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Update of JAEA-TDB: Additional Selection of Thermodynamic Data for Solid and Gaseous Phases on Nickel, Selenium, Zirconium, Technetium, Thorium, Uranium, Neptunium Plutonium and Americium, Update of Thermodynamic Data on Iodine, and Some Modifications

Akira KITAMURA, Kenso FUJIWARA, Reisuke DOI and Yasushi YOSHIDA

Geological Isolation Research Unit
Geological Isolation Research and Development Directorate

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独立行政法人日本原子力研究開発機構　研究技術情報部　研究技術情報課
〒319-1195　茨城県那珂郡東海村白方白根 2 番地 4
電話 029-282-6387, Fax 029-282-5920, E-mail:ird-support@jaea.go.jp

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Intellectual Resources Section, Intellectual Resources Department,
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2-4 Shirakata Shirane, Tokai-mura, Naka-gun, Ibaraki-ken 319-1195 Japan
Tel +81-29-282-6387, Fax +81-29-282-5920, E-mail:ird-support@jaea.go.jp

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Akira KITAMURA, Kenso FUJIWARA, Reisuke DOI and Yasushi YOSHIDA*

Geological Isolation Research Unit
Geological Isolation Research and Development Directorate
Japan Atomic Energy Agency
Tokai-mura, Naka-gun, Ibaraki-ken

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We additionally selected thermodynamic data for solid and gaseous phases of nickel, selenium, zirconium, technetium, thorium, uranium, neptunium, plutonium and americium to our thermodynamic database JAEA-TDB for geological disposal of radioactive waste of high-level and TRU wastes. We thermodynamically obtained equiribrium constant from addition and subtraction of Gibbs free energy of formation on nickel, selenium, zirconium, technetium, thorium, uranium, neptunium plutonium and americium, which were selected in the Thermochemical Database Project by the Nuclear Energy Agency in the Organisation for Economic Co-operation and Development. Furthermore, we collected and updated thermodynamic data on iodine, changed master species of technetium(IV), and added thermodynamic data on selenium due to improving reliability of the thermodynamic database. We prepared text files of the updated thermodynamic database (JAEA-TDB) for geochemical calculation programs of PHREEQC, EQ3/6 and Geochemist's Workbench. These text files are contained in the attached CD-ROM and will be available on our Website (http://migrationdb.jaea.go.jp/).

Keywords: Geological Disposal, High-level Radioactive Waste, TRU Waste, Thermodynamic Database, Update of JAEA-TDB, Iodine, Geochemical Calculation Programs

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* NESI Company Ltd.

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JAEA-TDB の更新：ニッケル，セレン，ジルコニウム，テクネチウム，トリウム，ウラン，ネプツニウム，プルトニウムおよびアメリシウムの固相および気相の熱力学データの追加選定，ヨウ素の熱力学データ更新および選定値の修正

日本原子力研究開発機構
地層処分研究開発部門
地層処分基盤研究開発ユニット
北村　暁，藤原　健壮，土井　玲祐，吉田　泰*

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高レベル放射性廃棄物および TRU 廃棄物の地層処分の性能評価に用いるための熱力学データベース（JAEA-TDB）について，ニッケル，セレン，ジルコニウム，テクネチウム，トリウム，ウラン，ネプツニウム，プルトニウムおよびアメリシウムの固相および気相に関する熱力学データを追加選定した。選定した熱力学データは，経済協力開発機構原子力機関による熱化学データベースプロジェクトで採用されたニッケル，セレン，ジルコニウム，テクネチウム，トリウム，ウラン，ネプツニウム，プルトニウムおよびアメリシウムの Gibbs 標準自由エネルギーの加減算によって得られた平衡定数である。併せて，熱力学データベースの信頼性向上のために，ヨウ素の熱力学データの収集および更新，テクネチウム（IV）の親化学種の変更，およびセレンの熱力学データの追加を行った。この JAEA-TDB のテキストファイルとして，PHREEQC，EQ3/6，Geochemist's Workbench といった地球化学計算コード用フォーマットを整備した。これらのテキストファイルは，本報告書付属の CD-ROM に収納されるとともに，インターネット（http://migrationdb.jaea.go.jp/）でも公開され利用できるようになる予定である。

核燃料サイクル工学研究所（駐在）：〒319-1194　茨城県那珂郡東海村村松 4-33
* 株式会社 NESI

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1. Introduction

Many radionuclides are contained in high-level radioactive waste (HLW) and are part of TRU waste packages and some of them have long half-lives (more than 10^4 year). It is necessary to estimate the solubility of the radionuclides in groundwaters and porewaters in an engineered barrier system for performance assessment of geological disposal of HLW and TRU wastes. Thermodynamic data, e.g., the equilibrium constant of solubility limiting solids at standard state (i.e. ionic strength of 0), are needed to estimate the solubility and aqueous species in the groundwater and porewater, and also data are fundamental information to estimating sorption and diffusion behaviors of chemical species on/in engineered barriers and host rocks. Therefore, the most reliable thermodynamic data should be integrated to carry out the reliable performance assessment by an implementation and regulatory organizations.

Japan Atomic Energy Agency (JAEA) has developed the thermodynamic database (JAEA-TDB) for the performance assessment of geological disposal of radioactive waste [1,2]. Main part of the thermodynamic data in JAEA-TDB were selected and estimated by JAEA, however, some part of therm were taken from data selected by the Nuclear Energy Agency (NEA) in the Organisation for Economic Co-operation and Development (OECD) [3] and those selected by Japan Nuclear Cycle Development Institute (JNC; one of the predecessor of JAEA) [4]. The thermodynamic data were compiled and converted to be available for use of geochemical calculation programs, e.g., PHREEQC [5], EQ3/6 [6] and Geochemist's Workbench [7] (shown in Tables 18 and 19 in the TDB report [1]).

We accepted equilibrium constant values selected by the NEA [3] to the previous version of JAEA-TDB. However, the NEA also selects many other thermodynamic data such as the Gibbs free energy of formation for compounds and gaseous species of which equilibrium constant has not been selected. Equibrium constant can be derived from addition and subtraction of the Gibbs free energy of formation thermodynamically. In the present report, we calculated and additionally selected equilibrium constant values for using the Gibbs free energy of formation which the NEA selected from comprehensive point of view. Some equilibrium constant values selected by the NEA for gaseous species were also selected additionally, because it might be important to evaluate distribution of radionuclides in the air in case of a severe accident of nuclear power plant such as the Fukushima Daiichi.

Also we collected and updated thermodynamic data on iodine, which was important to evaluate distribution of radioiodine especially in the air at a severe accident of nuclear power

plant. Although we surveyed many literatures and tried to review and select thermodynamic data on iodine, it was difficult to select thermodynamic data due to lack of experimental conditions or continuous quotations within quotations. Therefore, we collected thermodynamic data from some representative handbooks and tables and replaced previous data with the present ones from a comprehensive point of view.

Furthermore, we revised thermodynamic data on selenium and technetium through accepting the latest values from several literatures and modifying master species, respectively.

2. Brief Summary on Development of JAEA-TDB

2.1 Selection of Thermodynamic Data

Selection of thermodynamic data for JAEA-TDB was performed on the basis of the fundamental plan [1], the content of which was briefly described below.

Selection of equilibrium constant of reaction at standard state (K°) was obligatorily performed, and selection of other thermodynamic values on enthalpy, entropy and heat capacity was recommended.

