Adsorption Capacity: Langmuir and Freundlich Isotherms

Equilibrium loading of an adsorbent by the Langmuir and Freundlich isotherms, and the adsorbent mass to take up a solute load (Perry's sec. 16).

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Fluid-phase concentration	50.000	mg/L
Langmuir monolayer capacity	0.30000	kg/kg
Langmuir constant	50.000	m³/kg
Freundlich constant (q at c = 1 kg/m³)	0.50000	kg/kg
Freundlich exponent n (q = K_F c^{1/n})	2.5000	
Solute to remove	10.000	kg
Basis of K_F	SI: q in kg/kg at c = 1 kg/m³	

Calculated results

Parameter	Value	Unit
Langmuir loading	0.21429	kg/kg
Freundlich loading	0.15085	kg/kg
Adsorbent needed (Langmuir)	46.667	kg
Adsorbent needed (Freundlich)	66.289	kg

Notes for this case

- The adsorbent mass is the equilibrium minimum; real beds need more because of the unused mass-transfer zone.

Formula and method

$$q_L = \frac{q_m K_L c}{1 + K_L c}, \quad q_F = K_F c^{1/n}, \quad M_{ads} = \frac{M_s}{q}$$

Variables

c	Fluid-phase concentration	kg/m³
q_m	Langmuir monolayer capacity	kg/kg
K_L	Langmuir constant	m³/kg
K_F	Freundlich constant (q at c = 1 kg/m³)	kg/kg
n	Freundlich exponent n (q = K_F c^{1/n})	-
M_s	Solute to remove	kg
q_L	Langmuir loading	kg/kg
q_F	Freundlich loading	kg/kg
$M_{ads,L}$	Adsorbent needed (Langmuir)	kg
$M_{ads,F}$	Adsorbent needed (Freundlich)	kg
basis	Basis of K_F	-

Method and standards

Isotherms as in Perry's sec. 16.

Assumptions and limits

- Equilibrium; single solute.
- K_F depends on the concentration unit. Most published values use q in mg/g with c in mg/L; choose that basis so the calculator converts c, otherwise a K_F with n = 2.5 is out by a factor of about 16.
- At zero concentration the adsorbent masses are not shown.

References

- Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 16 (adsorption equilibrium): Langmuir and Freundlich isotherms

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/chemical/unit-operations/langmuir-freundlich-isotherm

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.