Ion Exchange Binary Equilibrium: Maximum Loading and Bed Volumes

Maximum useful resin loading of a target ion against a competing ion from the separation factor and total capacity, and the bed volumes treated to exhaustion.

Input parameters

Unit system: SI

Parameter	Value	Unit
Target ion in the water (e.g. nitrate)	1.8000	
Competing (presaturant) ion, same unit (e.g. chloride)	0.50000	
Separation factor of the target over the competing ion	3.2000	
Total resin capacity, eq/L of resin	1.4000	

Calculated results

Parameter	Value	Unit
Reverse separation factor	0.31250	
Equivalent fraction of the target in water	78.261	%
Equivalent fraction of the target on the resin at equilibrium	92.013	%
Maximum loading of the target, meq/L of resin	1,288.2	
Bed volumes treated to exhaustion	715.65	

Notes for this case

- Enter the water concentrations in meq/L; the bed volumes are litres of water per litre of resin. Equilibrium (no mass-transfer zone) gives the upper limit of the run; other competing ions such as sulfate shorten it.

Formula and method

$$q_i = \frac{C_i q_T}{C_i + C_j \alpha_{j/i}}, \quad \alpha_{j/i} = \frac{1}{\alpha_{i/j}}, \quad BV = \frac{q_i}{C_i}$$

Variables

C_i	Target ion in the water (e.g. nitrate)	-
C_j	Competing (presaturant) ion, same unit (e.g. chloride)	-
$\alpha_{i/j}$	Separation factor of the target over the competing ion	-
q_T	Total resin capacity, eq/L of resin	-
$\alpha_{j/i}$	Reverse separation factor	-
x_i	Equivalent fraction of the target in water	-
y_i	Equivalent fraction of the target on the resin at equilibrium	-
q_i	Maximum loading of the target, meq/L of resin	-
BV	Bed volumes treated to exhaustion	-

Method and standards

Binary exchange equilibrium with a constant separation factor.

Assumptions and limits

- Two ions only; equilibrium loading.

Report details

Report reference	FCC-CZ98-Z7FV (the same inputs always give the same reference)
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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/drinking-water/ion-exchange-binary-equilibrium

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.