Hydrogen Fuel Cell Reversible Voltage and Nernst Equation

Gibbs energy, reversible open-circuit voltage and efficiency limit of a hydrogen-oxygen fuel cell at any temperature, with the Nernst correction for gas pressures.

Method: Reversible cell voltage from the Gibbs energy; Nernst equation

Input parameters

Unit system: SI

Parameter	Value	Unit
Cell temperature	80.000	°C
Product water	Liquid (up to 100 °C)	
Hydrogen partial pressure	1.5000	bar
Oxygen partial pressure	0.30000	bar
Water vapour partial pressure (vapour product only)	0.50000	bar

Calculated results

Parameter	Value	Unit
Enthalpy of reaction at T	-284.09	kJ/mol
Gibbs energy of reaction at T	-228.31	kJ/mol
Reversible voltage at 1 bar	1.1831	V
Nernst voltage at the partial pressures	1.1801	V
Efficiency limit Δg/Δh (higher heating value)	79.876	%

Notes for this case

• E° = −Δg/(2F) with Δh and Δs at T from the 25 °C NIST-JANAF values and heat capacities (Shomate gases, IAPWS-IF97 liquid water). Nernst: E = E° + (RT/2F) ln[p_H₂ p_O₂^½ / p_H₂O] with pressures in bar (liquid water has unit activity). Real open-circuit voltages are lower because of fuel crossover.

Formula and method

$$E^0 = \frac{-\Delta \bar{g}_f}{2F}, \quad \Delta \bar{g}_f = \Delta \bar{h}_f - T\Delta \bar{s}, \quad E = E^0 + \frac{RT}{2F} \ln \frac{p_{H_2} p_{O_2}^{1/2}}{p_{H_2O}}$$

Variables

T	Cell temperature	K
water	Product water	-
p_{H_2}	Hydrogen partial pressure	Pa
p_{O_2}	Oxygen partial pressure	Pa
p_{H_2O}	Water vapour partial pressure (vapour product only)	Pa
$\Delta \bar{h}_f$	Enthalpy of reaction at T	J/mol
$\Delta \bar{g}_f$	Gibbs energy of reaction at T	J/mol
E^0	Reversible voltage at 1 bar	V
E	Nernst voltage at the partial pressures	V
η_{max}	Efficiency limit Δg/Δh (higher heating value)	-

Method and standards

Thermodynamics of the hydrogen-oxygen cell.

Assumptions and limits

- Ideal gases; pure hydrogen fuel.

References

Reversible cell voltage from the Gibbs energy; Nernst equation

Report details

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This calculator online

https://calc.firecad.com/environmental/hydrogen-fuel-cells/fuel-cell-nernst-voltage

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Reopens the calculator with the inputs of this report.