Thermodynamic data for chemical compounds and species for radioelements with naturally occurring elements (e.g., halogen, oxygen, carbon, nitrogen, sulfur, phosphorus) and some organic ligands were selected. Other thermodynamic data which were needed to select were quoted from those called "Auxiliary Data" selected by the NEA [3].

Review and selection of thermodynamic values obtained from experimental data should be based on the "TDB-1" guideline by the OECD/NEA [8]. Thermodynamic values or databases selected by the NEA [3] and Lothenbach *et al.* [9], which were based on the "TDB-1" guideline [8], could be selected to the JAEA-TDB after surveying the latest literature and checking consistency of the value in the database. Otherwise review and selection of thermodynamic values should be performed after surveying the literature to collect proposed thermodynamic data.

Application of chemical analogues and models should be considered to obtain thermodynamic values for some species for which there has been no published experimental data. Some unreliable thermodynamic values, which are important for the performance assessment of geological disposal of radioactive wastes, may be selected as tentative values while specifying their reliability and the needs for the values to be determined.

All thermodynamic values should be standardized at 298.15 K and at zero ionic strength, using the Brønsted-Guggenheim-Scatchard Model (usually called the "specific ion interaction theory (SIT)") [3] for correction of ionic strength.

2.2 Calculation of Equilibrium Constant from Gibbs Free Energy of Formation

Using the Hess's law, change in Gibbs free energy of reaction ($\Delta_r G^{\circ}_m$) for some arbitrary reaction, e.g.,

$$a\,\mathrm{A} + b\,\mathrm{B} \Leftrightarrow c\,\mathrm{C} + d\,\mathrm{D}\,, \qquad (1)$$

where A, B, C and D are substances involving the reaction, and a, b, c and d are coefficients of the substances A, B, C and D, respectively,

is expressed using change in Gibbs free energy of formation ($\Delta_f G°_m$(X) for species or compound X) as follows:

$$\Delta_r G°_m = c\,\Delta_f G°_m(\mathrm{C}) + d\,\Delta_f G°_m(\mathrm{D}) - a\,\Delta_f G°_m(\mathrm{A}) - b\,\Delta_f G°_m(\mathrm{B})\ . \quad (2)$$

Logarithm of equilibrium constant at standard state ($\log_{10} K°$) is derived from $\Delta_r G°_m$ using the following equation:

$$\log_{10} K° = -(\log_{10} e / R\,T)\,\Delta_r G°_m \quad (3)$$

where R and T denote gas constant ($\mathrm{J\cdot K^{-1}\cdot mol^{-1}}$) and absolute temperature (K), respectively. Uncertainty (σ) of $\Delta_r G°_m$ and $\log_{10} K°$ is obtained from error propagation of $\Delta_f G°_m$(X) as follows:

$$\sigma(\Delta_r G°_m) = (c\,\sigma(\Delta_r G°_m(\mathrm{C}))^2 + d\,\sigma(\Delta_r G°_m(\mathrm{D}))^2 + a\,\sigma(\Delta_r G°_m(\mathrm{A}))^2 + b\,\sigma(\Delta_r G°_m(\mathrm{B}))^2)^{1/2} \quad (4)$$

$$\sigma(\log_{10} K°) = -(\log_{10} e / R\,T)\,\sigma(\Delta_r G°_m). \quad (5)$$

The obtained uncertainty of equilibrium constant ($\sigma(\log_{10} K°)$) calculated using reactions (4) and (5) was usually larger than that obtained experimentally. We took smaller values of uncertainty from either experimentally obtained or calculated.

For use with geochemical calculation programs, dissociation reactions are defined for all compounds and gaseous species, i.e., the objective compounds and species are put on left-hand side and aqueous master species of the objective elements are put on right-hand side in their reactions.

3. Additional Selection or Revision of Thermodynamic data

3.1 Nickel

Additionally calculated and selected thermodynamic data on nickel compounds and gaseous species are listed in Table 1. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [10].

Table 1 Additionally selected thermodynamic data of nickel compounds and gaseous species

reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Ni(g) \Leftrightarrow Ni^{2+} + 2\ e^-$	-430.459 ± 8.435	75.413 ± 1.478
$NiF_2(cr) \Leftrightarrow Ni^{2+} + 2\ F^-$	1.033 ± 8.156	-0.181 ± 1.429
$NiCl_2(cr) \Leftrightarrow Ni^{2+} + 2\ Cl^-$	-49.464 ± 0.820	8.666 ± 0.144
$NiCl_2{\cdot}2H_2O(cr) \Leftrightarrow Ni^{2+} + 2\ Cl^- + 2\ H_2O(l)$	-28.105 ± 1.494	4.924 ± 0.262
$NiCl_2{\cdot}4H_2O(cr) \Leftrightarrow Ni^{2+} + 2\ Cl^- + 4\ H_2O(l)$	-21.821 ± 1.326	3.823 ± 0.232
$NiBr_2(cr) \Leftrightarrow Ni^{2+} + 2\ Br^-$	-58.065 ± 2.563	10.172 ± 0.449
$NiI_2(cr) \Leftrightarrow Ni^{2+} + 2\ I^-$	-54.861 ± 1.205	9.611 ± 0.211
$NiS_2(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow Ni^{2+} + 2\ HS^-$	102.545 ± 8.555	-17.965 ± 1.499
$Ni_3S_2(cr) + 2\ H^+ \Leftrightarrow 3\ Ni^{2+} + 2\ HS^- + 2\ e^-$	98.339 ± 5.087	-17.228 ± 0.891
$Ni_9S_8(cr) + 8\ H^+ \Leftrightarrow 9\ Ni^{2+} + 8\ HS^- + 2\ e^-$	432.790 ± 20.496	-75.821 ± 3.591
$NiSO_4(cr) \Leftrightarrow Ni^{2+} + SO_4^{2-}$	-27.089 ± 1.800	4.746 ± 0.315
α-$NiSO_4{\cdot}6H_2O \Leftrightarrow Ni^{2+} + SO_4^{2-} + 6\ H_2O(l)$	12.850 ± 1.397	-2.251 ± 0.245
β-$NiSO_4{\cdot}6H_2O \Leftrightarrow Ni^{2+} + SO_4^{2-} + 6\ H_2O(l)$	12.298 ± 2.031	-2.155 ± 0.356
$NiAs(cr) + 4\ H_2O(l) \Leftrightarrow Ni^{2+} + AsO_4^{3-} + 8\ H^+ + 7\ e^-$	321.010 ± 6.156	-56.238 ± 1.079
$Ni_5As_2(cr) + 8\ H_2O(l) \Leftrightarrow 5\ Ni^{2+} + 2\ AsO_4^{3-} + 6\ H^+ + 20\ e^-$	609.173 ± 23.653	-106.722 ± 4.144
$Ni_{11}As_8(cr) + 32\ H_2O(l) \Leftrightarrow 11\ Ni^{2+} + 8\ AsO_4^{3-} + 64\ H^+ + 62\ e^-$	2613.855 ± 51.471	-457.925 ± 9.017
$Ni_2SiO_4(oliv) + 4\ H^+ \Leftrightarrow 2\ Ni^{2+} + H_4SiO_4(aq)$	-110.840 ± 5.360	19.418 ± 0.939

3.2 Selenium

3.2.1 Additionally Selected Thermodynamic Data from Calculation using the Gibbs Free Energy of Formation

Additionally calculated and selected thermodynamic data on selenium compounds, gaseous species and some missing aqueous species are listed in Table 2. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [11].

