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Prigogine absolute energy attractors for dissolution, protolysis, and reduction-oxidation of nitrogen compounds

Solubility $N_2^{gas}+H_2O+\Delta G=N_{2aq}$ increases molar nitrogen energy from G_{N2}^{gas}=**-9,55** $^{kJ}/_{mol}$ to G_{N2aq}=**18,7** $^{kJ}/_{mol}$.

Published content of Alberty dissolute nitrogen **absolute** free energy in one mol is G_{N2aqua}=**18,7** $^{kJ}/_{mol}$, if pure gas mol fraction is one $[N_2^{gas}]$=1. Hundred grams of water dissolute nitrogen gas 0,00175 $^{g}/_{100g\_H2O}$, which has density 996 g/L. [8,1] Solubility $K_{sp}=[N_{2aqua}]$=0,00175/100,00175*996/28,02=0,01743/28,02=0,000622045 M and Prigogine attractor constant is $K_{eq}=K_{sp}/[H_2O]$=0,000622045/55,3=$10^{-4,9489}$. Endoergonic Prigogine attractor for solubility reaction has positive: ΔG_{eq}=-R•T•ln(K_{eq})=-8,3144*298,15*ln(10^(-4,9489))=**28,25** $^{kJ}/_{mol}$ value.

Hess sum energy change coincides $\Delta G_{spHessN2aqua}=G_{N2aqua}-(G_{N2}^{gas}+G_{H2O})$=**18,7**-(**-9,55**+0)=**28,25** $^{kJ}/_{mol}$ within absolute free energy scale. One mol $G_{N2}^{gas}=G_{N2aqua}-(\Delta G_{spHessN2aqua}+G_{H2O})$=**18,7**-(**28,25**+0)=**-9,55** $^{kJ}/_{mol}$ contains the free energy below the zero reference for water G_{H2O}=0 $^{kJ}/_{mol}$. The molar energy of solute the content increases to G_{N2aqua}=**18,7** $^{kJ}/_{mol}$. It is activated solute N_{2aqua} at pH=7,36 . [8] Alberty

$2NH_{3aq}$ Formation $N_{2aq}+3H_{2aq}>2NH_{3aq}$ by energies G_{N2aq}=**18,7** $^{kJ}/_{mol}$, G_{H2aq}=**103,24** $^{kJ}/_{mol}$, G_{NH3aq}=**91,1** $^{kJ}/_{mol}$ from aqua elements is $2\Delta G_{Hess\_NH3aq}=2G_{NH3aq}-(G_{N2aq}+3*G_{H2aq})$=2***91,1056**-(**18,7**+3***103,24**)=2***-73,1** $^{kJ}/_{mol}$ exoergonic and from $N_2^{gas}+3H_2^{gas}>2NH_3^{gas}$ gaseous G_{N2}^{gas}=**-9,55** $^{kJ}/_{mol}$, G_{H2}^{gas}=**85,64** $^{kJ}/_{mol}$, G_{NH3}^{gas}=**81,67** $^{kJ}/_{mol}$ is exoergonic too $G_{Hess\_NH3}^{gas}=2G_{NH3}^{gas}-(G_{N2}^{gas}+3*G_{H2}^{gas})$=2***81,67**-(**-9,55**+3***85,64**)=**-84,03**=2***-42,015** $^{kJ}/_{mol}$. [8] Formation from the elements G_{N2}^{gas}=**-9,55** $^{kJ}/_{mol}$, G_{H2}^{gas}=**85,64** $^{kJ}/_{mol}$ in an exergonic, spontaneous reaction

$2\Delta G°_{NH3}^{gas}=2G_{NH3}^{gas}-(G_{N2}^{gas}+3*G_{H2}^{gas})$= 2***107,285**-(**-9,55**+3***85,64**)=2*-16,4 $^{kJ}/_{mol}$ the content per mole

$2G_{NH3}^{gas}=2\Delta G°_{NH3}^{gas}+(G_{N2}^{gas}+3*G_{H2}^{gas})$=2*-16,4+(**-9,55**+3***85,64**)=214,57=2***107,285** $^{kJ}/_{mol}$ of ammonia remains positive. [1,8]

Solubility $NH_3^{gas}+H_2O=NH_{3aq}$ the energy decreases to G_{NH3aq}=**91,1** $^{kJ}/_{mol}$ from G_{NH3}^{gas}=**107,3** $^{kJ}/_{mol}$ and is favorable Prigogine attractor $[NH_{3aq}]/[NH_3^{gas}]/[H_2O]=K_{eq}$=exp(-$\Delta G_{eq}$/R/T)=exp(**16200**/8,3144/298,15)=**688,87**. $\Delta G_{eq}=G_{NH3aq}-(G_{NH3}^{gas}+G_{H2O})$=**91,1**-(**107,3**+0)=**-16,2** $^{kJ}/_{mol}$. K_{eq}*$[H_2O]=[NH_{3aq}]$=**688,87***55,3=38094,5 M.

Dissolution is exothermic $\Delta H_{Hydration}=\Delta H°_{NH3aq}-\Delta H°_{NH3}^{gas}-\Delta H°_{H2O}$=**-132,5608**+45,94-**286,65**=-373,27 $^{kJ}/_{mol}$; Entropy decreases $S_{Hydration}=\Delta S°_{NH3aqua}-\Delta S°_{NH3}^{gas}-\Delta S°_{H2O}$=**-739,2922**-192,77-69,9565=**-1002** $^{J}/_{mol/K}$. Solubility product is exoergonic $\Delta G_{Hydration}=\Delta H_{Hydration}-T*\Delta S_{Hydration}$=-373,27-**298,15***-1,002=**-74,5237** $^{kJ}/_{mol}$. Constant is favorable, spontaneous, because the solubility (hydration) constant K_{sp} is greater than one:

$[NH_{3aq}]/[NH_3^{gas}]/[H_2O]=K_{eq}$=exp(-$\Delta G_{Hydration}$/**R/T**)=exp(**74523,7**/8,3144/298,15)=$10^{13,056}$.

