

24) Solute Underflow Leaving Column based on Recovery of Solute Formula

Evaluate Formula

Formula

$$S_N = S_0 \cdot (1 - \text{Recovery})$$

Example with Units

$$1.97\,\text{kg/s} = 9.85\,\text{kg/s} \cdot (1 - 0.8)$$

25) Solution Discharged in Overflow based on Ratio of Overflow to Underflow and Solute Discharged Formula

Evaluate Formula

Formula

$$V = L + R \cdot (W - S)$$

Example with Units

$$1.0062\,\text{kg/s} = 0.5\,\text{kg/s} + 1.35 \cdot (0.75\,\text{kg/s} - 0.375\,\text{kg/s})$$

26) Solution Discharged in Underflow based on Ratio of Overflow to Underflow and Solute Discharged Formula

Evaluate Formula

Formula

$$W = S + \left(\frac{V - L}{R}\right)$$

Example with Units

$$0.7528\,\text{kg/s} = 0.375\,\text{kg/s} + \left(\frac{1.01\,\text{kg/s} - 0.5\,\text{kg/s}}{1.35}\right)$$

27) Solvent Decanted based on Original Weight of Solute and Number of Stages Formula

Evaluate Formula

Formula

$$b = a \cdot \left(\left(\left(\frac{S_{Solute}}{S_{N(Wash)}}\right)^{\frac{1}{N_{Washing}}}\right) - 1\right)$$

Example with Units

$$31.3013\,\text{kg} = 10.5\,\text{kg} \cdot \left(\left(\left(\frac{10\,\text{kg}}{0.01\,\text{kg}}\right)^{\frac{1}{5}}\right) - 1\right)$$

28) Solvent Remaining based on Original Weight of Solute and Number of Stages Formula

Evaluate Formula

Formula

$$a = \frac{b}{\left(\left(\frac{S_{Solute}}{S_{N(Wash)}}\right)^{\frac{1}{N_{Washing}}}\right) - 1}$$

Example with Units

$$10.0635\,\text{kg} = \frac{30\,\text{kg}}{\left(\left(\frac{10\,\text{kg}}{0.01\,\text{kg}}\right)^{\frac{1}{5}}\right) - 1}$$

29) Time of Batch Leaching Operation Formula

Evaluate Formula

Formula

$$t = \left(-\frac{V_{Leaching}}{A \cdot K_L}\right) \cdot \ln\left(\left(\frac{C_S - C}{C_S}\right)\right)$$

Example with Units

$$647.8416\,\text{s} = \left(-\frac{2.48\,\text{m}^3}{0.154\,\text{m}^2 \cdot 0.0147\,\text{mol/s*m}^2}\right) \cdot \ln\left(\left(\frac{56\,\text{kg/m}^3 - 25\,\text{kg/m}^3}{56\,\text{kg/m}^3}\right)\right)$$

30) Volume of Leaching Solution in Batch Leaching Formula

Evaluate Formula

Formula

$$V_{Leaching} = \frac{-K_L \cdot A \cdot t}{\ln\left(\left(\frac{C_S - C}{C_S}\right)\right)}$$

Example with Units

$$2.2969\,\text{m}^3 = \frac{-0.0147\,\text{mol/s*m}^2 \cdot 0.154\,\text{m}^2 \cdot 600\,\text{s}}{\ln\left(\left(\frac{56\,\text{kg/m}^3 - 25\,\text{kg/m}^3}{56\,\text{kg/m}^3}\right)\right)}$$

31) Weight of Solute remaining based on Number of Stages and Amount of Solvent Decanted Formula

Evaluate Formula

Formula

$$S_{N(Wash)} = \frac{S_{Solute}}{\left(1 + \frac{b}{a}\right)^{N_{Washing}}}$$

Example with Units

$$0.0117\,\text{kg} = \frac{10\,\text{kg}}{\left(1 + \frac{30\,\text{kg}}{10.5\,\text{kg}}\right)^{5}}$$

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

- **a** Amount of Solvent Remaining *(Kilogram)*
- **A** Area of Leaching *(Square Meter)*
- **b** Amount of Solvent Decanted *(Kilogram)*
- **C** Concentration of Solute in Bulk Solution at Time t *(Kilogram per Cubic Meter)*
- C_S Concentration of Saturated Solution with Solute *(Kilogram per Cubic Meter)*
- **f** Fractional Solute Discharge
- K_L Mass Transfer Coefficient for Batch Leaching *(Mole per Second Square Meter)*
- **L** Amount of Solute Discharge in Overflow *(Kilogram per Second)*
- **N** Number of Equilibrium Stages in Leaching
- $N_{Washing}$ Number of Washings in Batch Leaching
- **R** Ratio of Discharge in Overflow to Underflow
- **Recovery** Recovery of Solute in Leaching Column
- **S** Amount of Solute Discharge in Underflow *(Kilogram per Second)*
- S_0 Amount of Solute in Underflow Entering Column *(Kilogram per Second)*
- S_N Amount of Solute in Underflow Leaving Column *(Kilogram per Second)*
- $S_{N(Wash)}$ Weight of Solute remaining in Solid after Washing *(Kilogram)*
- S_{Solute} Original Weight of Solute in Solid *(Kilogram)*
- **t** Time of Batch Leaching *(Second)*
- **V** Amount of Solution Discharge in Overflow *(Kilogram per Second)*
- $V_{Leaching}$ Volume of Leaching Solution *(Cubic Meter)*
- **W** Amount of Solution Discharge in Underflow *(Kilogram per Second)*
- **β** Solvent Decanted per Solvent Remaining in Solid

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

- Functions: **exp**, exp(Number)
  n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.
- Functions: **ln**, ln(Number)
  The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.
- 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.
- Measurement: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Volume** in Cubic Meter (m^3)
  Volume Unit Conversion
- Measurement: **Area** in Square Meter (m^2)
  Area Unit Conversion
- Measurement: **Mass Flow Rate** in Kilogram per Second (kg/s)
  Mass Flow Rate Unit Conversion
- Measurement: **Mass Concentration** in Kilogram per Cubic Meter (kg/m^3)
  Mass Concentration Unit Conversion
- Measurement: **Molar Flux of Diffusing Component** in Mole per Second Square Meter ($mol/s*m^2$)
  Molar Flux of Diffusing Component Unit Conversion

- θ_N Fraction of Solute Remaining in Solid

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