Water Stability Lines and Metal Equilibrium Potential

Hydrogen and oxygen equilibrium potentials of water at a pH and temperature, and a metal's equilibrium potential at a chosen ion activity (immunity boundary).

Method: Potential–pH equilibria

Input parameters

Unit system: SI

Parameter	Value	Unit
pH	7.0000	
Temperature	25.000	°C
Hydrogen partial pressure (atm)	1.0000	
Oxygen partial pressure (atm)	0.21000	
Metal standard potential	-447.00	mV
Ion charge	2.0000	
Ion activity defining immunity	1.0000e-06	

Calculated results

Parameter	Value	Unit
Hydrogen line (below: water reduced)	-414.12	mV
Oxygen line (above: water oxidised)	804.86	mV
Metal equilibrium potential (immunity below)	-624.48	mV
Metal above the hydrogen line (corrodes with H^+ evolution if > 0)	-210.36	mV

Notes for this case

• Potentials vs SHE. Water is stable between the hydrogen line $2H^+ + 2e^- \rightarrow H_2$ ($E = -0.0592pH - 0.0296 \log p_{H_2}$ at 25 °C) and the oxygen line $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ ($E = 1.229 - 0.0592pH + 0.0148 \log p_{O_2}$). A metal is taken as immune below $E = E^0 + (0.0592/z)\log a$ with $a = 10^{-6}$. If that potential lies below the hydrogen line the metal can corrode with hydrogen evolution even without oxygen. The water lines' E^0 is kept at its 25 °C value; only the slope follows temperature. Passivity by oxides needs the full potential–pH diagram.

Formula and method

$$E_{H_2} = -0.0592pH - 0.0296 \log p_{H_2}, \quad E_{O_2} = 1.229 - 0.0592pH + 0.0148 \log p_{O_2}, \quad E_M = E^0 + \frac{0.0592}{z} \log a$$

Variables

pH	pH	-
T	Temperature	K
p_{H_2}	Hydrogen partial pressure (atm)	-
p_{O_2}	Oxygen partial pressure (atm)	-
E^0_M	Metal standard potential	V
z	Ion charge	-
$a_{M^{z+}}$	Ion activity defining immunity	-
E_{H_2}	Hydrogen line (below: water reduced)	V
E_{O_2}	Oxygen line (above: water oxidised)	V
E_M	Metal equilibrium potential (immunity below)	V
$E_M - E_{H_2}$	Metal above the hydrogen line (corrodes with H^+ evolution if > 0)	V

Method and standards

Potential–pH.

Assumptions and limits

- Equilibrium thermodynamics; ideal activities; water E^0 at 25 °C.

References

Potential–pH equilibria

Report details

Report reference	FCC-VRXF-JN6T (the same inputs always give the same reference)
Generated	23 November 2026, 18:18 UTC
Calculator	Water Stability Lines and Metal Equilibrium Potential
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
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/corrosion/water-stability-metal-immunity

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.