NH_{3aq} solution $G_{NH3}^{gas}=\Delta G_{NH3aq}-(\Delta G_{Hydrations}+G_{H2O})$=**91,1056**-(**-74,5537**+0)=**165,7** $^{kJ}/_{mol}$;[1,8]

Solutions for ammonia at pH=7,36, as ammonia dissolves in water by spontaneously hydration. [1,8] Exoergonic reaction $NH_3^{gas}+H_2O=NH_{3aq}$ has free energy decrease from G_{NH3}^{gas}=**107,3** $^{kJ}/_{mol}$ to G_{NH3aq}=**91,1** $^{kJ}/_{mol}$.

Substance	$\Delta H°_H$ $^{kJ}/_{mol}$	$\Delta S°_H$ $^{J}/_{mol/K}$	$\Delta G°_H$ $^{kJ}/_{mol}$
N_2^{gas}	2***-42,015**	format NH_3	**-9,55**
N_{2aq}	**–10,54**	**98,1**	**18,7**
N_2^{gas}	$N_2^{gas}+H_2O=N_{2aq}$ pH=7,36		**-9,55**
NH_3^{gas}	$\Delta G_{Hydration}$	**-74,5537**	**165,7**
NH_3^{gas}	2*-16,4	formation	**107,285**
[1]NH_3^{gas}	–45,9	192,77	-16,4
NH_{3aq}	**-132,5608**	**-739,2922**	**87,859**
NH_{3aq}	pK_{beq}= 6,4947		**91,1**
NH_4^+	pK_{aeq}=10,99ΔG_{aeq}=62,73		**50,81**

G_{O2}^{gas}=**303,1** $^{kJ}/_{mol}$; G_{N2}^{gas}=**-9,55** $^{kJ}/_{mol}$; G_{H2}^{gas}=**85,6** $^{kJ}/_{mol}$;

$G_{N2}^{gas}=2G_{NH3}^{gas}-(2\Delta G°_{NH3}^{gas}+3*G_{H2}^{gas})$=**-9,55** $^{kJ}/_{mol}$;

Solution N_{2aq} at pH=7,36 [8] .

$G_{N2}^{gas}=G_{N2aqua}-(\Delta G_{sp\_N2aqua}+G_{H2O})$=**18,7**-(**28,25**+0)=**-9,55** $^{kJ}/_{mol}$;

$G_{NH3}^{gas}=\Delta G_{NH3aq}-(\Delta G_{Hydrations}+G_{H2O})$=**165,7** $^{kJ}/_{mol}$;[1,8]

[1,8] $2G_{NH3}^{gas}=2\Delta G°_{NH3}^{gas}+(G_{N2}^{gas}+3*G_{H2}^{gas})$=2***107,3** $^{kJ}/_{mol}$;

$\Delta G°_{NH3}^{gas}=\Delta H_H-T*\Delta S_H$=-45,9-298,15*0,19277=-103,37 $^{kJ}/_{mol}$;

$\Delta G=\Delta H_H-T*\Delta S_H$=**-132,5608**-298,15***-0,739292**=**87,859** $^{kJ}/_{mol}$;[8]

$G_{NH3aq}=G_{NH4+}+G_{OH-}-(\Delta G_{beq}+G_{H2O})$=**91,1** $^{kJ}/_{mol}$; Wikipedia [28]

$G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_a+G_{H2O})$=**50,81** $^{kJ}/_{mol}$;

The classical ammonia protolytic base $NH_{3aq}+H_2O=NH_4^++OH^-$ constant without accounting the water has $K_b=[NH_4^+]*[OH^-]/[NH_{3aq}]=10^{\wedge(-4,752)}$ the exponent value pK_b=4,752. [1] The thermodynamic base constant calculates from the protolysis equilibrium with accounting a water concentration $[H_2O]$=55,3 M

$K_{beq}=K_b/[H_2O]=[NH_4^+]*[OH^-]/[NH_{3aq}]/[H_2O]=10^{\wedge(-4,752)}/55,3=3,20*10^{\wedge(-7)}=10^{\wedge(-6,4947)}$.

The Prigogine attractor constant of ammonia protolysis is pK_{beq}=6,4947 endoergonic, because the absolute free energy change by attractor and in Hess sum is positive and identical:

ΔG_{beq}=-R•T•ln(K_{beq})=-8,3144*298,15*ln(10^(-6,4947))=$G_{NH4+}+G_{OH-}-(G_{NH3aq}+G_{H2O})$=**37,0715** $^{kJ}/_{mol}$;

$\Delta G_{Hess\_beq}=G_{NH4+}+G_{OH-}-(G_{NH3aq}+G_{H2O})$=**50,81**+77,36-(**91,0985**+**0**)=**37,0715** $^{kJ}/_{mol}$. Wikipedia [28]

$G_{NH3aq}=G_{NH4+}+G_{OH-}-(\Delta G_{beq}+G_{H2O})$=**50,81**+77,36-(**37,0715**+**0**)=**91,0985** $^{kJ}/_{mol}$.

The protolysis of a weak acid $NH_4^++H_2O=NH_{3aq}+H_3O^+$ pK_{aeq}=10,99 is the minimum of the endoergonic ΔG_{aeq}=-R•T•ln(K_{aeq})=-8,3144*298,15*ln(10^(-10,99))=$G_{NH3Hydration}+G_{H3O}-G_{NH4+}-G_{H2O}$=**62,73** $^{kJ}/_{mol}$ standard energy change in the Prigogine attractor ΔG_{aeq}=-R•T•ln(K_{aeq}). The free energy content of ammonium per mole is

$G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_a+G_{H2O})$=**91,0985**+22,44-(**62,73**+0)=**50,81** $^{kJ}/_{mol}$.

