Diffusion Coefficient by Arrhenius and Equivalent Time

Diffusion coefficient at a temperature from D_0 and activation energy, the diffusion distance √(Dt), and the time for the same depth at another temperature.

Method: Arrhenius diffusion and √(Dt) scaling

Input parameters

Unit system: SI

Parameter	Value	Unit
Pre-exponential factor	0.23000	cm²/s
Activation energy	148.00	kJ/mol
Temperature	900.00	°C
Time at T_1	10.000	h
Second temperature	1,000.0	°C

Calculated results

Parameter	Value	Unit
Diffusion coefficient at T_1	5.9175e-08	cm²/s
Characteristic distance	0.46155	mm
Diffusion coefficient at T_2	1.9486e-07	cm²/s
Time at T_2 for the same depth	3.0368	h

Notes for this case

• D = D_0·exp(−Q_d/RT). For a given composition profile, depth scales with √(Dt), so the same profile at another temperature needs $t_2 = t_1 D_1/D_2$. Default: carbon in γ-iron (D_0 2.3 × 10^{-5} m²/s in the source, Q 148 kJ/mol) — enter D_0 in the units shown. Interstitial diffusion is fast; substitutional (self) diffusion has higher Q and is much slower.

Formula and method

$$D = D_0 \exp\left(-\frac{Q_d}{RT}\right), \quad t_2 = t_1 \frac{D_1}{D_2}$$

Variables

D_0	Pre-exponential factor	m²/s
Q_d	Activation energy	J/mol
T_1	Temperature	K
t_1	Time at T_1	s
T_2	Second temperature	K
D_1	Diffusion coefficient at T_1	m²/s
$\sqrt{D_1 t_1}$	Characteristic distance	m
D_2	Diffusion coefficient at T_2	m²/s
t_2	Time at T_2 for the same depth	s

Method and standards

Diffusivity.

Assumptions and limits

- Constant D_0 and Q over the range; same boundary conditions at both temperatures.

References

Arrhenius diffusion and √(Dt) scaling

Report details

Report reference	FCC-WW3X-ATH7 (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/materials/heat-treatment/arrhenius-diffusivity

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.