Gas–Liquid Reaction: Hatta Number and Enhancement Factor

Hatta number and enhancement factor for absorption with a fast pseudo-first-order reaction in the liquid, the regime, and the enhanced absorption flux.

Method: Levenspiel; Chemical Reaction Engineering; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Second-order rate constant (m³/(kmol·s))	5,000.0	
Liquid-phase reactant concentration (kmol/m³)	0.50000	
Diffusivity of the dissolved gas in the liquid	1.8000e-09	m²/s
Liquid-side mass-transfer coefficient	1.0000e-04	m/s
Interface concentration of the gas (kmol/m³)	0.020000	
Diffusivity of the liquid reactant (0 if unknown) Enables the instantaneous-reaction limit E_i; leave 0 to skip it.	0	m²/s
Moles of liquid reactant per mole of gas absorbed	1.0000	

Calculated results

Parameter	Value	Unit
Hatta number	21.213	
Enhancement factor	21.213	
Regime (1 slow, 2 intermediate, 3 fast)	3.0000	
Absorption flux (kmol/(m²·s))	4.2426e-05	

Notes for this case

• Pseudo-first-order: the liquid reactant is not depleted near the interface. Enter D_B to check against the instantaneous-reaction limit 1 + D_BC_B/(vD_AC_Ai). Film theory.

Formula and method

$$Ha = \frac{\sqrt{k_2 C_B D_A}}{k_L}, \quad E = \min\left(\frac{Ha}{\tanh Ha},\ E_i\right), \quad E_i = 1 + \frac{D_B C_B}{\nu D_A C_{Ai}}, \quad N_A = E k_L C_{Ai}$$

Variables

k_2	Second-order rate constant (m³/(kmol·s))	-
C_B	Liquid-phase reactant concentration (kmol/m³)	-
D_A	Diffusivity of the dissolved gas in the liquid	m²/s
k_L	Liquid-side mass-transfer coefficient	m/s
C_{Ai}	Interface concentration of the gas (kmol/m³)	-
Ha	Hatta number	-
E	Enhancement factor	-
regime	Regime (1 slow, 2 intermediate, 3 fast)	-
N_A	Absorption flux (kmol/(m²·s))	-
D_B	Diffusivity of the liquid reactant (0 if unknown)	m²/s
ν	Moles of liquid reactant per mole of gas absorbed	-
E_i	Instantaneous-reaction enhancement	-

Method and standards

Film theory, pseudo-first order.

Assumptions and limits

- Pseudo-first order; film theory.
- Without D_B the instantaneous limit is not applied and E can be overstated at high Ha. With D_B entered, E is limited to E_i, and a note warns when Ha exceeds E_i/2, where reactant depletion makes the pseudo-first-order value too high.

References

- Levenspiel
- Chemical Reaction Engineering
- 3rd ed. (Wiley, 1999)
- ch. 23 (fluid–fluid reactions: Hatta number and enhancement factor)
- Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 14 (absorption with chemical reaction)

Report details

Report reference	FCC-CWYF-MK8H (the same inputs always give the same reference)
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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/reactors/hatta-enhancement-factor

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.