The free energy content of one mole ammonia in water solution is G_{NH3aq}=**91,1** kJ/mol .
Endoergonic ammonia protolysis accumulates energy in the products $G_{NH4+}+G_{OH-}$=**50,81**+77,36=**128,17** kJ/mol.
The classic acid $NH_4^+=H^++NH_{3aqua}$ protolysis pK_a=9,25 does not include water like as zero G_{H2O}=0 kJ/mol.
Formation G_{N2aq}=**18,7** kJ/mol; G_{H2aq}=**103,2** kJ/mol; G_{N2}^{gas}=**-9,55** kJ/mol; G_{H2}^{gas}=**85,6** kJ/mol; $0{,}5N_2^{gas}+2H_2^{gas}=NH_4^+ + e^-$;

$\Delta G°_{NH4+}= G_{NH4+}+G_{e-}-(0{,}5N_2^{gas}+2H_2^{gas})$=**50,81**+**36,315**-(**-9,55**/2+2***85,6**)=-79,3 kJ/mol; [1,8]

$G_{e-}=\Delta G°_{NH4+}-G_{NH4+}+(0{,}5N_2^{gas}+2H_2^{gas})$=-79,3-**50,81**+(**-9,55**/2+2***85,6**)=**36,315** kJ/mol; [1,8]

G_{N2}^{gas}=**-9,55** kJ/mol; G_{H2}^{gas}=**85,6** kJ/mol; G_{O2}^{gas}=**303,1** kJ/mol; $\Delta G°_{HNO3}$=**-109,55** kJ/mol, $\Delta G°_{NO2-}$=**-33,01** kJ/mol. [8]

$G_{HNO3}=\Delta G°_{HNO3}+(0{,}5G_{N2}^{gas}+$**1,5**$G_{O2}^{gas}+0{,}5G_{H2}^{gas})$=-80,7+(0,5*-9,55+1,5***303,1**+**0,5*85,6**)= 411,975 kJ/mol; [1]

$G_{e-}=G_{NO3-}-(0{,}5G_{N2}^{gas}+$**1,5**$G_{O2}^{gas}+\Delta G°_{NO3-})$=**395,445**-(0,5*-9,55+1,5***303,1-109,55**)=**55,12** kJ/mol; [8]

$G_{e-}=G_{NO3-}-(0{,}5G_{N2}^{gas}+$**1,5**$G_{O2}^{gas}+\Delta G°_{NO3-})$=**395,445**-(0,5*-9,55+1,5***303,1**-111,3)=**56,87** kJ/mol; [1,8]

$G_{HNO2}=\Delta G°_{HNO2}+0{,}5G_{N2}^{gas}+G_{O2}^{gas}+0{,}5G_{H2}^{gas}$=-46+(0,5*-**9,55**+**303,1**+0,5***85,6**)=**295,025** kJ/mol; [1,8]

$G_{e-}=G_{NO2-}-(0{,}5G_{N2}^{gas}+G_{O2}^{gas}+\Delta G°_{NO2-})$=**300,513**-(0,5*-**9,55**+**303,1**-32,2)=**34,388** kJ/mol; [1,8]

$G_{e-}=G_{NO2-}-(0{,}5N_2^{gas}+O_2^{gas}+\Delta G°_{NO2-})$=**300,513**-(0,5*-**9,55**+**303,1-33,01**)=**35,198** kJ/mol; [8]

Formation from elements $\Delta G°_{NO}^{gas}=G_{NO}^{gas}-0{,}5G_{N2}^{gas}-G_{O2}/2$=**234,375**-0,5*-**9,55-303,1**/2=87,6 kJ/mol. [1,8]

Content in one mol $G_{NO}^{gas}{}_{Form}=\Delta G°_{NO}^{gas}+0{,}5G_{N2}^{gas}+G_{O2}/2$=87,6+0,5*-**9,55**+**303,1**/2=**234,375** kJ/mol. [1,8]

Substance	$\Delta H°_H$ kJ/mol	$\Delta S°_H$ J/mol/K	$\Delta G°_H$, kJ/mol
HNO_2	$E°_{HNO2}$=	**0,86926** V	**295,025**
HNO_2	protolīze	pK_a=3,15	**295,025**
HNO_2	-79,5	254,1	-46,0
HNO_2	Formation	-46,0	**295,025**
NO_2^-	-104,6	-123,0	-32,2
NO_2^- Ge-	formation	-32,2	**34,388**
NO_2^-	**-104,19**	**-238,7**	**-33,01**
NO_2^- Ge-	formation	**-33,01**	**35,198**
NO_2^-	$E°_{NO2-}$=	**0,81776** V	**300,97**
NO_2^-	protolysis	pK_a=3,15	**300,513**
NO_2^-	$E°_{NO2\text{-}O\,H}$=	**-0,31223V**	**300,97**
HNO_3	-174,1	155,6	-80,7
HNO_3	formation	-80,7	**242,145**
HNO_3	protolysis	pK_a=-1,4	**415,929**
HNO_3	$E°_{NOaq}$=	**0,89226** V	**426,39255**
NO_3^-	**-204,59**	**-318,8**	**-109,55**
NO_3^- Ge-	formation	**-109,55**	**55,12**
NO_3^-	$E°_{NO\text{–}NO3-}$=	**0,81776 V**	**413,89**
NO_3^-	$E°_{HNO2}$	**0,86926** V	**395,445**
NO_3^-	$E°_{NO2\text{-}O\,H}$=	**-0,31223V**	**395,4445**
NO_3^-	$E°_{NOaq}$=	**0,89226** V	**413,89**
NO_3^-	$E°_{NH4+H2O}$=	**0,766637**	**418,16**
NO_3^-	-207,4	146,4	-111,3
NO_3^- Ge-	formation	-111,3	**56,87**
NO_3^-	protolysis	pK_a=-1,4	**395,445**
NO^{gas}	91,3	210,8	87,6
NO^{gas}	formation	87,6	**234,375**
NO^{gas}	Solubility$\mathbf{K_{eq}}$=10^(-4,472)		**207,749**
NO_{aq}	formation	pH=7,36	**86,55**
NO_{aq}	formation	**86,55**	**233,325**
pH>1,4 NO_{aq}	$E°_{NOaq}$=	**0,89226** V	**245,381**
NH_4^+	-132,5	113,4	-79,3
NH_4^+ G_{e-}	formation	-79,3	**36,315**
NH_4^+	pK_a=10,99ΔG_a=62,73		**50,81**

