

Substance	$\Delta\text{H}^\circ_{\text{H}}/\text{kJ/mol}$	$\Delta\text{S}^\circ_{\text{H}}/\text{J/mol/K}$	$\Delta\text{G}^\circ_{\text{H}}/\text{kJ/mol}$
C _{gr}	0	5.74	0
C _{gas}	716.7	158.1	671.3
CO _{↑gas}	-110.525	197.674	-137.2
CO _{2↑gas}	-393.5	2.9	-394.36
CO _{2aq}	-413.8	117.5704	-385.98
HCO _{3⁻}	-692.495	-494.768	-544.9688
H _{2aq}	-5.02	-363.92	103.24
H _{2gas}	-0.82	-283.82	85.64
H _{2gas}	0	130.68	0
H _{atomic}	218.0	114.7	203.3
OH ⁻	-230.00	-10,539	-157,2
O _{2↑gas}	0	205.152	0
O _{2aq}	-11.715	110.876	16.4
O _{2aq}	-11.7	-94.2	16.4
H _{2O₂aq}	-191.99	-481.688	-48.39
H _{2O₂(aq)}	-191.17	143.9	-134.03
H _{2O}	-285.85	69.9565	-237.191
H _{2O}	-286.65	-453.188	-151.549
H _{2O↑gas}	-241.8352	188.74024	-228.6
CH _{4aq}	-90.69	-763.476	136.95
CH _{4gas}	-76.46	-648.44	120.56
CH _{4gas}	-74.6	186.3	-50.5
NH _{3gas}	-45.9	192.8	-16.4
NH _{3gas}	G _{NH3gas} =	165,7	438,85
NH _{3aq}	-132.5608	-739.2922	91.1056
N _{2gas}	G _{N2gas} =	-15,26	107,2
N _{2aq}	-10.54	98.1	18.7
H _{2S_{gas}}	-33.4	205.8	-20.6
H _{2S_{aq}}	-22.96	-256.064	53.3896
HS ⁻	-17.6	62.8	12.1
S ²⁻	33.1	-14.6	85.8
S _{rombic}	-	28.5	-

$$\Delta\text{G}_{\text{eqStandard}} = (\text{E}^\circ_{\text{Red}} - \text{E}^\circ_{\text{Ox}}) * \text{F} * \text{n} = (0.7975 - 1.982) * 96485 * 2 = -228.6 \text{ kJ/mol}$$

carbon (graphite) G_{gr}=**91.26** kJ/mol;

$$\Delta\text{G}_{\text{eq}} = \text{G}_{\text{O2aq}} + \text{G}_{\text{O2sp}} + 2 * \text{G}_{\text{H2O}} - 2 * \text{G}_{\text{H2O2}} = -228.6 \text{ kJ/mol};$$

$$= 303.1 + 26.58 + 2 * 85.65 - (2 * \text{G}_{\text{H2O2}}) = -228.6 \text{ kJ/mol};$$

$$\text{G}_{\text{H2O2}} = (\text{G}_{\text{O2aq}} + \text{G}_{\text{O2sp}} + 2\text{G}_{\text{H2O}} - \Delta\text{G}_{\text{eq}}) / 2 = 364.79 \text{ kJ/mol}$$

$$364.79 \text{ kJ/mol} = 729.58 / 2 = (303.1 + 26.58 + 2 * 85.65 + 228.6) / 2 = \text{G}_{\text{H2O2}};$$

$$\text{G}_{\text{CgrCH4gas}} = \text{G}_{\text{CO2gr}} - \text{G}_{\text{Hess_CO2gas}} - \text{G}_{\text{O2gas}} = 394.36 - 303.1 = 91.26 \text{ kJ/mol};$$

Alberty R.A. Biochemical Thermodynamic's 1-463, (2006).

$$\text{G}^\circ_{\text{H2gas}} = (-\text{G}^\circ_{\text{H2O}} - \text{G}_{\text{O2gas}}) = (237.19 - 303.1) / 2 = 85.64 \text{ kJ/mol}; \text{ Alberty R.A.}$$

$$\text{G}_{\text{O2gas}} = 303.1 \text{ kJ/mol}; \text{ H}_{2\text{gas}} + 1/2 \text{O}_{2\text{gas}} \Rightarrow \text{H}_2\text{O}; \text{ G}^\circ_{\text{H2O}} = -237.19 \text{ kJ/mol};$$

$$2\text{H}_{2\text{gas}} + \text{O}_{2\text{aq}} \Rightarrow 2\text{H}_2\text{O} \Leftrightarrow \text{H}_3\text{O}^+ + \text{OH}^-;$$

$$\Delta\text{G}_{\text{eqH2gas+O2gas}} = (2\text{G}_{\text{H2O}} - 2\text{G}^\circ_{\text{H2gas}} - \text{G}_{\text{O2gas}}) / 2 = -474.38 / 2 = -237.19 \text{ kJ/mol};$$

$$\text{G}^\circ_{\text{H2O}} = 2 * 0 - 2 * 85.64 - 303.1 = -474.38 / 2 = -237.19 \text{ kJ/mol};$$

$$\text{G}_{\text{O2gas}} = (-\Delta\text{G}^\circ_{\text{H2O}} - \text{G}^\circ_{\text{H2gas}}) * 2 = (237.19 - 85.64) * 2 = 303.1 \text{ kJ/mol};$$

$$\text{Oxygen aqua } \text{G}_{\text{O2aq}} = \text{G}_{\text{O2gas}} + \text{G}_{\text{O2sp}} = 303.1 + 26.58 = 329.68 \text{ kJ/mol};$$

$$\text{G}_{\text{O2sp}} = -\text{R} * \text{T} * \ln(\text{K}_{\text{sp}}) = 26.58 \text{ kJ/mo}; \text{ K}_{\text{sp}} = 2.205 * 10^{-5}; \text{ 3}^{\text{rd}} \text{ page}; [14]$$

$$\Delta\text{G}_{\text{HessH2O}} = \text{G}^\circ_{\text{H2O}} - (\text{HessG}^\circ_{\text{H2}} - \text{HessG}^\circ_{\text{O2gas}} / 2) = -273.19 - (0 + 0) = -273.19 \text{ kJ/mol}$$

$$\text{BioChem zero } \Delta\text{G}_{\text{H2O}} = \text{G}^\circ_{\text{H2O}} - (-\text{G}^\circ_{\text{H2gas}}) + 1/2 * (-\text{G}^\circ_{\text{H2O}} - \text{G}^\circ_{\text{H2gas}}) = 0 \text{ kJ/mol};$$

$$2\text{G}_{\text{OH}} - \text{G}_{\text{H2aq}} - \text{G}_{\text{O2aq}} = 2\text{G}_{\text{OH}} - 103.24 - 329.68 =$$

$$\text{H}_{2\text{aq}} + \text{O}_{2\text{aq}} + 2\text{e}^- \Leftrightarrow 2\text{OH}^-; \text{ E}^\circ_{\text{H2aqO2aq=2OH}} = ??? \text{ Volts}$$

$$\text{H}_{2\text{aq}} + \text{O}_{2\text{aq}} + 2\text{e}^- \Leftrightarrow 2\text{OH}^-; \text{ E}^\circ_{\text{H2aqO2aq=2OH}} = ??? \text{ Volts}$$

BioTherm2006 Alberty R.A. Biochem. Thermodynamic's 463, 2006

Thermodynamic Hess law standard values of elements:

$$\text{HessG}^\circ_{\text{O2gas}} = 0; \text{ HessG}^\circ_{\text{H2}} = 0; \text{ HessG}^\circ_{\text{gr}} = 0; \text{ HessG}^\circ_{\text{N2gas}} = 0; \text{ HessG}^\circ_{\text{Srombic}} = 0;$$

$$\text{G}_{\text{NH3gas}} = \Delta\text{G}^\circ_{\text{NH3aq}} - \Delta\text{G}_{\text{Hess-sp-NH3gas}} - \text{G}^\circ_{\text{H2O}} = 165,7 \text{ kJ/mo}$$

$$\text{G}_{\text{NH3gas}} = 91,1056 - (-74,5537) - (-0) = 165,7 \text{ kJ/mol}; [8] \text{ Alberty}$$

$$\text{G}_{\text{N2gas}} = 2 * 165,6593 - (-32,8) - (3 * 85,64) = 107,2 \text{ kJ/mol}; [8] \text{ Alberty};$$

$$\text{G}_{\text{N2gas}} = 2\text{G}^\circ_{\text{NH3gas}} - 2\Delta\text{G}_{\text{Hess-NH3gas}} - 3 * \text{G}^\circ_{\text{H2gas}} = 107,2 \text{ kJ/mol}; [8] \text{ Alberty};$$

$$\text{G}_{\text{N2gas}} = \text{G}^\circ_{\text{N2aq}} - (\Delta\text{G}_{\text{Hess-sp-N2aq}} + \text{G}^\circ_{\text{H2O}}) = 18,7 - (33,957 + 0) = -15,26 \text{ kJ/mol}$$

solubility CRC2010 0.00175 g/100g density 0.996 g/L

$$\text{BioTherm2006 Alberty R.A. } \text{G}_{\text{H2O}} = 85,65 \text{ kJ/mol}$$

is Thermodynamic Hess law level:

$\text{G}^\circ_{\text{H2O}} = 0 \text{ kJ/mol}$; BioChem background level for product water is zero 0 free energy content and reactants:

$$\Delta\text{G}_{\text{HessH2O}} = \text{G}^\circ_{\text{H2O}} - (\text{G}^\circ_{\text{H2gas}} + \text{G}_{\text{O2gas}} / 2) = 0 - (85.64 + 303.1 / 2) = -273.19 \text{ kJ/mol}, \text{ are positive .}$$

$$\text{G}_{\text{O2gas}} = 303.1 \text{ kJ/mol}; \text{ and half is } \text{G}_{\text{O2gas}} / 2 = 151.55 \text{ kJ/mol}; \text{ G}_{\text{O2aq}} = \text{G}_{\text{O2gas}} + \text{G}_{\text{O2sp}} = 303.1 + 26.58 = 329.68 \text{ kJ/mol};$$

$$\text{G}_{\text{O2gas}} = (-\text{G}^\circ_{\text{H2O}} - \text{G}^\circ_{\text{H2gas}}) * 2 = (237.19 - (237.19 - 151.55)) * 2 = (237.19 - 85.64) * 2 = 303.1 \text{ kJ/mol} = \text{G}_{\text{O2gas}};$$

$$\text{C}_{\text{gr}} + \text{O}_{2\text{gas}} \Rightarrow \text{CO}_{2\text{gas}}; \Delta\text{G}_{\text{Hess_CO2gas}} = \text{G}^\circ_{\text{CO2gas}} - (\text{G}^\circ_{\text{Cgr}} + \text{G}^\circ_{\text{O2}}) = -394.36 - (0 + 0) = -394.36 \text{ kJ/mol};$$

$$\text{G}^\circ_{\text{Cgr}} = -671.3 \text{ kJ/mol} \text{ is Hess Thermodynamic standard level:}$$

Reactants absolute free energy content is positive referring to $\text{CO}_{2\text{gas}}$ zero level $\text{G}^\circ_{\text{CO2gas}} = 0 \text{ kJ/mol}$.

$$\text{So graphite free energy content is } \text{G}_{\text{CO2gr}} = -\Delta\text{G}_{\text{Hess_CO2gas}} - \text{G}_{\text{O2gas}} = 394.36 - 303.1 = 91.26 \text{ kJ/mol} .$$

$$\text{G}^\circ_{\text{CO2gas}} = \Delta\text{G}_{\text{Hess_CO2gas}} + (\text{G}_{\text{CO2gr}} + \text{G}_{\text{O2gas}}) = -394.36 + (91.26 + 303.1) = 0 \text{ kJ/mol};$$

$$\Delta\text{G}_{\text{Hess_CO2gas}} = \text{G}^\circ_{\text{CO2gas}} - (\text{G}_{\text{CO2gr}} + \text{G}_{\text{O2}}) = 0 - (91.26 + 303.1) = -394.36 \text{ kJ/mol};$$

$$\text{C}_{\text{gr}} + 2\text{H}_{2\text{gas}} = \text{CH}_{4\text{gas}}; \Delta\text{G}_{\text{Hess_CH4gas}} = \text{G}^\circ_{\text{CH4gas}} - (\text{G}^\circ_{\text{Cgr}} + 2 * \text{HessG}^\circ_{\text{H2}}) = 120.56 - (0 + 2 * 0) = 120.56 \text{ kJ/mol}; \text{ Alberty} [8].$$

$$\text{G}_{\text{CO2gr}} = \text{G}_{\text{gr}} = 91.26; \Delta\text{G}_{\text{Hess_CH4gas}} = \text{G}^\circ_{\text{CH4gas}} - (\text{G}_{\text{Cgr}} + 2 * \text{G}^\circ_{\text{H2}}) = 120.56 - (91.26 + 2 * 85.64) = -141.98 \text{ kJ/mol}; \text{ spontaneous};$$

BioChem background level for $\text{CO}_{2\text{gas}}$ and water is zero 0: $\text{G}^\circ_{\text{CO2gas}} = \text{G}^\circ_{\text{H2O}} = 0 \text{ kJ/mol}$ and graphite free energy content is $\text{G}_{\text{CO2gr}} = \text{G}_{\text{CgrCH4gas}} = \text{G}^\circ_{\text{CH4gas}} - \text{G}_{\text{Hess_CH4gas}} - 2 * \text{G}^\circ_{\text{H2gas}} = 120.56 + 141.98 - (2 * 85.64) = 91.26 \text{ kJ/mol}$.

$$\text{C}_{\text{gr}} + 2\text{H}_{2\text{gas}} = \text{CH}_{4\text{gas}}; \Delta\text{G}_{\text{Hess_CH4gas}} = \text{G}^\circ_{\text{CH4gas}} - (\text{HessG}^\circ_{\text{Cgr}} + 2 * \text{HessG}^\circ_{\text{H2}}) = -50.5 - (0 + 2 * 0) = -50.5 \text{ kJ/mol}; \text{ CRC} [1] .$$

$\text{CO}_2\text{gas} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2\text{aq}; \Delta G_{\text{spCO}_2\text{aq}} = -R \cdot T \cdot \ln(K_{\text{spCO}_2\text{aq}}) = -8.3144 \cdot 298.15 \cdot \ln(0.034045)/1000 = 8.379 \text{ kJ/mol}$.

$\text{CO}_2\text{aq} + 2\text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HCO}_3^-$; $K_{\text{eqCAHCO}_3\text{aq}} = K_a \cdot \text{CO}_2\text{aq} / [\text{H}_2\text{O}]^2 = 10^{-7.0512}/55.3^2 = 2.906 \cdot 10^{-11}$.

$\text{GH}_3\text{O} + \text{HCO}_3 = \Delta G_{\text{spCO}_2\text{aq}} + \Delta G_{\text{eqCO}_2\text{aq}} = 8.379 + 60.14 = 68.52 \text{ kJ/mol}$. [1,8,14]

$\text{GCO}_2\text{gr} = \text{Ggr} = 91.26$; $\Delta G_{\text{Hess_CH}_4\text{gas}} = G^\circ \text{CH}_4\text{gas} - (\text{G}_{\text{Cgr}} + 2 \cdot G^\circ \text{H}_2) = -50.5 - (91.26 + 2 \cdot 85.64) = -313.04 \text{ kJ/mol}$. Graphite free energy content is $\text{GCO}_2\text{gr} = \text{GC}_{\text{gr}}\text{CH}_4\text{gas} = G^\circ \text{CH}_4\text{gas} - \text{G}_{\text{Hess_CH}_4\text{gas}} - 2 \cdot G^\circ \text{H}_2\text{gas} = -50.5 + 313.04 - (2 \cdot 85.64) = 91.26 \text{ kJ/mol}$.