Table 2 Additionally selected thermodynamic data of selenium compounds, gaseous species and some missing aqueous species using selected thermodynamic data by the NEA [11)]

reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Se(mono) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	42.190 ± 2.032	-7.391 ± 0.356
$SeO_2(cr) + H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ H^+$	46.545 ± 1.863	-8.154 ± 0.326
$SeO_3(cr) + H_2O(l) \Leftrightarrow SeO_4^{2-} + 2\ H^+$	-116.191 ± 2.643	20.356 ± 0.463
$SeCl_4(cr) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 4\ Cl^- + 6\ H^+$	-89.938 ± 3.608	15.756 ± 0.632
$PbSe(cr) + H^+ \Leftrightarrow HSe^- + Pb^{2+}$	117.169 ± 7.966	-20.527 ± 1.396
α-$ZnSe + H^+ \Leftrightarrow HSe^- + Zn^{2+}$	68.756 ± 4.502	-12.045 ± 0.789
α-$CdSe + H^+ \Leftrightarrow HSe^- + Cd^{2+}$	106.635 ± 2.888	-18.682 ± 0.506
$CdSeO_3(cr) \Leftrightarrow SeO_3^{2-} + Cd^{2+}$	53.307 ± 6.743	-9.339 ± 1.181
α-$HgSe + H^+ \Leftrightarrow HSe^- + Hg^{2+}$	259.338 ± 4.494	-45.434 ± 0.787
α-$CuSe + H^+ \Leftrightarrow HSe^- + Cu^{2+}$	145.346 ± 2.615	-25.463 ± 0.458
β-$CuSe + H^+ \Leftrightarrow HSe^- + Cu^{2+}$	143.421 ± 2.615	-25.126 ± 0.458
α-$Ag_2Se + H^+ \Leftrightarrow HSe^- + 2\ Ag^+$	244.563 ± 2.426	-42.845 ± 0.425
$Ni_{0.88}Se(cr) + H^+ + 0.24\ e^- \Leftrightarrow HSe^- + 0.88\ Ni^{2+}$	72.819 ± 2.680	-12.757 ± 0.470
$NiSe_2(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow 2\ HSe^- + Ni^{2+}$	153.524 ± 8.138	-26.896 ± 1.426
$Co_{0.84}Se(cr) + H^+ + 0.32\ e^- \Leftrightarrow HSe^- + 0.84\ Co^{2+}$	54.075 ± 6.859	-9.473 ± 1.202
$USe(cr) + H^+ \Leftrightarrow HSe^- + U^{4+} + 2\ e^-$	-213.134 ± 18.205	37.339 ± 3.189
$Na_2SeO_3(cr) \Leftrightarrow SeO_3^{2-} + 2\ Na^+$	-17.619 ± 2.014	3.087 ± 0.353
$Rb_2SeO_4(cr) \Leftrightarrow SeO_4^{2-} + 2\ Rb^+$	-2.403 ± 2.096	0.421 ± 0.367
$Ga_2(SeO_3)_3 \cdot 6H_2O(cr) \Leftrightarrow 3\ SeO_3^{2-} + 2\ Ga^{3+} + 6\ H_2O(l)$	211.198 ± 11.416	-37.000 ± 2.000
$In_2(SeO_3)_3 \cdot 6H_2O(cr) \Leftrightarrow 3\ SeO_3^{2-} + 2\ In^{3+} + 6\ H_2O(l)$	222.614 ± 11.416	-39.000 ± 2.000
$CoSeO_3 \cdot 2H_2O(cr) \Leftrightarrow SeO_3^{2-} + Co^{2+} + 2\ H_2O(l)$	45.094 ± 2.283	-7.900 ± 0.400
$CoSeO_4 \cdot 6H_2O(cr) \Leftrightarrow SeO_4^{2-} + Co^{2+} + 6\ H_2O(l)$	10.040 ± 0.245	-1.759 ± 0.043
$FeSeO_3^+ \Leftrightarrow SeO_3^{2-} + Fe^{3+}$	63.645 ± 0.628	-11.150 ± 0.110
$Fe_2(SeO_3)_3 \cdot 6H_2O(cr) \Leftrightarrow 3\ SeO_3^{2-} + 2\ Fe^{3+} + 6\ H_2O(l)$	237.340 ± 0.628	-41.580 ± 0.110
$MnSeO_3 \cdot 2H_2O(cr) \Leftrightarrow SeO_3^{2-} + Mn^{2+} + 2\ H_2O(l)$	43.381 ± 5.708	-7.600 ± 1.000
$Se(g) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	-152.456 ± 2.534	26.709 ± 0.444
$Se_2(g) + 2\ H^+ + 4\ e^- \Leftrightarrow 2\ HSe^-$	-5.500 ± 5.044	0.964 ± 0.884
$Se_3(g) + 3\ H^+ + 6\ e^- \Leftrightarrow 3\ HSe^-$	6.864 ± 12.077	-1.203 ± 2.116
$Se_4(g) + 4\ H^+ + 8\ e^- \Leftrightarrow 4\ HSe^-$	62.237 ± 15.661	-10.903 ± 2.744
$Se_5(g) + 5\ H^+ + 10\ e^- \Leftrightarrow 5\ HSe^-$	128.962 ± 11.404	-22.593 ± 1.998
$Se_6(g) + 6\ H^+ + 12\ e^- \Leftrightarrow 6\ HSe^-$	177.188 ± 13.083	-31.042 ± 2.292
$Se_7(g) + 7\ H^+ + 14\ e^- \Leftrightarrow 7\ HSe^-$	211.452 ± 14.988	-37.045 ± 2.626
$Se_8(g) + 8\ H^+ + 16\ e^- \Leftrightarrow 8\ HSe^-$	247.461 ± 16.583	-43.353 ± 2.905
$SeO(g) + 2\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 4\ H^+ + 2\ e^-$	81.033 ± 6.462	-14.196 ± 1.132
$SeO_2(g) + H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ H^+$	-10.086 ± 3.138	1.767 ± 0.550
$H_2Se(g) \Leftrightarrow HSe^- + H^+$	28.255 ± 0.291	-4.950 ± 0.051
$SeF_4(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 4\ F^- + 6\ H^+$	-11.515 ± 24.270	2.017 ± 4.252
$SeF_6(g) + 4\ H_2O(l) \Leftrightarrow SeO_4^{2-} + 6\ F^- + 8\ H^+$	-162.618 ± 4.417	28.489 ± 0.774
$SeOF_2(g) + 2\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ F^- + 4\ H^+$	64.260 ± 16.187	-11.258 ± 2.836
$SeCl_2(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ Cl^- + 6\ H^+ + 2\ e^-$	112.541 ± 4.813	-19.716 ± 0.843
$Se_2Cl_2(g) + 6\ H_2O(l) \Leftrightarrow 2\ SeO_3^{2-} + 2\ Cl^- + 12\ H^+ + 6\ e^-$	470.557 ± 10.606	-82.438 ± 1.858
$SeOCl_2(g) + 2\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ Cl^- + 4\ H^+$	-36.323 ± 3.067	6.363 ± 0.537
$SeBr_2(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ Br^- + 6\ H^+ + 2\ e^-$	145.911 ± 20.305	-25.562 ± 3.557
$SeS(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + HS^- + 5\ H^+ + 2\ e^-$	268.915 ± 7.402	-47.112 ± 1.297

reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$CSe(g) + 3\ H_2O(l) \Leftrightarrow HSe^- + CO_3^{2-} + 5\ H^+ + 2\ e^-$	-82.857 ± 9.431	14.516 ± 1.652
$CSe_2(g) + 3\ H_2O(l) \Leftrightarrow 2\ HSe^- + CO_3^{2-} + 4\ H^+$	66.525 ± 8.630	-11.655 ± 1.512
$SiSe(g) + 4\ H_2O(l) \Leftrightarrow HSe^- + H_4SiO_4(aq) + 3\ H^+ + 2\ e^-$	-413.823 ± 10.758	72.498 ± 1.885
$SnSe(g) + H^+ \Leftrightarrow HSe^- + Sn^{2+}$	-46.014 ± 15.899	8.061 ± 2.785
$PbSe(g) + H^+ \Leftrightarrow HSe^- + Pb^{2+}$	-63.633 ± 8.931	11.148 ± 1.565
$BSe_2(g) + 3\ H_2O(l) + e^- \Leftrightarrow 2\ HSe^- + B(OH)_3(aq) + H^+$	-302.306 ± 21.276	52.961 ± 3.727
$AlSe(g) + H^+ \Leftrightarrow HSe^- + Al^{3+} + e^-$	-654.605 ± 35.217	114.681 ± 6.170
$SeO_4^{2-} + Mn^{2+} \Leftrightarrow MnSeO_4(aq)$	-13.871 ± 0.285	2.430 ± 0.050
$SeO_4^{2-} + Co^{2+} \Leftrightarrow CoSeO_4(aq)$	-15.412 ± 0.285	2.700 ± 0.050

3.2.2 Additionally Selected Thermodynamic Data from Solubility Study

Iida *et al.* conducted a solubility study of selenium at high ionic strength with varing pH under anoxic conditions from oversaturation and undersaturation directions and determined the equilibrium constant at zero ionic strength ($\log_{10} K°$) of the following reactions using the Brønsted- Guggenheim-Scatchard Model (usually called "Specific Ion Interaction Theory (SIT)") [12]:

$$Se(am) + H^+ + 2\ e^- \Leftrightarrow HSe^- \qquad \log_{10} K° = -6.57 \pm 0.15 \quad (5 < pH < 8) \qquad (6)$$

$$4\ Se(cr) + 2\ e^- \Leftrightarrow Se_4^{2-} \qquad \log_{10} K° = -16.67 \pm 0.03 \quad (9 < pH < 13)\ . \qquad (7)$$

Experimental data obtained from both directions were identical, confirming that equilibrium was attained during the experimental periods. Considering the difference in activity coefficients between the calibration buffers and those of the high ionic strength solutions, they correctly determined pH. After equilibration for all experiments, all the XRD peaks of the solid phase were assigned to Se(cr). Therefore Se(am) and Se(cr) were recognized as candidates of the solubility-limiting solid. At 5 < pH < 8, the value of $\log_{10} K°$ for reaction ($Se(s) + H^+ + 2\ e^- \Leftrightarrow HSe^-$) was higher than the value of $\log_{10} K°$ for reaction ($Se(cr) + H^+ + 2\ e^- \Leftrightarrow HSe^-$) calculated from the existing thermodynamic data [11] of $\Delta_f G°_m(Se(cr))$ and $\Delta_f G°_m(HSe^-)$. They concluded that the solubility-limiting solid was not Se(cr) but Se(am) probably due to the rapid precipitation and slow crystallization kinetics of Se(am). On the other hand, the assumption that the solubility-limiting solid was Se(am) at 9 < pH < 13 led to the overestimation for the value of $\Delta_f G°_m(Se_4^{2-})$. They mentioned that the crystallization of selenium was presumed to occur through polymerization and homogeneous nucleation of Se_4^{2-} at the high-pH region and selected Se(cr) as solubility-limiting solid. $\Delta_f G°_m(Se_4^{2-})$ determined by them agrees with the existing

thermodynamic data [11] and has a smaller uncertainty.

We concluded the values of $\log_{10} K°$ for reaction (6) and (7) are reliable and accepted them for JAEA-TDB. For use of geochemical calculation programs, formation reaction of Se_4^{2-} was defined as follows:

$$4\ SeO_4^{2-} + 32\ H^+ + 26\ e^- \Leftrightarrow Se_4^{2-} + 16\ H_2O(l)\ . \qquad (8)$$

Use of $\log_{10} K°$ value in reaction (7) and that in the following reactions selected in JAEA-TDB

$$Se(cr,trigonal) + H^+ + 2\ e^- \Leftrightarrow HSe^- \qquad \log_{10} K° = -7.616 \pm 0.355 \qquad (9)$$

$$SeO_4^{2-} + 9\ H^+ + 8\ e^- \Leftrightarrow HSe^- + 4\ H_2O(l) \qquad \log_{10} K° = 81.570 \pm 0.435\ , \qquad (10)$$

the $\log_{10} K°$ of reaction (8) was determined to 340.074 ± 0.562.

Additionally selected thermodynamic data on selenium using the solubility data by Iida *et al.* [12] were summarized in Table 3.

Table 3 Additionally selected thermodynamic data on selenium using the solubility data by Iida *et al.* [12]

reaction	$\log_{10} K°$
$Se(am) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	–6.570 ± 0.150
$4\ SeO_4^{2-} + 32\ H^+ + 26\ e^- \Leftrightarrow Se_4^{2-} + 16\ H_2O(l)$	340.074 ± 0.562

3.3 Zirconium

Additionally calculated and selected thermodynamic data on zirconium compounds and gaseous species are listed in Table 4. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [13].

3.4 Technetium

3.4.1 Additionally Selected Thermodynamic Data

Additionally calculated and selected thermodynamic data on technetium compounds and gaseous species are listed in Table 5. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [14].

Table 4 Additionally selected thermodynamic data of zirconium compounds and gaseous species