$G_{HNO2}=G_{NO3-}+3\mathbf{G_{H3O}}-(\Delta\mathbf{G_{eq}}_{NO3}+4\mathbf{G_{H2O}})$=**295,025** kJ/mol;

$G_{HNO2}=G_{NO2-}+\mathbf{G_{H3O}}-(\Delta G_{eqHNO2}+\mathbf{G_{H2O}})$=**295,025** kJ/mol;

CRC [1]

$G_{HNO2}^{gas}=\Delta G°_{HNO2}^{gas}+0{,}5G_{N2}^{gas}+$**1**$G_{O2}^{gas}+0{,}5G_{H2}^{gas}$=**295** kJ/mol

[1] $\Delta G°=\Delta H-T*\Delta S$=-104,6-298,15*-0,123=-33,02 kJ/mol; [1]

$G_{e-}=G_{NO2-}-(0{,}5G_{N2}^{gas}+G_{O2}^{gas}+\Delta G°_{NO2-})$=**34,388** kJ/mol;

$\Delta G°=\Delta H-T*\Delta S$=**-104,19**-298,15***-0,2387**=**-33,02** kJ/mol; [8] pH=7,36

$G_{e-}=G_{NO2-}-(0{,}5N_2^{gas}+O_2^{gas}+\Delta G°_{NO2-})$=**35,198** kJ/mol;

$G_{NO2-}=G_{NO3-}+2\mathbf{G_{H3O}}-(\Delta\mathbf{G_{eq}}_{NO2-}+3\mathbf{G_{H2O}})$=**300,97** kJ/mol;

$G_{NO2-}=\Delta G_{eqHNO2}-G_{H3O}+(G_{HNO2}+G_{H2O})$=**300,513** kJ/mol;

$G_{NO2-}=G_{NO3-}+\mathbf{G_{H2O}}-(\Delta\mathbf{G_{eq}}_{NO3-OH}+2\mathbf{G_{OH}})$=**300,97** kJ/mol;

$\Delta G°_{NO3-}=\Delta H_H-T*\Delta S_H$=-207-298,15*0,146=-250,5886 kJ/mol; [1]

$G_{HNO3Form}=\Delta G°_{HNO3}+(0{,}5G_{N2}^{gas}+$**1,5**$G_{O2}^{gas}+0{,}5G_{H2}^{gas})$=**242,145** kJ/mol;

$G_{HNO3}=G_{NO3-}+G_{H3O}-(\Delta G_{eqHNO3}+G_{H2O})$=**415,929** kJ/mol;

$G_{HNO3}=\Delta\mathbf{G_{eq}}_{NO(g)H3O+}-3\mathbf{G_{H3O}}+(G_{NOaq}+5\mathbf{G_{H2O}})$= **426,39255** kJ/mol;

$\Delta G=\Delta H-T\Delta S$=**-204,59**-298,15***-0,3188**=**-109,54** kJ/mol; [8] pH=7,36

$G_{e-}=G_{NO3-}-(0{,}5G_{N2}^{gas}+$**1,5**$G_{O2}^{gas}+\Delta G°_{NO3-})$=**55,12** kJ/mol;

$G_{NO3-}=\Delta\mathbf{G_{eq}}_{NO2-}-2\mathbf{G_{H3O}}+(G_{NO2-}+3\mathbf{G_{H2O}})$=**413,89** kJ/mol;

$G_{NO3-}=\Delta\mathbf{G_{eq}}_{NO3}-3\mathbf{G_{H3O}}+(G_{HNO2}+4\mathbf{G_{H2O}})$=**395,445** kJ/mol,

$G_{NO3-}=\Delta\mathbf{G_{eq}}_{NO3-OH}-\mathbf{G_{H2O}}+(G_{NO2-}+2\mathbf{G_{OH}})$=**395,4445** kJ/mol;

$G_{NO3-}=\Delta\mathbf{G_{eq}}_{NO(g)H3O+}-4\mathbf{G_{H3O}}+(G_{NOaq}+6\mathbf{G_{H2O}})$=**413,89** kJ/mol;

$G_{NO3-}=\Delta\mathbf{G_{eq}}_{NH4+H2O}-10\mathbf{G_{H3O}}+(G_{NH4+}+13\mathbf{G_{H2O}})$=**418,16** kJ/moll;

$\Delta G°_{NO3-}=\Delta H_H-T*\Delta S_H$=-206,85-298,15*0,1467=-250,5886 kJ/mol; [1]

$G_{e-}=G_{NO3-}-(0{,}5G_{N2}^{gas}+$**1,5**$G_{O2}^{gas}+\Delta G°_{NO3-})$=**56,87** kJ/mol;

$G_{NO3-}=\Delta G_{eqHNO3}-\mathbf{G_{H3O}}+(G_{HNO3}+\mathbf{G_{H2O}})$=**395,445** kJ/mol;

[1]

$G_{NO}^{gas}{}_{Form}=\Delta G°_{NO}^{gas}+0{,}5G_{N2}^{gas}+$**0**$,5G_{O}^{gas}$=**234,375** kJ/mol; [1,8]

$G_{NO}^{gas}=G_{NOaq}-(G_{H2O}+\Delta G_{eq})$=**233,275**-(**0**+**25,526**)=**207,749** kJ/mol;

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$G_{NOaq}=\Delta G°_{NOaq\_Form}+0{,}5G_{N2}^{gas}+0{,}5G_{O}^{gas}$=**233,325** kJ/mol; [8]

$G_{NOaq}=G_{NO3-}+4\mathbf{G_{H3O}}-(\Delta\mathbf{G_{eq}}_{NO(g)H3O+}+6\mathbf{G_{H2O}})$=**245,381** kJ/mol;

$\Delta\Gamma°_{NH4+}=\Delta H_H\square T*\Delta\Sigma_H=-132{,}5-298{,}15*0{,}1134=-166{,}31$ кэ/моль; [1]

$G_{e-}=\Delta G°_{NH4+}-G_{NH4+}+(0{,}5N_2^{gas}+2H_2^{gas})$=**36,315** kJ/mol;

$G_{NH4+}=G_{NH3aq}+G_{H3O}-(\Delta G_{aeq}+\mathbf{G_{H2O}})$=**91,1**+22,44-62,73-**0**=**50,81** kJ/mol;

Nernst oxidation and inverse **reduction** absolute potentials and **Prigogine attractors** of nitrogen compounds.