Glucose photosynthesis $6\text{H}_3\text{O}^+ + 6\text{HCO}_3 \rightleftharpoons \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\text{aq} + 6\text{H}_2\text{O}$ accumulate free energy content:

$\Delta G_{\text{Lehninger}} = 2840 \text{ kJ/mol} = \text{GC}_6\text{H}_{12}\text{O}_6 + 6 \cdot \text{GO}_2\text{Biochem_arterial} + 6 \cdot \text{GH}_2\text{O_Biochem} - 6 \cdot \text{GH}_3\text{O} + \text{HCO}_3^-$. Photosynthesis equilibrium free energy $\text{GC}_6\text{H}_{12}\text{O}_6 = 2840 - 6 \cdot 78.08 - 6 \cdot 85.64 + 6 \cdot 68.52 = 2840 - 468.48 - 513.84 + 411.12 = 2268.8 \text{ kJ/mol}$. is [6th page](#):

$\text{H}_2\text{gas} + \text{H}_2\text{O} \xrightarrow{\text{Aquaporin}} \text{H}_{2\text{aq}}$ accumulate $\Delta G_{\text{H}_2\text{sp}} = \text{GH}_{2\text{aq}} - \text{GH}_2\text{gas} - \text{GH}_2\text{O_Biochem} = 103.24 - 85.64 - 85.6 = -68.05 \text{ kJ/mol}$ [Alberty](#):

Solubility $[\text{H}_{2\text{aq}}] = K_{\text{sp}} \cdot [\text{H}_2\text{O}] = 10^{11.9} \cdot 55.3 = 10^{13.6} \text{ M}$, if H_2gas mol fraction is one $[\text{H}_2\text{gas}] = 1$ pure gas.

$[\text{H}_{2\text{aq}}]/[\text{H}_2\text{gas}]/[\text{H}_2\text{O}] = K_{\text{sp}} = \text{EXP}(-\Delta G_{\text{Alberty}}/R/T) = \text{EXP}(68050/8.3144/298.15) = 10^{11.9}$. [8]

0.000155 g/100g density 0.996 g/L Solubility $[\text{H}_{2\text{aq}}] = 0,000155/2/100,000155 \cdot 996 = 0,000771899 \text{ M}$;

$K_{\text{sp}} = 0,0015438/[\text{H}_2\text{O}] = 0,000771899/55,3 = 0,000013958$;

$\Delta G_{\text{sp}} = -R \cdot T \cdot \ln(K_{\text{sp}}) = -8,3144 \cdot 298,15 \cdot \ln(0,000013958) = 27,7 \text{ kJ/mol}$. [1] CRC

[Engineering Toolbox](#) -; G.W.C. Kaye and T.H. Laby, "Tables of Physical and Chemical Constants," 15th ed., Longman, NY, 1986, p. 219.

Proton reduction at hydroxonium capture electron from crystal lattice $(\text{Pt}) + e^- : \text{H}_3\text{O}^+ + (\text{Pt}) + e^- \rightleftharpoons (\text{Pt})\text{H} + \text{H}_2\text{O}$.

Hess free energy change potential is $\Delta G_{\text{eq}(\text{Pt})\text{H}} = E^\circ_{\text{H}} \cdot F \cdot 1 = 0,10166 \cdot 96485/1000 = 9.81 \text{ kJ/mol}$. It shows free energy change minimum.

The **proton reduction potential** in sulfuric acid $[\text{H}_3\text{O}^+] = 1 \text{ M}$ water $[\text{H}_2\text{O}] = 963/18 = 53.5 \text{ M}$ $53,5 - 1 = 52,5 \text{ M}$ has classic 0 Volts , but thermodynamic standard potential of metal $(\text{Pt})\text{H}$ is $E^\circ = 0 + 0,0591 \cdot \log(1/52,5) = 0,10166 \text{ V}$.

Hess law by [Alberty](#) [8] give $\Delta G_{\text{Hess}(\text{Pt})\text{H}} = \text{GH}_3\text{O} + \text{G}_{(\text{Pt})} + \text{G}_{e^-} - (\text{GH}_2\text{O} + \text{G}_{(\text{Pt})\text{H}}) = 22,44 + 38,375 + 0 - (0 + 51,05) = 9,765 \text{ kJ/mol}$.

free energy change positive greater about free energy change $\Delta G_{\text{eq}(\text{Pt})\text{H}} = E^\circ_{\text{H}} \cdot F \cdot 1 = 9.81 \text{ kJ/mol}$ on zero subjects reference scale $\text{GH}_2\text{O} = \text{GCO}_2\text{gas} = \text{G}_{e^-} = 0 \text{ kJ/mol}$ of water, CO_2gas and electron $+e^-$.

$K_{(\text{Pt})\text{H}} = \frac{X_{\text{H}_3\text{O}^+}}{X_{\text{H}_2\text{O}}} = 0,0191 = \text{EXP}(-\Delta G_{\text{Alberty}}/R/T) = \text{EXP}(-9810/8,3144/298,15) = 0,0191 = 1/;$

Concentration $[\text{H}_3\text{O}^+] = K_{(\text{Pt})\text{H}} \cdot [\text{H}_2\text{O}] = 0,0191 \cdot 52,5 = 1 \text{ M}$ creates classic Standard hydrogen electrode 0 Volts. At $[\text{H}_3\text{O}^+] = 10^{-(7,36)} \text{ M}$ $E = 0,10166 + 0,0591 \cdot \log(10^{-(7,36)}/55,3) = -0,436 \text{ Volts}$ metallic $(\text{Pt})\text{H}$ is strong reducing agent:

Red: $2(\text{Pt})\text{H} + 2\text{H}_2\text{O} \rightleftharpoons 2\text{H}_3\text{O}^+ + 2e^- + 2(\text{Pt})$; $E^\circ_{\text{H}^+} = 0,1016 \text{ V}$;

Ox: $2\text{H}_3\text{O}^+ + 2e^- \rightleftharpoons \text{H}_{2\text{aq}} + 2\text{H}_2\text{O}$; $\Delta G_{\text{Hess_H}_3\text{O}^+} = 2\text{GH}_3\text{O} + 2\text{G}_{e^-} - (\text{GH}_{2\text{aq}} + 2\text{GH}_2\text{O}) = 2 \cdot 22,44 - 2 \cdot 0 - 103,24 - 2 \cdot 0 = -58,36 \text{ kJ/mol}$;

$2(\text{Pt})\text{H} \rightleftharpoons \text{H}_{2\text{aq}} + 2(\text{Pt})$; $2(\text{Pt})\text{H} + \text{H}_2\text{O} \rightleftharpoons \text{H}_{2\text{aq}} + 2(\text{Pt})$; $E^\circ_{\text{H}_3\text{O}^+} = -58,36 \cdot 1000/96485/2 = -0,302 \text{ V}$;

$\Delta E^\circ_{\text{eqH}_3\text{O}^+} = 0,10166 - (-0,302) = 0,40366 \text{ V}$; $\Delta G_{\text{eqH}_3\text{O}^+} = \Delta E^\circ_{\text{H}_3\text{O}^+} \cdot F \cdot 2 = 0,40366 \cdot 96485 \cdot 2 = 77,89 \text{ kJ/mol}$;

$2(\text{Pt})\text{H} \rightleftharpoons \text{H}_{2\text{aq}} + 2(\text{Pt})$; $\Delta G_{\text{Hess_sk}(\text{Pt})\text{H}} = \text{GH}_{2\text{aq}} + 2\text{G}_{(\text{Pt})} - 2\text{G}_{(\text{Pt})\text{H}} = 103,24 + 2 \cdot \text{G}_{(\text{Pt})} - 2 \cdot 51,05 = 77,89 \text{ kJ/mol}$.

$2\text{G}_{(\text{Pt})} = \Delta G_{\text{Hess_sk}(\text{Pt})\text{H}} - \text{GH}_{2\text{aq}} + 2\text{G}_{(\text{Pt})\text{H}} = 77,89 - 103,24 + 2 \cdot 51,05 = 76,75 = 2 \cdot 38,375 \text{ kJ/mol}$

$\Delta G_{\text{Hess_skH}_2} = \text{GH}_{2\text{aq}} + 2\text{G}_{(\text{Pt})} - (2\text{G}_{(\text{Pt})\text{H}} + \text{GH}_2\text{O}) = 103,24 + 2 \cdot 38,375 - (2 \cdot 51,05 + 0) = 77,89 \text{ kJ/mol}$. [8] ;

Solubility from metal hydrogen $(\text{Pt})\text{H}$ is $K_{\text{sp}(\text{Pt})\text{H}} = \text{EXP}(-\Delta G_{(\text{Pt})\text{H}}/R/T) = \text{EXP}(-77890/8,3144/298,15) = 10^{-(13,65)}$;

$[\text{H}_{2\text{aq}}] \cdot [(\text{Pt})]^2 / [\text{H}_2\text{O}] / [(\text{Pt})\text{H}]^2 = K_{\text{sp}(\text{Pt})\text{H}} = 10^{-(13,65)}$. [8] ; $[\text{H}_{2\text{aq}}] = 1/K_{\text{spH}_2} \cdot [\text{H}_2\text{O}] = 10^{-(13,65)} \cdot 55,3 = 10^{-(11,9)} \text{ M}$.