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Zr(cr) \Leftrightarrow Zr^{4+} + 4\ e^-$	-528.509 ± 9.227	92.590 ± 1.616
$Zr(g) \Leftrightarrow Zr^{4+} + 4\ e^-$	-1095.391 ± 9.333	191.903 ± 1.635
$ZrO(g) + 2\ H^+ \Leftrightarrow Zr^{4+} + H_2O(l) + 2\ e^-$	-796.225 ± 28.650	139.492 ± 5.019
$ZrO_2(g) + 4\ H^+ \Leftrightarrow Zr^{4+} + 2\ H_2O(l)$	-704.403 ± 47.938	123.405 ± 8.398
$ZrH(cr) \Leftrightarrow Zr^{4+} + H^+ + 5\ e^-$	-463.823 ± 9.262	81.258 ± 1.623
$\varepsilon\text{-}ZrH_2 \Leftrightarrow Zr^{4+} + 2\ H^+ + 6\ e^-$	-404.228 ± 9.382	70.817 ± 1.644
$ZrF(g) \Leftrightarrow Zr^{4+} + F^- + 3\ e^-$	-851.385 ± 9.326	149.155 ± 1.634
$ZrF_2(g) \Leftrightarrow Zr^{4+} + 2\ F^- + 2\ e^-$	-598.786 ± 9.440	104.902 ± 1.654
$ZrF_3(g) \Leftrightarrow Zr^{4+} + 3\ F^- + e^-$	-307.365 ± 9.608	53.848 ± 1.683
$ZrF_4(g) \Leftrightarrow Zr^{4+} + 4\ F^-$	-20.023 ± 9.690	3.508 ± 1.698
$ZrCl(cr) \Leftrightarrow Zr^{4+} + Cl^- + 3\ e^-$	-395.246 ± 9.446	69.244 ± 1.655
$ZrCl(g) \Leftrightarrow Zr^{4+} + Cl^- + 3\ e^-$	-860.144 ± 25.321	150.690 ± 4.436
$ZrCl_2(cr) \Leftrightarrow Zr^{4+} + 2\ Cl^- + 2\ e^-$	-294.792 ± 15.962	51.645 ± 2.796
$ZrCl_2(g) \Leftrightarrow Zr^{4+} + 2\ Cl^- + 2\ e^-$	-636.632 ± 21.908	111.532 ± 3.838
$ZrCl_3(cr) \Leftrightarrow Zr^{4+} + 3\ Cl^- + e^-$	-232.418 ± 9.713	40.718 ± 1.702
$ZrCl_3(g) \Leftrightarrow Zr^{4+} + 3\ Cl^- + e^-$	-411.589 ± 13.032	72.107 ± 2.283
$ZrCl_4(cr) \Leftrightarrow Zr^{4+} + 4\ Cl^-$	-163.227 ± 9.315	28.596 ± 1.632
$ZrCl_4(g) \Leftrightarrow Zr^{4+} + 4\ Cl^-$	-216.952 ± 9.287	38.008 ± 1.627
$ZrBr_4(g) \Leftrightarrow Zr^{4+} + 4\ Br^-$	-279.240 ± 9.992	48.920 ± 1.750
$ZrI(cr) \Leftrightarrow Zr^{4+} + I^- + 3\ e^-$	-429.816 ± 9.306	75.300 ± 1.630
$ZrI(g) \Leftrightarrow Zr^{4+} + I^- + 3\ e^-$	-929.551 ± 14.386	162.849 ± 2.520
$ZrI_2(cr) \Leftrightarrow Zr^{4+} + 2\ I^- + 2\ e^-$	-358.158 ± 13.609	62.746 ± 2.384
$ZrI_2(g) \Leftrightarrow Zr^{4+} + 2\ I^- + 2\ e^-$	-709.718 ± 18.532	124.337 ± 3.247
$ZrI_3(cr) \Leftrightarrow Zr^{4+} + 3\ I^- + e^-$	-298.101 ± 17.615	52.225 ± 3.086
$ZrI_3(g) \Leftrightarrow Zr^{4+} + 3\ I^- + e^-$	-497.805 ± 10.213	87.211 ± 1.789
$ZrI_4(cr) \Leftrightarrow Zr^{4+} + 4\ I^-$	-254.543 ± 9.957	44.594 ± 1.744
$ZrI_4(g) \Leftrightarrow Zr^{4+} + 4\ I^-$	-329.446 ± 9.963	57.716 ± 1.745
$ZrS_{1.5}(cr) + 1.5\ H^+ \Leftrightarrow 1.5\ HS^-$	520.472 ± 5.017	-91.182 ± 0.879
$ZrS_2(cr) + 2\ H^+ \Leftrightarrow 2\ HS^-$	590.236 ± 12.738	-103.404 ± 2.232
$ZrS_3(cr) + 3\ H^+ \Leftrightarrow 3\ HS^-$	638.649 ± 7.978	-111.886 ± 1.398
$Zr(SO_3)_2(cr) \Leftrightarrow Zr^{4+} + 2\ SO_3^{2-}$	331.417 ± 15.825	-58.061 ± 2.772
$Zr(SO_4)_2(cr) \Leftrightarrow Zr^{4+} + 2\ SO_4^{2-}$	-7.063 ± 9.519	1.237 ± 1.668
$Zr(SO_4)_2{\cdot}4H_2O(cr) \Leftrightarrow Zr^{4+} + 2\ SO_4^{2-} + 4\ H_2O(l)$	43.685 ± 9.626	-7.653 ± 1.686
$ZrN(cr) + 3\ H_2O(l) \Leftrightarrow Zr^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	413.969 ± 9.441	-72.524 ± 1.654
$\alpha\text{-}Zr(HPO_4)_2 \Leftrightarrow Zr^{4+} + 2\ PO_4^{3-} + 2\ H^+$	407.509 ± 24.981	-71.392 ± 4.377
$Zr(HPO_4)_2{\cdot}H_2O(cr) \Leftrightarrow Zr^{4+} + 2\ PO_4^{3-} + 2\ H^+ + H_2O(l)$	377.897 ± 22.434	-66.204 ± 3.930
$ZrC(cr) + 3\ H_2O(l) \Leftrightarrow Zr^{4+} + CO_3^{2-} + 6\ H^+ + 8\ e^-$	-141.513 ± 9.591	24.792 ± 1.680
$Ca_2ZrSi_3O_{12}(cr) + 12\ H^+ + 4\ e^- \Leftrightarrow 2\ Ca^{2+} + Zr^{4+} + 3\ H_4SiO_4(aq)$	394.131 ± 18.135	-69.048 ± 3.177
$Ca_3ZrSi_2O_9(cr) + 10\ H^+ \Leftrightarrow 3\ Ca^{2+} + Zr^{4+} + 2\ H_4SiO_4(aq) + H_2O(l)$	-270.242 ± 14.189	47.344 ± 2.486
$SrZrSi_2O_7(cr) + H_2O(l) + 6\ H^+ \Leftrightarrow Sr^{2+} + Zr^{4+} + 2\ H_4SiO_4(aq)$	-26.712 ± 10.429	4.680 ± 1.827
$Na_2ZrSiO_5(cr) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + H_4SiO_4(aq) + H_2O(l)$	-73.792 ± 22.060	12.928 ± 3.865
$Na_2ZrSi_2O_7(cr) + H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 2\ H_4SiO_4(aq)$	-18.343 ± 13.817	3.214 ± 2.421
$Na_2ZrSi_3O_9{\cdot}2H_2O(cr) + H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 3\ H_4SiO_4(aq)$	-84.480 ± 22.298	14.800 ± 3.906
$Na_2ZrSi_4O_{11}(cr) + 5\ H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 4\ H_4SiO_4(aq)$	83.345 ± 22.508	-14.601 ± 3.943

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Na_2ZrSi_6O_{15}·3H_2O(cr) + 6\ H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 6\ H_4SiO_4(aq)$	-84.985 ± 32.146	14.889 ± 5.632
$Na_4Zr_2Si_3O_{12}(cr) + 2\ H^+ \Leftrightarrow 4\ Na^+ + 2\ Zr^{4+} + 3\ H_4SiO_4(aq)$	-84.030 ± 27.477	14.721 ± 4.814
$NaZr_2P_3O_{12}(cr) \Leftrightarrow Na^+ + 2\ Zr^{4+} + 3\ PO_4^{3-}$	161.524 ± 27.782	-28.298 ± 4.867