$HNO_2+4H_2O=NO_3^-+3H_3O^++2e^-$; pH<3,15; Expression of potential has standard $E°_{Classic}$=0,94 V [18], water logarithm and $\Delta E°$: $E°_{NO3}=E°_{classic}-0{,}0591/2*\lg(1/[H_2O]^4)+\Delta E°$=0,934+0,206+0,10166-0,37239=**0,8693** V;

$$E_{NO3}=E°_{NO3}+0{,}0591/2\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^3}{[HNO_2]\cdot[H_2O]^4}=\mathbf{0{,}86926}\ V+0{,}0591/2\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^3}{[HNO_2]\cdot[H_2O]^4}$$

$$\Delta G_{eqNO3}=E°_{NO3}\bullet F\bullet 2=\mathbf{0{,}86926}*96485*2=\mathbf{167{,}74}\ {}^{kJ}/_{mol},$$

$$\Delta G_{eqNO3}=G_{NO3-}+3\mathbf{G_{H3O}}+2G_{e-}-(G_{HNO2}+4\mathbf{G_{H2O}})=\mathbf{395{,}445}+3*22{,}44+2*\mathbf{0}-(\mathbf{295{,}025}+4*0)=\mathbf{167{,}74}\ {}^{kJ}/_{mol},$$

$$G_{HNO2}=G_{NO3-}+3\mathbf{G_{H3O}}+2G_{e-}-(\Delta\mathbf{G_{eqNO3}}+4\mathbf{G_{H2O}})=\mathbf{395{,}445}+3*22{,}44+2*\mathbf{0}-(\mathbf{167{,}74}+4*0)=\mathbf{295{,}025}\ {}^{kJ}/_{mol};$$

$$G_{NO3-}=\Delta\mathbf{G_{eqNO3}}-3\mathbf{G_{H3O}}-2G_{e-}+(G_{HNO2}+4\mathbf{G_{H2O}})=\mathbf{167{,}74}-3*22{,}44-2*\mathbf{0}+(\mathbf{295{,}025}+4*0)=\mathbf{395{,}445}\ {}^{kJ}/_{mol}.$$

$$2G_{e-}=\Delta\mathbf{G_{eqNO3}}-G_{NO3-}-3\mathbf{G_{H3O}}++(G_{HNO2}+4\mathbf{G_{H2O}})=\mathbf{167{,}74}-\mathbf{395{,}445}-3*22{,}44+(\mathbf{295{,}025}+4*0)=2*\mathbf{0}\ {}^{kJ}/_{mol},$$

Acid protolysis constant $K_{eq}=K_a/[H_2O]$ calculate dividing the classic acid constant by water $[\mathbf{H_2O}]=55{,}3$ M.

1. $HNO_2+H_2O=NO_2^-+H_3O^+$; $pK_a=3.15$; $K_{eq}=K_a/[\mathbf{H_2O}]=10^{\wedge(-3.15)}/55{,}3=0{,}0000128$; Prigogine endoergonic attractor is positive $\Delta G_{eqHNO2}=-R\bullet T\bullet\ln(K_{eq})=-8{,}3144*298{,}15*\ln(0{,}0000128)=G_{NO2-}+\mathbf{G_{H3O}}-(G_{HNO2}+\mathbf{G_{H2O}})=\mathbf{27{,}928}\ {}^{kJ}/_{mol}$

and Hess expression too $\Delta G_{eqHNO2}=G_{NO2-}+\mathbf{G_{H3O}}-(G_{HNO2}+\mathbf{G_{H2O}})=\mathbf{300{,}513}+\mathbf{22{,}44}-(\mathbf{295{,}025}+\mathbf{0})=\mathbf{27{,}928}\ {}^{kJ}/_{mol}$;

$$G_{NO2-}=\Delta G_{eqHNO2}-\mathbf{G_{H3O}}+(G_{HNO2}+\mathbf{G_{H2O}})=\mathbf{27{,}928}-\mathbf{22{,}44}+(\mathbf{295{,}025}+\mathbf{0})=\mathbf{300{,}513}\ {}^{kJ}/_{mol};$$

$$G_{HNO2}=G_{NO2-}+\mathbf{G_{H3O}}-(\Delta G_{eqHNO2}+\mathbf{G_{H2O}})=\mathbf{300{,}513}+\mathbf{22{,}44}-(\mathbf{27{,}928}+\mathbf{0})=\mathbf{295{,}025}\ {}^{kJ}/_{mol};$$