$\Delta G_{\text{sp}(\text{Pt})\text{H}} = -R \cdot T \cdot \ln(K_{\text{sp}}) = -8,3144 \cdot 298,15 \cdot \ln(10^{-(13,65)}) = 77,89 \text{ kJ/mol}$.

The mol fraction of metallic hydrogen is one $[(\text{Pt})\text{H}]^2 = 1$ create solubility concentration $[\text{H}_{2\text{aq}}] = 10^{-(11,9)} \text{ M}$ and in distilled water $[\text{H}_{2\text{aq}}] = K_{\text{sp}} \cdot [\text{H}_2\text{O}] = 0,000771899 \text{ M}$ create gas $[\text{H}_2\text{gas}] = 1$ mol fraction.

Substance	$\Delta H^\circ_{\text{H}} \text{ kJ/mol}$	$\Delta S^\circ_{\text{H}} \text{ J/mol/K}$	$\Delta G^\circ_{\text{H}} \text{ kJ/mol}$
SO_4^{2-}	-909.3	20.1	-744.5
HSO_4^-	-887.3	131.8	-755.9
H_2SO_4	-814.0	156.9	-690.0

$\text{HSO}_4^- + \text{H}_2\text{O} = \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$; $\text{pKa}_1 = -2.8$;

$\text{H}_2\text{SO}_4 + \text{H}_2\text{O} = \text{H}_3\text{O}^+ + \text{HSO}_4^-$; $\text{pKa}_2 = 1.99$;

1 M density 1.061 g/mL; 1061-98=963 g/L; 963/18=53.5 mol;

$53.5 - 1 = 52.5 \text{ mol/L} = [\text{H}_2\text{O}]$

Oxygen reduction half reaction and Thermodynamic standard potential $E^\circ_{\text{O}_2} = 1.485 \text{ Volts}$:

Oxidising agent oxygen $\text{O}_2\text{aq} + 4\text{H}_3\text{O}^+ + 4e^- \rightleftharpoons 6\text{H}_2\text{O}$ oxidises four metallic hydrogen atoms half reactions in platinum crystallic lattice corpus as reducing agent: $4(\text{Pt})\text{H} + 4\text{H}_2\text{O} \rightleftharpoons 4\text{H}_3\text{O}^+ + 4e^-$ the thermodynamic standard potential is $E^\circ_{\text{H}} = 0.10166 \text{ V}$. Metallic hydrogen $(\text{Pt})\text{H}$ with oxygen solution produces water: $\text{O}_2\text{aq} + 4(\text{Pt})\text{H} \rightleftharpoons 2\text{H}_2\text{O}$; Free energy change: $\Delta G_{\text{eqOxRed}} = 2\text{GH}_2\text{O} - 4\text{G}_{(\text{Pt})\text{H}} - \text{GO}_2\text{aq} = (2 \cdot 0 - 4 \cdot \text{G}_{(\text{Pt})\text{H}} - 329,68) = -533,886 \text{ kJ/mol}$ minimum for equilibrium state of four metallic hydrogen $4(\text{Pt})\text{H}$ oxidation with oxygen solution:

$\Delta G_{\text{eq}2\text{H}_2\text{O}} = (E^\circ_{\text{H}} - E^\circ_{\text{O}_2}) \cdot F \cdot 4 = (0.10166 - 1.485) \cdot 96485 \cdot 4 = -1.383 \cdot 96485 \cdot 4/1000 = -533,9 = 2 \cdot 266,94 \text{ kJ/mol}$;

$\text{G}_{(\text{Pt})\text{H}} = (2\text{GH}_2\text{O} - \Delta G_{\text{eq}2\text{H}_2\text{O}} - \text{GO}_2\text{aq})/4 = (2 \cdot 0 + 533,886 - 329,68)/4 = 204,2/4 = 51,05 \text{ kJ/mol}$;

Four moles of metallic hydrogen free energy content referring to zero $\text{GH}_2\text{O} = \text{GCO}_2\text{gas} = \text{G}_{e^-} = 0 \text{ kJ/mol}$ scale:

$$\text{NH}_3\text{gas} + \text{H}_2\text{O} \Rightarrow \text{NH}_3\text{aq}; \Delta H_{\text{hidratācija}} = \Delta H^\circ_{\text{NH}_3\text{aq}} - \Delta H^\circ_{\text{NH}_3\text{gas}} - \Delta H^\circ_{\text{H}_2\text{O}} = -132,5608 + 45,94 - 286,65 = -373,3 \text{ kJ/mol};$$

$$G_{\text{NH}_3\text{gas}} = (2\Delta G_{\text{Hess_NH}_3\text{gas}} + (G_{\text{N}_2\text{gas}} + 3 \cdot G^\circ_{\text{H}_2})) / 2 = (-32,8 + (653,58 + 3 \cdot 85,64)) / 2 = 438,85 \text{ kJ/mol};$$

$$G_{\text{NH}_3\text{aq}} = (2\Delta G_{\text{Hess_NH}_3\text{aq}} + (G_{\text{N}_2\text{gas}} + 3 \cdot G^\circ_{\text{H}_2})) / 2 = (-32,8 + (107,2 + 3 \cdot 85,64)) / 2 = 165,7 \text{ kJ/mol};$$

$$\Delta G_{\text{Hydration}} = \Delta G_{\text{NH}_3\text{aq}} - \Delta G_{\text{NH}_3\text{gas}} - \Delta G_{\text{H}_2\text{O}} = 91,1056 - (-16,4 - 0) = 107,5 \text{ kJ/mol};$$

$$G_{\text{Hydration}} + G_{\text{NH}_3\text{gas}} + \Delta G_{\text{H}_2\text{O}} = G_{\text{NH}_3\text{aq}} = 107,5 + 165,7 + 0 = 273,2 \text{ kJ/mol};$$

$$\Delta S_{\text{Hydration}} = \Delta S^\circ_{\text{NH}_3\text{aq}} - \Delta S^\circ_{\text{NH}_3\text{gas}} - \Delta S^\circ_{\text{H}_2\text{O}} = -739,2922 - 192,77 - 69,9565 = -1002 \text{ J/mol/K};$$

$$\Delta G_{\text{Hess-sp-NH}_3\text{gas}} = \Delta H_{\text{Hydrations}} - T \cdot \Delta S_{\text{Hydration}} = -373,3 - 298,15 \cdot (-1,002) = -74,5537 \text{ kJ/mol};$$

$$K_{\text{sp}} = \exp(-\Delta G_{\text{Hydration}} / R / T) = \exp(74553,7 / 8,3144 / 298,15) = 10^{13,06};$$

$$\text{For zero } G_{\text{H}_2\text{O}} = 0 \text{ kJ/mol: } = 2 \cdot (-16,4) - (0 + 3 \cdot 0) = -32,8 \text{ kJ/mol};$$

$$\text{N}_2\text{gas} + 3\text{H}_2\text{gas} = 2\text{NH}_3\text{gas}; 2\Delta G_{\text{Hess_NH}_3\text{gas}} = 2G^\circ_{\text{NH}_3\text{gas}} - (G^\circ_{\text{N}_2\text{gas}} + 3 \cdot G^\circ_{\text{H}_2}) = 2 \cdot (-16,4) - (0 + 3 \cdot 0) = -32,8 \text{ kJ/mol}; \text{CRC 2010.}$$

$$G_{\text{N}_2\text{gas}} = 2G^\circ_{\text{NH}_3\text{gas}} - (2\Delta G_{\text{Hess_NH}_3\text{gas}} - 3 \cdot G^\circ_{\text{H}_2\text{gas}}) = 2 \cdot 438,85 - (-32,8) - (3 \cdot 85,64) = 653,58 \text{ kJ/mol};$$

$$G_{\text{N}_2\text{aq}} = 2G^\circ_{\text{NH}_3\text{aq}} - (2\Delta G_{\text{Hess_NH}_3\text{aq}} - 3 \cdot G^\circ_{\text{H}_2\text{aq}}) = 2 \cdot 165,6593 - (-32,8) - (3 \cdot 85,64) = 107,2 \text{ kJ/mol}; [8] \text{ Alberty}$$