Table 5 Additionally selected thermodynamic data of technetium compounds and gaseous species

reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Tc(cr) + 4\ H_2O(l) \Leftrightarrow TcO_4^- + 8\ H^+ + 7\ e^-$	311.154 ± 7.618	-54.512 ± 1.335
$Tc(g) + 4\ H_2O(l) \Leftrightarrow TcO_4^- + 8\ H^+ + 7\ e^-$	-319.557 ± 26.136	55.984 ± 4.579
$TcO(g) + 3\ H_2O(l) \Leftrightarrow TcO_4^- + 6\ H^+ + 5\ e^-$	-283.480 ± 57.508	49.663 ± 10.075
$TcO_2(cr) + 2\ H_2O(l) \Leftrightarrow TcO_4^- + 4\ H^+ + 3\ e^-$	238.724 ± 14.013	-41.822 ± 2.455
$Tc_2O_7(cr) + H_2O(l) \Leftrightarrow 2\ TcO_4^- + 2\ H^+$	-87.392 ± 21.776	15.310 ± 3.815
$Tc_2O_7(g) + H_2O(l) \Leftrightarrow 2\ TcO_4^- + 2\ H^+$	-132.852 ± 22.428	23.275 ± 3.929
$Tc_2O_7·H_2O(s) \Leftrightarrow 2\ TcO_4^- + 2\ H^+$	-80.512 ± 21.732	14.105 ± 3.807
$TcS(g) + 4\ H_2O(l) \Leftrightarrow TcO_4^- + HS^- + 7\ H^+ + 5\ e^-$	-168.528 ± 65.480	29.525 ± 11.472
$TcC(g) + 7\ H_2O(l) \Leftrightarrow TcO_4^- + CO_3^{2-} + 14\ H^+ + 11\ e^-$	-270.928 ± 40.967	47.464 ± 7.177
$CsTcO_4(cr) \Leftrightarrow TcO_4^- + Cs^+$	20.646 ± 0.268	-3.617 ± 0.047

3.4.2 Change of Master Species of Technetium(IV)

Technetium(IV) monooxo ion (TcO^{2+}) was set as a master species of technetium(IV) in the previous version of JAEA-TDB [1,2] as shown in Table 6. However, the Gibbs free energy of formation of TcO^{2+} is shown as a lower limit (> 116.799 kJ·mol^{-1}) [14], hence many $\log_{10} K°$ values have not been determined. Therefore we changed master species of technetium(IV) to $TcO(OH)_2(aq)$ based on the recommendation by the NEA [15]. Selected $\log_{10} K°$ values in the present version of JAEA-TDB are listed in Table 7.

Table 6 Selected thermodynamic data on technetium(IV) in the previous version of JAEA-TDB [1,2]

reaction	$\log_{10} K°$
$TcO^{2+} + 3\ H_2O(l) \Leftrightarrow TcO_4^{2-} + 6\ H^+ + 2\ e^-$	> -44.214
$TcO^{2+} + 3\ H_2O(l) \Leftrightarrow TcO_4^- + 6\ H^+ + 3\ e^-$	> -33.414
$TcO^{2+} + H_2O(l) \Leftrightarrow TcO(OH)^+ + H^+$	> 0.563
$TcO^{2+} + 2\ H_2O(l) \Leftrightarrow TcO(OH)_2(aq) + 2\ H^+$	> -4.000
$TcO^{2+} + 3\ H_2O(l) \Leftrightarrow TcO(OH)_3^- + 3\ H^+$	> -14.900
$TcO^{2+} + H_2O(l) + CO_3^{2-} \Leftrightarrow TcCO_3(OH)_2(aq)$	> 15.267

reaction	$\log_{10} K°$
$TcO^{2+} + 2\ H_2O(l) + CO_3^{2-} \Leftrightarrow TcCO_3(OH)_3^- + H^+$	> 6.967
$TcO^{2+} + (cit)^{3-} \Leftrightarrow TcO(cit)^-$	11.990
$TcO^{2+} + H^+ + (cit)^{3-} \Leftrightarrow TcOH(cit)(aq)$	14.110
$TcO_2 \cdot 1.6H_2O(s) + 2\ H^+ \Leftrightarrow TcO^{2+} + 2.6\ H_2O(l)$	< -4.415

Table 7 Revised thermodynamic data on technetium(IV) in the present version of JAEA-TDB

reaction	$\log_{10} K°$	
$TcO_4^- + 6\ H^+ + 3\ e^- \Leftrightarrow\ TcO^{2+} + 3\ H_2O(l)$	< 33.414	
$TcO(OH)_2(aq) + H^+ \Leftrightarrow TcO(OH)^+ + H_2O(l)$	4.563	± 0.216
$TcO(OH)_2(aq) + 2\ H^+ \Leftrightarrow TcO^{2+} + 2\ H_2O(l)$	< 4.000	
$TcO(OH)_2(aq) + H_2O(l) \Leftrightarrow TcO(OH)_3^- + H^+$	-10.900	± 0.400
$TcO(OH)_2(aq) + 2\ H^+ + CO_3^{2-} \Leftrightarrow TcCO_3(OH)_2(aq) + H_2O(l)$	19.255	± 0.302
$TcO(OH)_2(aq) + H^+ + CO_3^{2-} \Leftrightarrow TcCO_3(OH)_3^-$	10.955	± 0.601
$TcO(OH)_2(aq) + 2\ H^+ + (cit)^{3-} \Leftrightarrow TcO(cit)^- + 2\ H_2O(l)$	< 15.999	
$TcO(OH)_2(aq) + 3\ H^+ + (cit)^{3-} \Leftrightarrow TcOH(cit)(aq) + 2\ H_2O(l)$	< 18.110	
$TcO_2 \cdot 1.6H_2O(s) \Leftrightarrow TcO(OH)_2(aq) + 0.6\ H_2O(l)$	-8.415	± 0.180

3.5 Iodine

3.5.1 Collection of Thermodynamic Data

Thermodynamic data on iodine were taken from NEA-TDB (auxiliary data) [3] and Cross *et al.* [16] in the previous JAEA-TDB tentatively. We surveyed many literatures and tried to review and select thermodynamic data on iodine in accordance with the guideline for JAEA-TDB [1,2].

As an example of articles reporting thermodynamic data on iodine, Horiguchi and Hagisawa [17] determined the iodine hydrolysis constant by measuring pH of iodine solution as follow,

$$I_2(cr) + H_2O(l) \Leftrightarrow HOI(aq) + H^+ + I^- \quad K° = 4.6 \times 10^{-13}\ . \tag{11}$$

They estimated HOI concentrarion to be same as H^+ concentration without considering the following side reaction reported by Eguchi et al,[18]

$$3\ HOI \Leftrightarrow IO_3^- + 3\ H^+ + 2I^- \qquad K° = 3.67 \times 10^{-7}. \tag{12}$$

Besides, the activity coefficients of all species were assumed to be unity in the evaluation of the equilibrium constant for equation (11). We judged that the equilibrium constants reported by

Horiguchi and Hagisawa [17] were unreliable due to these problematic points. On the other hand, the equilibrium constant for equation (12) were also unreliable because ionic strength for each sample was unadjusted in the experiment by Eguchi et al. [18]

Allen and Keefer [19] determined the equilibrium constant for equation (11) ($K° = 5.40 \times 10^{-13}$) and the following equation,

$$I_2(aq) + H_2O(l) \Leftrightarrow H_2OI^+(aq) + I^- \qquad K° < 1 \times 10^{-10} \qquad (13)$$

by means of spectrophotometric analyses of aqueous solutions of iodine. However, they did not confirm the existence of HOI(aq) and H_2OI^+(aq). For this reason, we rejected their reported values, too.

It was difficult to select thermodynamic data due to lack of experimental conditions or continuous quotations within quotations. Therefore, for the purpose of making data set more exhaustive we collected thermodynamic data from some representative handbooks and tables(NEA-TDB [3], CRC Handbook [20], Kagaku Binran [21] and NBS Tables [22]) and replaced previous data with the present ones. NEA-TDB [3] are reliable because only original experimental data were evaluated, not estimates, values from compilations or secondary citations with the emphasis on the scientific reliability. Numerous international experts made contributions to CRC Handbook [20] which quoted data from NIST-JANAF Thermochemical Tables Fourth Edition [23] as well as NBS Tables [22]. Thermodynamic data for Se and Po in NBS Tables [22] were introduced for JNC to develop TDB [4], while Kagaku Binran [21] has never been adopted in the past TDB development project. For these reasons, we determined priority of data collection in order of NEA-TDB [3], CRC Handbook [20], NBS Tables [22] and Kagaku Binran [21]. The collected data are shown in Table 8, including previously selected data and calculated $\Delta_r G°_m$ and $\log_{10} K°$ values using equations (2) and (3). The present data on iodine has approximately quardrupled in the number of iodide species from the previous one. We recognize that data without assigning uncertanties quoted from CRC Handbook [20], Kagaku Binran [21] and NBS Tables [22] should be treated as tentative values due to lack of the traceability of data.