2. $HNO_3+H_2O=NO_3^-+H_3O^+$; $pK_a=-1{,}4$; $K_{eq}=K_a/[\mathbf{H_2O}]=10^{\wedge(1{,}4)}/55{,}3=0{,}4542$; Endoergonic Prigogine attractor is positive: $\Delta G_{eqHNO3}=-R\bullet T\bullet\ln(K_{eq})=-8{,}3144*298{,}15*\ln(0{,}4542)=G_{NO3-}+\mathbf{G_{H3O}}-(G_{HNO3}+\mathbf{G_{H2O}})=\mathbf{1{,}956}\ {}^{kJ}/_{mol}$

and Hess equation too $\Delta G_{eqHNO3}=G_{NO3-}+\mathbf{G_{H3O}}-(G_{HNO3}+\mathbf{G_{H2O}})=\mathbf{340{,}175}+\mathbf{22{,}44}-(\mathbf{360{,}68}+\mathbf{0})=\mathbf{1{,}956}\ {}^{kJ}/_{mol}$;

$$G_{HNO3}=G_{NO3-}+\mathbf{G_{H3O}}-(\Delta G_{eqHNO3}+\mathbf{G_{H2O}})=\mathbf{340{,}175}+\mathbf{22{,}44}-(\mathbf{1{,}956}+\mathbf{0})=\mathbf{360{,}68}\ {}^{kJ}/_{mol};$$

$$G_{NO3-}=\Delta G_{eqHNO3}-\mathbf{G_{H3O}}+(G_{HNO3}+\mathbf{G_{H2O}})=\mathbf{1{,}956}-\mathbf{22{,}44}+(\mathbf{360{,}68}+\mathbf{0})=\mathbf{340{,}175}\ {}^{kJ}/_{mol};$$

$NO_2^-+2OH^-=NO_3^-+H_2O+\mathbf{2e^-}$; pH>7 Expression of potential has standard $E°_{classic}=0{,}01$ V [1], water logarithm and $\Delta E°$: $E°_{NO3-OH}=E°_{classic}-0{,}0591/2*\lg([H_2O])+\Delta E°=0{,}01-0{,}0515+0{,}10166-0{,}37239=\mathbf{-0{,}3122}$ V;

$$E_{NO3-OH}=E°_{NO3-OH}+0{,}0591/2\bullet\log\frac{[NO_3^-]\cdot[H_2O]}{[NO_2^-]\cdot[OH^-]^2}=\mathbf{-0{,}3122}\ V+0{,}0591/2\bullet\log\frac{[NO_3^-]\cdot[H_2O]}{[NO_2^-]\cdot[OH^-]^2}$$

$$\Delta G_{eqNO3-O\,H}=E°_{NO3-O\,H}\bullet F\bullet 2=\mathbf{-0{,}3122}*96485*2=\mathbf{-60{,}245}\ {}^{kJ}/_{mol};$$

$$\Delta G_{eqNO3-OH}=G_{NO3-}+\mathbf{G_{H2O}}+2G_{e-}-(G_{NO2-}+2\mathbf{G_{OH}})=\mathbf{395{,}445}+0+2*\mathbf{0}-(\mathbf{300{,}97}+2*77{,}36)=\mathbf{-60{,}245}\ {}^{kJ}/_{mol};$$

$$G_{NO3-}=\Delta G_{eqNO3-OH}-\mathbf{G_{H2O}}-2G_{e-}+(G_{NO2-}+2\mathbf{G_{OH}})=\mathbf{-60{,}2455}-0-2*\mathbf{0}+(\mathbf{300{,}97}+2*77{,}36)=\mathbf{395{,}4445}\ {}^{kJ}/_{mol};$$

$$G_{NO2-}=G_{NO3-}+\mathbf{G_{H2O}}+2G_{e-}-(\Delta G_{eqNO3-OH}+2\mathbf{G_{OH}})=\mathbf{395{,}445}+0+2*\mathbf{0}-(\mathbf{-60{,}245}+2*77{,}36)=\mathbf{300{,}97}\ {}^{kJ}/_{mol};$$

$$2G_{e-}=\Delta G_{eqNO3-OH}-G_{NO3-}-\mathbf{G_{H2O}}++(G_{NO2-}+2\mathbf{G_{OH}})=\mathbf{-60{,}245}-\mathbf{395{,}445}-0+(\mathbf{300{,}97}+2*77{,}36)=2*\mathbf{0}\ {}^{kJ}/_{mol};$$

$NO_2^-+3H_2O=NO_3^-+2H_3O^++\mathbf{2e^-}$; pH>3,15 Expression of potential has standard $E°_{classic}=0{,}934$ V [1], water logarithm and $\Delta E°$: $E°_{NO2-}=E°-0{,}0591/2*\lg(1/[H_2O]^3)+\Delta E°=0{,}934+0{,}1545+0{,}10166-0{,}37239=\mathbf{0{,}81776}$ V

$$\Delta G_{eqNO2-}=E°_{NO2-}\bullet F\bullet 2=\mathbf{0{,}817763}*96485*2=\mathbf{157{,}8}\ {}^{kJ}/_{mol};$$

$$\Delta G_{eqNO2-}=G_{NO3-}+2\mathbf{G_{H3O}}+2G_{e-}-(G_{NO2-}+3\mathbf{G_{H2O}})=\mathbf{413{,}89}+2*22{,}44+2*\mathbf{0}-(\mathbf{300{,}97}+3*0)=\mathbf{157{,}8}\ {}^{kJ}/_{mol};$$

$$G_{NO3-}=\Delta G_{eqNO2-}-2\mathbf{G_{H3O}}-2G_{e-}+(G_{NO2-}+3\mathbf{G_{H2O}})=\mathbf{157{,}8}-2*22{,}44-2*\mathbf{0}+(\mathbf{300{,}97}+3*0)=\mathbf{413{,}89}\ {}^{kJ}/_{mol};$$

$$G_{NO2-}=G_{NO3-}+2\mathbf{G_{H3O}}+2G_{e-}-(\Delta G_{eqNO2-}+3\mathbf{G_{H2O}})=\mathbf{413{,}89}+2*22{,}44+2*\mathbf{0}-(\mathbf{157{,}8}+3*0)=\mathbf{300{,}97}\ {}^{kJ}/_{mol};$$

$$2G_{e-}=\Delta G_{eqNO2-}-G_{NO3-}-2\mathbf{G_{H3O}}+(G_{NO2-}+3\mathbf{G_{H2O}})=\mathbf{157{,}8}-\mathbf{413{,}89}-2*22{,}44+(\mathbf{300{,}97}+3*0)=\mathbf{0}\ {}^{kJ}/_{mol};$$