$$\text{Solubility } \text{N}_2\text{gas} + \text{H}_2\text{O} > \text{N}_2\text{aq}; \Delta G_{\text{Hess_sp-N}_2\text{aq}} = G^\circ_{\text{N}_2\text{aq}} - (G^\circ_{\text{N}_2\text{gas}} + G^\circ_{\text{H}_2\text{O}}) = 18,7 - (0 - 273,292) = 292 \text{ kJ/mol}; \text{CRC 2010.}$$

$$\Delta G_{\text{Hess_sp-N}_2\text{aq}} = G^\circ_{\text{N}_2\text{aq}} - (G^\circ_{\text{N}_2\text{gas}} + G^\circ_{\text{H}_2\text{O}}) = 18,7 - (107,2 + 0) = -88,5 \text{ kJ/mol}; [8] \text{ Alberty}$$

$$G_{\text{N}_2\text{gas}} = G^\circ_{\text{N}_2\text{aq}} - (\Delta G_{\text{Hess_sp-N}_2\text{aq}} + G^\circ_{\text{H}_2\text{O}}) = 18,7 - (-292 + 0) = -273,3 \text{ kJ/mol}; \text{CRC 2010}$$

$$G_{\text{N}_2\text{aq}} = G^\circ_{\text{N}_2\text{aq}} - (\Delta G_{\text{Hess_sp-N}_2\text{aq}} + G^\circ_{\text{H}_2\text{O}}) = 18,7 - (-88,5 + 0) = 107,2 \text{ kJ/mol}; [8] \text{ Alberty}$$

$$G_{\text{N}_2\text{aq}} = G^\circ_{\text{N}_2\text{aq}} - (\Delta G_{\text{Hess_sp-N}_2\text{aq}} + G^\circ_{\text{H}_2\text{O}}) = 18,7 - (33,957 + 0) = -15,26 \text{ kJ/mol}; \text{solubility CRC2010} + \text{Alberty}$$

$$[\text{N}_2\text{aq}] / [\text{N}_2\text{gas}] / [\text{H}_2\text{O}] = K_{\text{sp}} = \text{EXP}(-\Delta G_{\text{Alberty}} / R / T) = \text{EXP}(-292000 / 8,3144 / 298,15) = 10^{-51,2};$$

$$0,00175 \text{ g/100g density } 0,996 \text{ g/L Solubility } [\text{N}_2\text{aq}] = 0,00175 / 100,00175 \cdot 996 = 0,00174297 / 28,02 = 10^{-4,206} \text{ M};$$

$$K_{\text{sp}} = 10^{(-4,206)} / [\text{H}_2\text{O}] = 10^{(-4,206)} / 55,3 = 10^{-5,949}; \Delta G_{\text{sp}} = -R \cdot T \cdot \ln(K_{\text{sp}}) = -8,3144 \cdot 298,15 \cdot \ln(10^{(-5,949)}) = 33,957 \text{ kJ/mol.}$$

$$\text{NH}_4^+ + \text{H}_2\text{O} \Rightarrow \text{NH}_3\text{aq} + \text{H}_3\text{O}^+; pK_{\text{eq}} = 10,99; G_{\text{NH}_4^+} = G_{\text{NH}_3\text{aq}} + G_{\text{H}_3\text{O}^+} - \Delta G_{\text{eq}} - G_{\text{H}_2\text{O}} = 273,2 + 22,44 - 62,75 - 0 = 232,9 \text{ kJ/mol},$$

$$\Delta G_{\text{eq}} = -R \cdot T \cdot \ln(K_{\text{eq}}) = -8,3144 \cdot 298,15 \cdot \ln(1,014 \cdot 10^{(-11)}) = G_{\text{NH}_3\text{Hydration}} + G_{\text{H}_3\text{O}^+} - G_{\text{NH}_4^+} - G_{\text{H}_2\text{O}} = 62,76 \text{ kJ/mol}; \text{16th page:}$$

$$\Delta G_{\text{eq}} = G_{\text{NH}_3\text{aq}} + G_{\text{H}_3\text{O}^+} - G_{\text{NH}_4^+} - G_{\text{H}_2\text{O}} = 273,2 + 22,44 - 232,89 - 0 = 62,76 \text{ kJ/mol}; \text{16th page:}$$

$$S_{\text{rombic}} + \text{H}_2\text{gas} = \text{H}_2\text{Sgas};$$

$$\Delta G_{\text{Hess_H}_2\text{Sgas}} = G^\circ_{\text{H}_2\text{Sgas}} - (\text{Hess } G^\circ_{\text{rombic}} + \text{Hess } G^\circ_{\text{H}_2}) = -20,6 - (0 + 0) = -20,6 \text{ kJ/mol}; \text{CRC 2010.}$$

$$G_{\text{Srombic}} = -85,64 \text{ kJ/mol}; G_{\text{Srombic}} = G^\circ_{\text{H}_2\text{Sgas}} - \Delta G_{\text{Hess_H}_2\text{Sgas}} - G^\circ_{\text{H}_2\text{gas}} = -20,6 - (-20,6) - (85,64) = -85,64 \text{ kJ/mol};$$

$$\Delta G_{\text{Hess_H}_2\text{Sgas}} = G^\circ_{\text{H}_2\text{Sgas}} - (G_{\text{Srombic}} + G^\circ_{\text{H}_2}) = -20,6 - (-85,64 + 85,64) = -20,6 \text{ kJ/mol}; \text{spontaneous};$$

$$S_{\text{rombic}} + 2e^- = S^{2-}; E^\circ = -0,47627 \text{ V}; S_{\text{rombic}} + \text{H}_2\text{O} + 2e^- = \text{HS}^- + \text{OH}^-; E^\circ_{\text{H}_2\text{O}} = -0,478 - 0,0515 = -0,5295 \text{ V};$$

$$\Delta E^\circ_{\text{H}_2\text{O}} = -0,0591 / 2 \cdot \log([\text{H}_2\text{O}]) = -0,0591 / 2 \cdot \log(55,3333) = -0,0515 \text{ V}; 2S_{\text{rombic}} + 2e^- = S_2^{2-}; E^\circ = -0,42836 \text{ V};$$

Oxygen reduction half reaction and Thermodynamic standard potential $E^\circ_{\text{O}_2} = 1,383 \text{ Volts}$:

Oxidising agent oxygen $\text{O}_{2\text{aq}} + 4\text{H}_3\text{O}^+ + 4e^- \Leftrightarrow 6\text{H}_2\text{O}$ oxidises four metallic hydrogen atoms half reactions in platinum crystal lattice corpus as reducing agent: $4(\text{Pt})\text{H} + 4\text{H}_2\text{O} \Leftrightarrow 4\text{H}_3\text{O}^+ + 4e^-$. Thermodynamic standard potential is $E^\circ_{\text{H}} = 0,10166 \text{ V}$. Oxidation metallic hydrogen $(\text{Pt})\text{H}$ with oxygen solution $\text{O}_{2\text{aq}}$ produces water H_2O :

$$\text{O}_{2\text{aq}} + 4(\text{Pt})\text{H} \Leftrightarrow 2\text{H}_2\text{O}; \Delta G_{\text{eq}} = 2G_{\text{H}_2\text{O}} - 4G_{\text{H}(\text{Pt})} - G_{\text{O}_{2\text{aq}}} = (2 \cdot 0 - 4 \cdot G_{\text{H}(\text{Pt})} - 329,68) = -494,5 \text{ kJ/mol}; \text{Free energy change}$$

$$[\text{O}_{2\text{aq}}] = 6 \cdot 10^{-5}; \text{minimum for equilibrium state of four metallic hydrogen } 4(\text{Pt})\text{H} \text{ oxidation with oxygen solution:}$$

$$\Delta G_{\text{eq}2\text{H}_2\text{O}} = (E^\circ_{\text{H}} - E^\circ_{\text{O}_2}) \cdot F \cdot 1 \cdot 4 = (0,10166 - 1,383) \cdot 96485 \cdot 4 = -1,28 \cdot 96485 \cdot 4 / 1000 = -494,5 \text{ kJ/mol};$$

$$\Delta G_{\text{eq}2\text{H}_2\text{O}} = 2G_{\text{H}_2\text{O}} - 4G_{\text{H}(\text{Pt})} - G_{\text{O}_{2\text{aq}}} = 2 \cdot 0 - (4 \cdot G_{\text{H}(\text{Pt})} + 329,68) = -494,5 \text{ kJ/mol}; 4G_{\text{H}(\text{Pt})} = 164,82 \text{ kJ/mol};$$

$$4G_{\text{H}(\text{Pt})} = 2G_{\text{H}_2\text{O}} - \Delta G_{\text{eq}2\text{H}_2\text{O}} - G_{\text{O}_{2\text{aq}}} = 2 \cdot 0 + 494,5 - 329,68 = 164,82 \text{ kJ/mol}; G_{\text{H}(\text{Pt})} = 164,82 / 4 = 41,2 \text{ kJ/mol};$$