3.5.2 Solubility Estimation for Simulated Porewaters

We recalculated distribution of aqueous iodine species for some simulated porewaters determined in the Second Progress Report on Geological Disposal of High-level Radioactive Waste (H12) [24]. We selected 3 typically simulated porewaters proposed in the “H12” report, which are Fresh-Reducing-High-pH (FRHP), Saline-Reducing-High-pH (SRHP) and Fresh-Oxidizing-High-pH (FOHP) porewaters [25], to check evaluated and estimated solubility

Table 8 Selected thermodynamic data on iodine

Compound/Species	$\Delta_f G°_m$ (kJ.mol^{-1})	ref.	reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$	ref.
I_2(cr)	0	3				
I^-	-51.724 ± 0.112	3	I_2(cr) + 2 e^- ⇔ 2 I^-	-103.448 ± 0.224	18.123 ± 0.039	3
I(g)	70.172 ± 0.060	3	I(g) + e^- ⇔ I^-	-121.896 ± 0.127	21.355 ± 0.022	3
I_2(g)	19.323 ± 0.120	3	I_2(g) + 2 e^- ⇔ 2 I^-	-122.771 ± 0.254	21.508 ± 0.045	present
HI(g)	1.700 ± 0.110	3	HI(g) ⇔ I^- + H^+	-53.424 ± 0.157	9.359 ± 0.028	present
IO_3^-	-126.338 ± 0.779	3	I^- + 3 H_2O(l) ⇔ IO_3^- + 6 H^+ + 6 e^-	636.806 ± 0.797	-111.563 ± 0.140	present
HIO_3(aq)	-130.836 ± 0.797	3	IO_3^- + H^+ ⇔ HIO_3(aq)	-4.498 ± 0.166	0.788 ± 0.029	3
NiI_2(cr)	-94.36 ± 0.898	10	NiI_2(cr) ⇔ 2 I^- + Ni^{2+}	-54.861 ± 1.205	9.611 ± 0.211	present
β-$Ni(IO_3)_2$	-332.591 ±1.743	10	β-$Ni(IO_3)_2$ ⇔ 2 IO_3^- + Ni^{2+}	25.287 ± 0.114	-4.430 ± 0.020	10
$Ni(IO_3)_2·2H_2O$(cr)	-815.133 ±1.832	10	$Ni(IO_3)_2·2H_2O$(cr) ⇔ 2 H_2O(l) + 2 IO_3^- + Ni^{2+}	29.339 ± 0.571	-5.140 ± 0.100	10
ThI_4(cr)	-659.487 ±2.668	3	ThI_4(cr) ⇔ 4 I^- + Th^{4+}	-252.192 ± 5.949	44.182 ± 1.042	present
ThI_4(g)	-518.316 ±5.753	3	ThI_4(g) ⇔ 4 I^- + Th^{4+}	-393.363 ± 7.834	68.914 ± 1.372	present
$ThIO_3^{3+}$	-854.752 ± 5.385	3	Th^{4+} + IO_3^- ⇔ $ThIO_3^{3+}$	-23.631 ± 0.571	4.140 ± 0.100	3
$Th(IO_3)_2^{2+}$	-997.243 ± 5.565	3	Th^{4+} + 2 IO_3^- ⇔ $Th(IO_3)_2^{2+}$	-39.785 ± 0.685	6.970 ± 0.120	3
$Th(IO_3)_3^+$	-1140.134 ± 5.825	3	Th^{4+} + 3 IO_3^- ⇔ $Th(IO_3)_3^+$	-56.338 ± 0.628	9.870 ± 0.110	3
UI(g)	288.861 ±25.045	14	UI(g) ⇔ U^{4+} + I^- + 3 e^-	-870.445 ± 25.107	152.494 ± 4.399	present
UI_2(g)	40.341 ± 25.177	14	UI_2(g) ⇔ U^{4+} + 2 I^- + 2 e^-	-673.649 ± 25.240	118.018 ± 4.422	present
UI_3(cr)	-466.122 ±4.892	14	UI_3(cr) ⇔ U^{3+} + 3 I^-	-165.523 ± 5.227	28.998 ± 0.916	present
UI_3(g)	-198.654 ±25.178	14	UI_3(g) ⇔ U^{3+} + 3 I^-	-432.991 ± 25.245	75.856 ± 4.423	present
UI_4(cr)	-512.671 ±3.761	14	UI_4(cr) ⇔ U^{4+} + 4 I^-	-224.085 ± 4.179	39.258 ± 0.732	present
UI_4(g)	-369.585 ±6.210	14	UI_4(g) ⇔ U^{4+} + 4 I^-	-367.171 ± 6.471	64.325 ± 1.134	present
$UClI_3$(cr)	-615.789 ±11.350	14	$UClI_3$(cr) ⇔ U^{4+} + Cl^- + 3 I^-	-200.460 ± 11.492	35.119 ± 2.013	present
UCl_2I_2(cr)	-723.356 ±11.350	14	UCl_2I_2(cr) ⇔ U^{4+} + 2 Cl^- + 2 I^-	-172.386 ± 11.491	30.201 ± 2.013	present
UCl_3I(cr)	-829.877 ±8.766	14	UCl_3I(cr) ⇔ U^{4+} + 3 Cl^- + I^-	-145.358 ± 8.950	25.465 ± 1.568	present
$UO_2IO_3^+$	-1090.315 ± 1.917	14	UO_2^{2+} + IO_3^- ⇔ $UO_2IO_3^+$	-11.416 ± 0.114	2.000 ± 0.200	14
$UO_2(IO_3)_2$(aq)	-1225.718 ± 2.493	14	UO_2^{2+} + 2 IO_3^- ⇔ $UO_2(IO_3)_2$(aq)	-20.492 ± 0.856	3.590 ± 0.150	14
$UO_2(IO_3)_2$(cr)	-1250.206 ± 2.410	14	$UO_2(IO_3)_2$(cr) ⇔ UO_2^{2+} + 2 IO_3^-	44.979 ± 0.571	-7.880 ± 0.100	14
NpI^{3+}	-512.498 ± 3.715	14	Np^{4+} + I^- ⇔ NpI^{3+}	-8.562 ± 2.283	1.500 ± 0.400	14