[1] Formation $G_{NO}=\Delta G°_{NO}+0{,}5N_2{}^{gas}+0{,}5O_2{}^{gas}=87{,}6+(0{,}5*\mathbf{-9{,}55}+0{,}5*\mathbf{303{,}1})=\mathbf{234{,}375}\ {}^{kJ}/_{mol}$;

[18] Formation $G_{NOaq\_Form}=\Delta G°_{NOaq}+0{,}5G_{N2}{}^{gas}+0{,}5G_{O}{}^{gas}=\mathbf{86{,}55}+(0{,}5*\mathbf{-9{,}55}+0{,}5*\mathbf{303{,}1})=\mathbf{233{,}325}\ {}^{kJ}/_{mol}$;

https://en.wikipedia.org/wiki/Nitric_oxide ($w\%=0{,}0056/(0{,}00562+99{,}6)*100=0{,}0056222\%$;)

Molarity $M_{NO}=30{,}006\ {}^{g}/_{mol}$; solubility NO^{gas} $0{,}00562\ {}^{g}/_{99{,}6g}$ 20 C ;product $[NO_{aq}]=(0{,}00562/100*996)/30{,}006=0{,}001865$ M, if pure gas mol fraction is one $[NO^{(g)}]=1$;

Solubility $NO^{gas}+H_2O=NO_{aq}$ constant is $\mathbf{K_{eq}}=[NO_{aq}]/[NO^{gas}]/[H_2O]=0{,}001865/1/55{,}3=10^{\wedge(-4{,}472)}$.

Prigogine attractor is $\Delta\mathbf{G_{eq}}=\mathbf{-R\bullet T\bullet\ln(K_{eq})}=-8{,}3144*298{,}15*\ln(10^{\wedge(-4{,}472)})=-8{,}3144\bullet 298{,}15\bullet -10{,}297=\mathbf{25{,}5256}\ {}^{kJ}/_{mol}$;

Hess expression for standard is $\Delta G_{eq}=G_{NOaq}-(G_{H2O}+G_{NO}{}^{gas})=\mathbf{233{,}275}-(\mathbf{0}+G_{NO}{}^{gas})=\mathbf{25{,}5256}\ {}^{kJ}/_{mol}$. Energy content is $G_{NO}{}^{gas}=G_{NOaq}-(G_{H2O}+\Delta G_{eq})=\mathbf{233{,}275}-(\mathbf{0}+\mathbf{25{,}5256})=\mathbf{207{,}749}\ {}^{kJ}/_{mol}$ with Prigogine attractor $\Delta G_{eq}=\mathbf{25{,}5256}\ {}^{kJ}/_{mol}$;

$NO_{aq}+6H_2O=NO_3^-+4H_3O^++\mathbf{3e^-}$; pH>-1,4; Expression of potential has standard $E°_{Classic}=0{,}957$ V [1], water logarithm, $\Delta E°$: $E°_{NO(g)H3O+}=E°_{classic}-0{,}0591/3*\lg(1/[H_2O]^6)+\Delta E°=0{,}957+0{,}206+0{,}10166-0{,}37239=\mathbf{0{,}89226}$ V;

$$E_{NO(g)H3O+}=E°_{NO-NO3-}+0{,}0591/3\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^6}=\mathbf{0{,}89226}\ V+0{,}0197\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^4}{[NO_{aq}]\cdot[H_2O]^6}$$

$$\Delta G_{eqNO(g)H3O+}=E°_{NO(g)H3O+}\bullet F\bullet 3=\mathbf{0{,}89226}*96485*3=\mathbf{258{,}2691}\ {}^{kJ}/_{mol};$$

$$\Delta G_{eqNO(g)H3O+}=G_{NO3-}+4\mathbf{G_{H3O}}+3G_{e-}-(G_{NOaq}+6\mathbf{G_{H2O}})=\mathbf{413{,}89}+4*22{,}44+3*\mathbf{0}-(\mathbf{245{,}381}+6*0)=\mathbf{258{,}2691}\ {}^{kJ}/_{mol};$$

$$G_{NOaq}=G_{NO3-}+4\mathbf{G_{H3O}}+3G_{e-}-(\Delta G_{eqNO(g)H3O+}+6\mathbf{G_{H2O}})=\mathbf{413{,}89}+4*22{,}44+3*\mathbf{0}-(\mathbf{258{,}2691}+6*0)=\mathbf{245{,}381}\ {}^{kJ}/_{mol};$$

$$G_{NO3-}=\Delta G_{eqNO(g)H3O+}-4\mathbf{G_{H3O}}-3G_{e-}+(G_{NOaq}+6\mathbf{G_{H2O}})=\mathbf{258{,}2691}-4*22{,}44-3*\mathbf{0}+(\mathbf{245{,}381}+6*0)=\mathbf{413{,}89}\ {}^{kJ}/_{mol};$$

$$3G_{e-}=\Delta G_{eqNO(g)H3O+}-G_{NO3-}-4\mathbf{G_{H3O}}+(G_{NOaq}+6\mathbf{G_{H2O}})=\mathbf{258{,}269}-\mathbf{413{,}89}-4*22{,}44+(\mathbf{245{,}381}+6*0)=3*\mathbf{0{,}000}\ {}^{kJ}/_{mol};$$

Solubility of gas NO^{gas} compensate water molecule from $6H_2O$ to $5H_2O$:and $NO_3^-+H_3O^+=HNO_3+H_2O$**;** $NO_{aq}+5H_2O=HNO_3+3H_3O^++\mathbf{3e^-}$; pH<-1,4; Expression of potential has standard $E°_{Classic}$=0,957 V [1], water logarithm, ΔE°: $E°_{NO(g)H3O+}=E°_{classic}-0{,}0591/3*\lg(1/[H_2O]^5)+\Delta E°$=0,957+0,17166+0,10166-0,37239=**0,857928** V;

$$E_{NO(g)H3O+}=E°_{NO\text{-}NO3\text{-}}+0{,}0591/3\bullet\log\frac{[HNO_3]\cdot[H_3O^+]^3}{[NO_{aq}]\cdot[H_2O]^5}=\mathbf{0{,}857928}\text{ V}+0{,}0197\bullet\log\frac{[HNO_3]\cdot[H_3O^+]^3}{[NO_{aq}]\cdot[H_2O]^5}$$