Four moles of metallic hydrogen free energy content referring to zero $G_{\text{H}(\text{Pt})} = G_{\text{H}_2\text{O}} = G_{\text{O}_{2\text{aq}}} = G_{\text{e}^-} = 0 \text{ kJ/mol}$ scale:

Water Hess free energy two standard values of formation $2\Delta G_{\text{HessH}_2\text{O}} = 2 \cdot -273,19 \text{ kJ/mol}$ from elements: [1]

$$\text{O}_{2\text{gas}} + 2\text{H}_{2\text{gas}} \Leftrightarrow 2\text{H}_2\text{O}; \Delta G_{\text{Hess}2\text{H}_2\text{O}} = 2\Delta G_{\text{H}_2\text{O}} - (2\Delta G^\circ_{\text{H}_2\text{gas}} + \Delta G^\circ_{\text{O}_{2\text{gas}}}) = 2 \cdot -273,19 - (2 \cdot 0 + 0) = 2 \cdot -273,19 \text{ kJ/mol. CRC [1]}$$

$$\text{O}_{2\text{aq}} + 2\text{H}_{2\text{aq}} \Leftrightarrow 2\text{H}_2\text{O}; \Delta G_{\text{Hess}2\text{H}_2\text{O}} = 2\Delta G^\circ_{\text{H}_2\text{O}} - 2\Delta G^\circ_{\text{H}_2\text{aq}} - \Delta G^\circ_{\text{O}_{2\text{aq}}} = 2 \cdot -237,191 - (2 \cdot 99,13 + 16,4) = 2 \cdot -344,5 \text{ kJ/mol}$$

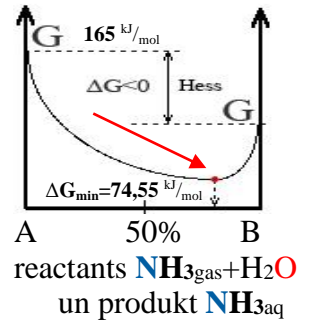
$$G_{\text{H}_2\text{aq}} = 103 \text{ kJ/mol}. \Delta G_{\text{HessH}_2\text{O}} = G_{\text{H}_2\text{O}} - G_{\text{H}_2\text{aq}} - G_{\text{O}_{2\text{aq}}} / 2 = 0 - (103,24 + 329,68 / 2) = -268 \text{ kJ/mol};$$

and $\Delta G_{\text{HessH}_2\text{O}} = G_{\text{H}_2\text{O}} - (G_{\text{H}_2\text{gas}} + G_{\text{O}_{2\text{gas}}} / 2) = 0 - (2 \cdot 85,6 + 303) = -474,2 / 2 = -237,1 \text{ kJ/mol}$ from gas elements. Alberty [8]

$$\Delta G_{\text{eq}} / F / n = (E^\circ_{\text{C}_6\text{H}_{12}\text{O}_6} - E^\circ_{\text{O}_2}) = \Delta E^\circ = -2840000 / 96485 / 24 = (E^\circ_{\text{C}_6\text{H}_{12}\text{O}_6} - 1,383) = -1,226 \text{ V}$$

$$E^\circ_{\text{C}_6\text{H}_{12}\text{O}_6} = \Delta E^\circ + E^\circ_{\text{O}_2} = -1,226 + 1,383 = 0,157 \text{ V}; E^\circ_{\text{C}_6\text{H}_{12}\text{O}_6} = \Delta E^\circ + E^\circ_{\text{O}_2} = -1,226 + 0,731 = -0,495 \text{ V};$$

$$\Delta G_{\text{eq}} / F / n = (E^\circ_{\text{C}_6\text{H}_{12}\text{O}_6} - E^\circ_{\text{O}_2}) = \Delta E^\circ = -2840000 / 96485 / 24 = (E^\circ_{\text{C}_6\text{H}_{12}\text{O}_6} - 0,731) = -1,226 \text{ V}$$



Sulfur reduction half reaction and Thermodynamic standard potential

Oxidising agent: $S_{\text{rombic}} + 2H_3O^+ + 2e^- = H_2S_{\text{aq}} + 2H_2O$; $E^{\circ}_s = 0.245$ Volts: $S_{\text{rombic}} + 2(Pt)H \leftrightarrow H_2S_{\text{aq}}$; [CRC](#) [8] :

Metallic hydrogen (Pt)H reduction with rombic sulfure : $S_{\text{rombic}} + 2(Pt)H \leftrightarrow H_2S_{\text{aq}}$;

Free energy change minimum for equilibrium state of metallic hydrogen (Pt)H oxidation with oxygen solution:

$$\Delta G_{\text{eq}} = (E^{\circ}_H - E^{\circ}_s) \cdot F \cdot 1 \cdot 2 = (0.10166 - 0.245) \cdot 96485 \cdot 2 = -0.14334 \cdot 96485 \cdot 2 / 1000 = -27.7 \text{ kJ/mol};$$

$$\Delta G_{\text{HessH}_2\text{S}} = G_{H_2S_{\text{aq}}} - (2G_{H(Pt)} + G_{S_{\text{rombic}}}) = G_{H_2S_{\text{aq}}} - (2 \cdot -219.85.64) = -27.7 \text{ kJ/mol}.$$

$$G_{H_2S_{\text{aq}}} = \Delta G_{\text{HessH}_2\text{S}} + (2G_{H(Pt)} + G_{S_{\text{rombic}}}) = -27.7 + (2 \cdot -219.85.64) = -551 \text{ kJ/mol}.$$

Hess law standard values of elements are zero $G_{O_2\text{gas}} = G_{H_2} = G_{\text{gr}} = G_{N_2\text{gas}} = G_{S_{\text{rombic}}} = 0$;

Free energy content of homeostasis products water and $CO_2\text{gas}$ are zero $G_{H_2O} = G_{CO_2\text{gas}} = 0 \text{ kJ/mol}$ and

some reactants free energy content referring to homeostasis products zero values scale are:

$$\text{Glucose } G_{C_6H_{12}O_6} = 2268.8 \text{ kJ/mol} > G_{H_3O^+} + G_{HO_2^-} = 22.44 + 418.32 = 441 \text{ kJ/mol} >$$

$$\text{peroxide } G_{H_2O_2} = 365 \text{ kJ/mol} > G_{O_2\text{aq}} = 330 \text{ kJ/mol} > G_{O_2\text{gas}} = 303 \text{ kJ/mol} > \text{ammonium } G_{NH_4^+} = 232.9 \text{ kJ/mol} >$$

$$> G_{N_2\text{gas}} = 107.2 \text{ kJ/mol} > \text{protolysis of water } pH = pOH = 7 \quad G_{H_3O^+} + G_{OH^-} = G_{H_3O^+} + G_{OH^-} = 22.44 + 77.36 = 99.8 \text{ kJ/mol} >$$

$$> G_{H_2\text{gas}} = 85.6 \text{ kJ/mol} \equiv G_{H_2O_{\text{Biochemistry}}} = 85.6 \text{ kJ/mol} > G_{O_2\text{Biochem_arterial}} = 78.1 \text{ kJ/mol} >$$

$$\text{protolysis of } CO_2\text{aq} \text{ solution by Carbonic Anhydrase } G_{H_3O^+} + G_{HCO_3^-} = G_{H_3O^+} + G_{HCO_3^-} = 22.44 + 46.08 = 68.5 \text{ kJ/mol} >$$

$$> G_{H(Pt)} = 51 \text{ kJ/mol} > G_{(Pt)} = 38.4 \text{ kJ/mol} > \text{homeostasis products zero values } G_{H_2O} = G_{CO_2\text{gas}} = 0 \text{ kJ/mol} >$$

$$> G_{S_{\text{rombic}}} = -85.64 \text{ kJ/mol} > G_{H_2S_{\text{aq}}} = -551 \text{ kJ/mol};$$

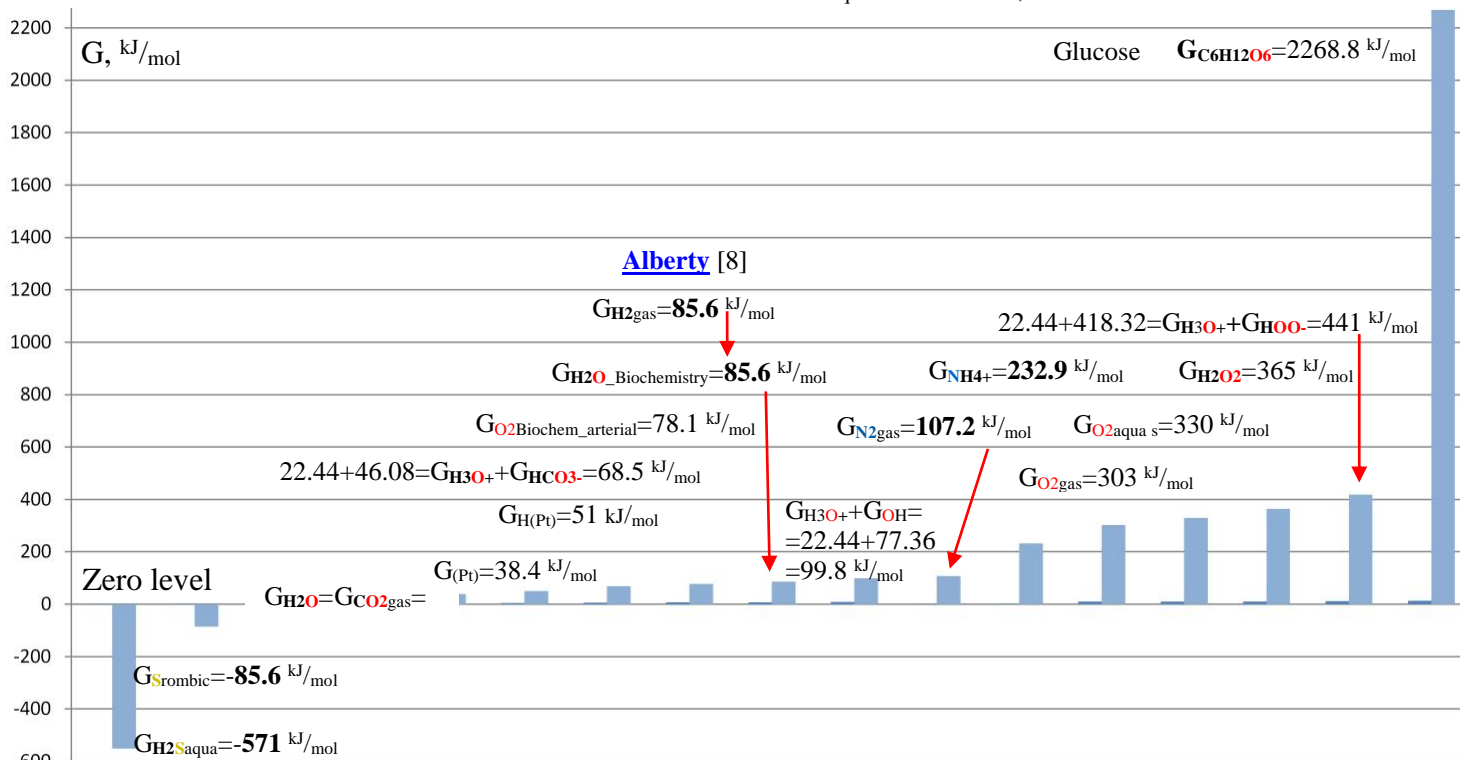
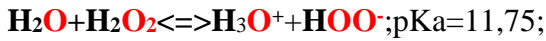


Figure 1. Free energy content starting from zero $G_{H_2O} = G_{CO_2\text{gas}} = 0 \text{ kJ/mol}$ of Homeostasis metabolites ascending.

References.

1. [David R. Lide. CRC Handbook of Chemistry and Physics .90th ed. Taylor and Francis Group LLC; 2010 .](#)
8. [Alberty RA. Biochemical Thermodynamic's : Applications of Mathematics. John Wiley & Sons, Inc. 1-463, \(2006\).](#)
14. [Kaksis A. The Biosphere Self-Organization Attractors drive perfect order homeostasis reactions to link bioenergetic with functionally activate oxygen and carbon dioxide molecules. 7th International Conference on New Trends in Chemistry September 25-26, 2021.27-32.](#)



$$K_{\text{eqH}_2\text{O}_2} = K_a / [\text{H}_2\text{O}] = [\text{H}_3\text{O}^+][\text{HOO}^-] / [\text{H}_2\text{O}][\text{H}_2\text{O}_2] = 10^{-(11,75)} / 55,3 = 10^{-(13,31)}; pK_{\text{eqH}_2\text{O}_2} = 13,31;$$

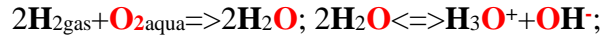
$$\Delta G_{\text{eqH}_2\text{O}_2} = -R \cdot T \cdot \ln(K_{\text{eqH}_2\text{O}_2}) = -8,3144 \cdot 298,15 \cdot \ln(10^{-(13,31)}) / 1000 = 75,97 \text{ kJ/mol}.$$

$$\Delta G_{\text{eqH}_2\text{O}_2} = G_{\text{H}_3\text{O}^+} + G_{\text{HOO}^-} - G_{\text{H}_2\text{O}} - G_{\text{H}_2\text{O}_2} = 75,97 \text{ kJ/mol}.$$

$$\Delta G_{\text{eqH}_2\text{O}_2} = G_{\text{H}_3\text{O}^+} + G_{\text{HOO}^-} - 0 - 364,79 = 75,97 \text{ kJ/mol}.$$

$$G_{\text{H}_3\text{O}^+} + G_{\text{HOO}^-} = 22,44 + 418,32 = \Delta G_{\text{eqH}_2\text{O}_2} + G_{\text{H}_2\text{O}} + G_{\text{H}_2\text{O}_2} = 75,97 + 0 + 364,79 = 440,76 \text{ kJ/mol}.$$

OH⁻	-230,00	-10,539	-157,2
H₃O⁺	-285,81	-3,854	-213,275
OH_{gas}	39,00	183,7	34,2
OOH_{gas}	10,50	229,0	22,6
H₂O_{2aq}	-191,99	-481,688	-48,39
H₂O_{2aq}	-191,17	143,9	-134,03



$$\Delta G_{\text{eqH}_2\text{gas} + \text{O}_2\text{gas}} = 2\Delta G^\circ_{\text{H}_2\text{O}} - 2G^\circ_{\text{H}_2\text{gas}} - G^\circ_{\text{O}_2\text{gas}} = -474,38 \text{ kJ/mol}$$

$$= 2 \cdot 0 - 2 \cdot 85,64 - 303,1 = -474,38 \text{ kJ/mol};$$

$$\Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} = G_{\text{H}_3\text{O}^+} + G_{\text{OH}^-} - 2\Delta G^\circ_{\text{H}_2\text{O}} = 99,8 \text{ kJ/mol}$$

$$\Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} = G_{\text{H}_3\text{O}^+} + G_{\text{OH}^-} - G_{\text{H}_2\text{O}} = -R \cdot T \cdot \ln(K_{\text{H}_3\text{O}^+ + \text{OH}^-}) + 2 \cdot 0 = 99,8 \text{ kJ/mol};$$

$$\text{H}_2\text{O} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-; K_{\text{eq}} = [\text{H}_3\text{O}^+][\text{OH}^-] / [\text{H}_2\text{O}]^2 = 3,26 \cdot 10^{(-18)}; \Delta G_{\text{eq}} = -R \cdot T \cdot \ln(K_{\text{eq}}) = 99,8 \text{ kJ/mol}.$$

$$\Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} = G_{\text{H}_3\text{O}^+} + G_{\text{OH}^-} - 2\Delta G^\circ_{\text{H}_2\text{O}} = -R \cdot T \cdot \ln(K_{\text{H}_3\text{O}^+ + \text{OH}^-}) = -8,3144 \cdot 298,15 \cdot \ln(3,26 \cdot 10^{(-18)}) / 1000 = 99,8 \text{ kJ/mol}.$$

$$G_{\text{H}_3\text{O}^+} + G_{\text{OH}^-} = G_{\text{H}_3\text{O}^+ + \text{OH}^-} = \Delta G_{\text{H}_3\text{O}^+ + \text{OH}^-} + \Delta G^\circ_{2\text{H}_2\text{O}} = -R \cdot T \cdot \ln(K_{\text{H}_3\text{O}^+ + \text{OH}^-}) + 2 \cdot 0 = 99,8 \text{ kJ/mol} \quad [1,8,14]$$

$$\Delta G_{\text{Hess}} = \Delta G^\circ_{\text{OH}^-} + \Delta G^\circ_{\text{H}_3\text{O}^+} - 2\Delta G^\circ_{\text{H}_2\text{O}} = -157,2 - 213,275 - 2 \cdot (-237,191) = 103,907 \text{ kJ/mol};$$

$$\Delta G_{\text{Hess}} = G^\circ_{\text{OH}^-} + G^\circ_{\text{H}_3\text{O}^+} - 2G^\circ_{\text{H}_2\text{O}} = (-157,2 + 237,191) + (-213,275 + 237,191) - 2 \cdot 0 = 79,991 + 23,916 = 103,907 \text{ kJ/mol};$$

$$G^\circ_{\text{OH}^-} = (-157,2 + 237,191) = 79,991 \text{ kJ/mol}; G^\circ_{\text{H}_3\text{O}^+} = (-213,275 + 237,191) = 23,916 \text{ kJ/mol};$$