$\Delta\mathbf{G_{eq}}_{NO(g)H3O+}=E°_{NO(g)H3O+}\bullet F\bullet 3=\mathbf{0{,}857928}*96485*3=\mathbf{248{,}33155}$ $^{kJ}/_{mol}$;

$\Delta\mathbf{G_{eq}}_{NO(g)H3O+}=G_{HNO3}+3\mathbf{G_{H3O}}+3G_{e\text{-}}-(G_{NOaq}+5\mathbf{G_{H2O}})=\mathbf{426{,}39255}+3*22{,}44+3*\mathbf{0}-(\mathbf{245{,}381}+5*0)=\mathbf{248{,}33155}$ $^{kJ}/_{mol}$;

$G_{NOaq}=G_{HNO3}+3\mathbf{G_{H3O}}+3G_{e\text{-}}-(\Delta\mathbf{G_{eq}}_{NO(g)H3O+}+5\mathbf{G_{H2O}})=\mathbf{426{,}39255}+3*22{,}44+3*\mathbf{0}-(\mathbf{248{,}33155}+5*0)=\mathbf{245{,}381}$ $^{kJ}/_{mol}$;

$G_{HNO3}=\Delta\mathbf{G_{eq}}_{NO(g)H3O+}-3\mathbf{G_{H3O}}-3G_{e\text{-}}+(G_{NOaq}+5\mathbf{G_{H2O}})=\mathbf{248{,}33155}-3*22{,}44-3*\mathbf{0}+(\mathbf{245{,}381}+5*0)=\mathbf{426{,}39255}$ $^{kJ}/_{mol}$;

$3G_{e\text{-}}=\Delta\mathbf{G_{eq}}_{NO(g)H3O+}-G_{HNO3}-3\mathbf{G_{H3O}}+(G_{NOaq}+5\mathbf{G_{H2O}})=\mathbf{248{,}33155}-\mathbf{426{,}39255}-3*22{,}44+(\mathbf{245{,}381}+5*0)=3*\mathbf{0{,}00}$ $^{kJ}/_{mol}$;

$NH_4^++13H_2O=NO_3^-+10H_3O^++\mathbf{8e^-}$; Expression of potential has standard $E°_{classic}$=0,87 V [17], water logarithm and ΔE°: $E°_{NH4+H2O}=E°_{classic}-0{,}0591/8*\lg(1/[H_2O]^{13})+\Delta E°$=0,87+0,16737+0,10166-0,37239=**0,766637** V;

$$\text{pH>1,4 } E_{NH4+H2O}=E°_{NH4+H2O}+0{,}0591/8\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^{10}}{[NH_4^+]\cdot[H_2O]^{13}}=\mathbf{0{,}766637}\text{ V}+0{,}00739\bullet\log\frac{[NO_3^-]\cdot[H_3O^+]^{10}}{[NH_4^+]\cdot[H_2O]^{13}}$$

$\Delta\mathbf{G_{eq}}_{NH4+H2O}=E°_{NH4+H2O}\bullet F\bullet 8=\mathbf{0{,}766637}*96485*8=\mathbf{591{,}75}$ $^{kJ}/_{mol}$,

$\Delta\mathbf{G_{eq}}_{NH4+H2O}=G_{NO3-}+10\mathbf{G_{H3O}}+8G_{e\text{-}}-(G_{\mathbf{NH4+}}+13\mathbf{G_{H2O}})=\mathbf{418{,}16}+10*22{,}44+8*\mathbf{0}-(\mathbf{50{,}81}+13*\mathbf{0})=\mathbf{591{,}75}$ $^{kJ}/_{mol}$;

$G_{NO3-}=\Delta\mathbf{G_{eq}}_{NH4+H2O}-10\mathbf{G_{H3O}}-8G_{e\text{-}}+(G_{\mathbf{NH4+}}+13\mathbf{G_{H2O}})=\mathbf{591{,}75}-10*22{,}44-8*\mathbf{0}+(\mathbf{50{,}81}+13*\mathbf{0})=\mathbf{418{,}16}$ $^{kJ}/_{mol}$;

$G_{\mathbf{NH4+}}=G_{NO3-}+10\mathbf{G_{H3O}}+8G_{e\text{-}}-(\Delta\mathbf{G_{eq}}_{NH4+H2O}+13\mathbf{G_{H2O}})=\mathbf{418{,}16}+10*22{,}44+8*\mathbf{0}-(\mathbf{591{,}75}+13*\mathbf{0})=\mathbf{50{,}81}$ $^{kJ}/_{mol}$;

$8G_{e\text{-}}=\Delta\mathbf{G_{eq}}_{NH4+H2O}-G_{NO3-}-10\mathbf{G_{H3O}}+(G_{\mathbf{NH4+}}+13\mathbf{G_{H2O}})=\mathbf{591{,}75}-\mathbf{418{,}16}-10*22{,}44+(\mathbf{50{,}81}+13*\mathbf{0})=8*\mathbf{0{,}0}$ $^{kJ}/_{mol}$;

Formation $0{,}5N_2^{gas}+2H_2^{gas}=NH_4^++\mathbf{e^-}$;

$\Delta G°_{NH4+}=G_{NH4+}+G_{e\text{-}}-(0{,}5N_2^{gas}+2H_2^{gas})=\mathbf{36{,}315}+\mathbf{50{,}81}-(0{,}5*\mathbf{-9{,}55}+2*\mathbf{85{,}6})=$-79,3 $^{kJ}/_{mol}$;

$G_{e\text{-}}=\Delta G°_{NH4+}-G_{NH4+}+(0{,}5N_2^{gas}+2H_2^{gas})=$-79,3-**50,81**+(0,5*-**9,55**+2***85,6**)=**36,315** $^{kJ}/_{mol}$;

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