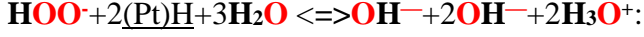
$$G^\circ_{\text{OH}^-} / G^\circ_{\text{H}_3\text{O}^+} = (103,907 - 23,916) / 23,916 = 3,345;$$

$$G_{\text{H}_3\text{O}^+} + G_{\text{OH}^-} = 22,44 + 77,36 = 99,8 \text{ kJ/mol}; G_{\text{OH}^-} / G_{\text{H}_3\text{O}^+} = 77,36 / 22,44 = 3,345;$$

$$G_{\text{H}_3\text{O}^+} = 22,44 \text{ kJ/mol}; G_{\text{OH}^-} = 77,36 \text{ kJ/mol};$$



$$E_{\text{OH}^- + \text{H}_2\text{O}} = (E^\circ_{\text{HOO}^- + \text{H}_2\text{O} = 3\text{OH}^-} - 0,0591 / 2 \cdot \log[\text{H}_2\text{O}]) = (0,878 - 0,0591 / 2 \cdot \log(55,3)) = 0,8265 \text{ Volts Thermodynamic}.$$



$$\Delta G_{\text{EHOO}^-} = \Delta G_{\text{OH}^-} + 2\Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} - G_{\text{HOO}^-} - 2G_{\text{H}(\text{Pt})} - 3G_{\text{H}_2\text{O}} = \Delta G_{\text{OH}^-} + 2 \cdot 99,8 - G_{\text{HOO}^-} + 2 \cdot 219 - 3 \cdot 0 = -139,9 \text{ kJ/mol};$$

$$\Delta G_{\text{eq}} = (E^\circ_{\text{H}(\text{Pt})} - E^\circ_{\text{HOO}^- + \text{H}_2\text{O} = 3\text{OH}^-}) \cdot F \cdot 2 = (0,10166 - 0,8265) \cdot 96485 \cdot 2 = -0,7235 \cdot 96485 \cdot 2 / 1000 = -139,9 \text{ kJ/mol};$$

$$\Delta G_{\text{EHOO}^-} - 2\Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} + G_{\text{HOO}^-} + 2G_{\text{H}(\text{Pt})} + 3G_{\text{H}_2\text{O}} = \Delta G_{\text{OH}^-} = -139,9 - 2 \cdot 99,8 + 418,32 - 2 \cdot 219 + 3 \cdot 0 = 418,32 - 777,2 = -359,2 \text{ kJ/mol};$$

$$\Delta G_{\text{OH}^-} - G_{\text{HOO}^-} = -139,9 - 2 \cdot 99,8 - 2 \cdot 219 + 3 \cdot 0 = -777,5 \text{ kJ/mol} = \Delta G_{\text{EHOO}^-} - 2\Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} + 2G_{\text{H}(\text{Pt})} + 3G_{\text{H}_2\text{O}};$$

$$\text{Solubility zero level } \text{CO}_2\text{gas} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2\text{aq} \text{ solute product value } 8,379 \text{ kJ/mol};$$

$$K_{\text{spCO}_2\text{aq}} = [\text{CO}_2\text{aq}] / [\text{CO}_2\text{gas}] / [\text{H}_2\text{O}] = \text{EXP}(-\Delta G_{\text{spCO}_2\text{aq}} / R / T) = \text{EXP}(-8379 / 8,3144 / 298,15) = 0,034045 \text{ and}$$

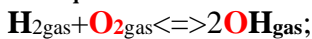
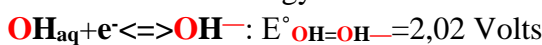
$$\text{Free energy increase } \Delta G_{\text{spCO}_2\text{aq}} = -R \cdot T \cdot \ln(K_{\text{spCO}_2\text{aq}}) = -8,3144 \cdot 298,15 \cdot \ln(0,034045) / 1000 = 8,379 \text{ kJ/mol}.$$

$$\text{CO}_2\text{aq} + 2\text{H}_2\text{O} + \Delta G + Q = v_1 \text{CA} > \text{H}_3\text{O}^+ + \text{HCO}_3^- \text{ velocity constant } k_1\text{CO}_2\text{aq} = 1,5 \times 10^8 \text{ M}^{-1}\text{s}^{-1} \quad [9]$$

$$\frac{[\text{HCO}_3^-]_{\text{aq}} \cdot [\text{H}_3\text{O}^+]}{[\text{CO}_2]_{\text{aq}} \cdot [\text{H}_2\text{O}]^2} = K_{\text{eqCAHCO}_3\text{aq}} = K_a \cdot \text{CO}_2\text{aq} / [\text{H}_2\text{O}]^2 = 10^{-7,0512} / 55,3^2 = 2,906 \cdot 10^{-11}. \text{ CA equilibrium constant}$$

$$\text{accumulate energy: } \Delta G_{\text{eqCO}_2\text{aq}} = -R \cdot T \cdot \ln(K_{\text{eqCO}_2\text{aq}}) = -8,3144 \cdot 298,15 \cdot \ln(2,906 \cdot 10^{(-11)}) / 1000 = 60,14 \text{ kJ/mol}.$$

$$\text{Accumulate free energy total is } G_{\text{H}_3\text{O}^+ + \text{HCO}_3^-} = \Delta G_{\text{spCO}_2\text{aq}} + \Delta G_{\text{eqCO}_2\text{aq}} = 8,379 + 60,14 = 68,52 \text{ kJ/mol} \quad [1,8,14]$$



$$G_{\text{H}_3\text{O}^+} = 22,44 \text{ kJ/mol}; G_{\text{OH}^-} = 77,36 \text{ kJ/mol};$$

$$G_{\text{H}_3\text{O}^+} + G_{\text{OH}^-} = \Delta G_{\text{eqH}_3\text{O}^+ + \text{OH}^-} + 2G^\circ_{\text{H}_2\text{gas}} + G^\circ_{\text{O}_2\text{gas}} = -374,58 + 2 \cdot 85,64 + 303,1 = 99,8 \text{ kJ/mol};$$

$$G_{\text{HOO}^-} = 440,76 - 22,44 = 418,32 \text{ kJ/mol}; G_{\text{H}_3\text{O}^+} + G_{\text{HOO}^-} = 22,44 + G_{\text{HOO}^-} = 440,76 \text{ kJ/mol};$$

$$G_{\text{H}_3\text{O}^+} + G_{\text{HOO}^-} = \Delta G_{\text{a}_\text{H}_2\text{O}_2} + G_{\text{H}_2\text{O}} + G_{\text{H}_2\text{O}_2} = 75,97 + 0 + 364,79 = 440,76 \text{ kJ/mol}.$$

$$G_{\text{HCO}_3^-} = 68,52 - 22,44 = 46,08 \text{ kJ/mol}; 22,44 + G_{\text{HCO}_3^-} = 68,52 \text{ kJ/mol}.$$

$$G_{\text{H}_3\text{O}^+} + G_{\text{HCO}_3^-} = 22,44 + 46,08 = \Delta G_{\text{spCO}_2\text{aq}} + \Delta G_{\text{eqCO}_2\text{aq}} = 8,379 + 60,14 = 68,52 \text{ kJ/mol} \quad [1,8,14]$$