Compound/Species	$\Delta_f G°_m$ (kJ.mol^{-1})		ref.	reaction	$\Delta_r G°_m$ (kJ·mol^{-1})		$\log_{10} K°$		ref.
NpI_3(cr)	-512.498	±3.715	14	$NpI_3(cr) \Leftrightarrow Np^{3+} + 3\ I^-$	-155.540	± 6.786	27.249	± 1.189	present
NpO_2IO_3(aq)	-1036.957	± 5.934	14	$NpO_2^+ + IO_3^- \Leftrightarrow NpO_2IO_3(aq)$	-2.854	± 1.712	0.500	± 0.300	14
$NpO_2IO_3^+$	-929.126	± 5.922	14	$NpO_2^{2+} + IO_3^- \Leftrightarrow NpO_2IO_3^+$	-6.850	± 1.712	1.200	± 0.300	14
PuI_3(cr)	-579.000	±4.551	14	$PuI_3(cr) \Leftrightarrow Pu^{3+} + 3\ I^-$	-155.156	± 5.296	27.182	± 0.928	present
PuI_3(g)	-366.517	±15.655	14	$PuI_3(g) \Leftrightarrow Pu^{3+} + 3\ I^-$	-367.639	± 15.888	64.407	± 2.783	present
PuOI(cr)	-776.626	±20.495	14	$PuOI(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + I^- + H_2O(l)$	-91.222	± 20.671	15.981	± 3.621	present
AmI_3(cr)	-609.451	± 10.068	14	$AmI_3(cr) \Leftrightarrow Am^{3+} + 3\ I^-$	-144.419	± 11.139	25.301	± 1.952	present
β-$Co(IO_3)_2$	-332.165	±1.919	26	β-$Co(IO_3)_2 \Leftrightarrow 2\ IO_3^- + Co^{2+}$	25.089	± 0.505	-4.395	± 0.088	26
$Co(IO_3)_2{\cdot}2H_2O$(cr)	-810.474	±2.112	26	$Co(IO_3)_2{\cdot}2H_2O(cr) \Leftrightarrow 2\ IO_3^- + Co^{2+} + 2\ H_2O(l)$	29.118	± 1.013	-5.101	± 0.177	26
I_2(aq)	16.40		22	$2\ I^- \Leftrightarrow I_2(aq) + 2\ e^-$	119.848		-20.996		present
I_3^-	-51.4		22	$3\ I^- \Leftrightarrow I_3^- + 2\ e^-$	103.772		-18.180		present
IO^-	-38.5		22	$I^- + H_2O(l) \Leftrightarrow IO^- + 2\ H^+ + 2\ e^-$	250.364		-43.862		present
IO(g)	102.5		20	$IO(g) + 2\ H^+ + 3\ e^- \Leftrightarrow I^- + H_2O(l)$	-391.364		68.564		present
IO_4^-	-58.5		22	$I^- + 4\ H_2O(l) \Leftrightarrow IO_4^- + 8\ H^+ + 8\ e^-$	941.784		-164.992		present
I_2O^{2-}	-82.4		22	$2\ I^- + H_2O(l) \Leftrightarrow I_2O^{2-} + 2\ H^+ + 2\ e^-$	258.188		-45.232		present
HI(aq)	-51.57		22	$I^- + H^+ \Leftrightarrow HI(aq)$	0.154		-0.027		present
HIO(aq)	-99.1		22	$I^- + H_2O(l) \Leftrightarrow HIO(aq) + H^+ + 2\ e^-$	189.764		-33.245		present
H_2OI^+	-106.7		22	$I^- + H_2O(l) \Leftrightarrow H_2OI^+ + 2\ e^-$	182.164		-31.914		present
I_2OH^-	-230.1		22	$2\ I^- + H_2O(l) \Leftrightarrow I_2OH^- + H^+ + 2\ e^-$	110.488		-19.357		present
IF(g)	-118.51		22	$IF(g) + 2\ e^- \Leftrightarrow I^- + F^-$	-214.737		37.620		present
IF_7(g)	-818.3		22	$IF_7(g) + 8\ e^- \Leftrightarrow I^- + 7\ F^-$	-1204.085		210.945		present
ICl(g)	-5.46		22	$ICl(g) + 2\ e^- \Leftrightarrow I^- + Cl^-$	-177.481		31.093		present
ICl(aq)	-17.1		22	$I^- + Cl^- \Leftrightarrow ICl(aq) + 2\ e^-$	165.841		-29.054		present
ICl_2^-	-161.0		22	$I^- + 2\ Cl^- \Leftrightarrow ICl_2^- + 2\ e^-$	153.158		-26.832		present
ICl_3(cr)	-22.29		22	$ICl_3(cr) + 4\ e^- \Leftrightarrow I^- + 3\ Cl^-$	-423.085		74.121		present
I_2Cl^-	-116.3		22	$2\ I^- + Cl^- \Leftrightarrow I_2Cl^- + 2\ e^-$	118.365		-20.737		present
IBr(aq)	-4.2		22	$I^- + Br^- \Leftrightarrow IBr(aq) + 2\ e^-$	151.374		-26.519		present
IBr(g)	3.69		22	$IBr(g) + 2\ e^- \Leftrightarrow I^- + Br^-$	-159.264		27.902		present
IBr_2^-	-123.0		22	$I^- + 2\ Br^- \Leftrightarrow IBr_2^- + 2\ e^-$	136.424		-23.900		present
BrI_2^-	-110.0		22	$2\ I^- + Br^- \Leftrightarrow BrI_2^- + 2\ e^-$	97.298		-17.046		present

Compound/Species	$\Delta_f G°_m$ (kJ.mol^{-1})	ref.	reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$	ref.
$HBrI_2$(aq)	-110.0	22	$2\ I^- + H^+ + Br^- \Leftrightarrow HBrI_2$(aq) $+ 2\ e^-$	97.298	-17.046	present
$IBrCl^-$	-146.4	22	$I^- + Cl^- + Br^- \Leftrightarrow IBrCl^- + 2\ e^-$	140.391	--24.595	present
AgI(cr)	-66.2	20	AgI(cr) $\Leftrightarrow I^- + Ag^+$	91.572	-16.043	present
$AgIO_3$(cr)	-93.7	20	$AgIO_3$(cr) $\Leftrightarrow IO_3^- + Ag^+$	44.458	-7.789	present
KI(cr)	-324.9	20	KI(cr) $\Leftrightarrow I^- + K^+$	-9.334	1.635	present
KIO_3(cr)	-418.4	20	KIO_3(cr) $\Leftrightarrow IO_3^- + K^+$	9.552	-1.673	present
KIO_4(cr)	-361.4	20	KIO_4(cr) $+ 2\ H^+ + 2\ e^- \Leftrightarrow IO_3^- + K^+ + H_2O$(l)	-284.588	49.857	present
NaI(cr)	-286.1	20	NaI(cr) $\Leftrightarrow I^- + Na^+$	-27.577	4.831	present
$NaIO_4$(cr)	-323.0	20	$NaIO_4$(cr) $+ 2\ H^+ + 2\ e^- \Leftrightarrow IO_3^- + Na^+ + H_2O$(l)	-302.431	52.983	present
CsI(cr)	-340.6	20	CsI(cr) $\Leftrightarrow I^- + Cs^+$	-2.580	0.452	present
BI_3(g)	20.75	21	BI_3(g) $+ 3\ H_2O$(l) $\Leftrightarrow 3\ I^- + B(OH)_3$(aq) $+ 3\ H^+$	-433.770	75.993	present
BaI_2(cr)	-597.69	21	BaI_2(cr) $\Leftrightarrow 2\ I^- + Ba^{2+}$	-63.414	11.110	present
CaI_2(cr)	-528.9	21	CaI_2(cr) $\Leftrightarrow 2\ I^- + Ca^{2+}$	-127.354	22.311	present
CdI_2(cr)	-201.38	21	CdI_2(cr) $\Leftrightarrow 2\ I^- + Cd^{2+}$	20.199	-3.539	present
CoI_2(cr)	-90.77	21	CoI_2(cr) $\Leftrightarrow 2\ I^- + Co^{2+}$	-67.078	11.751	present
CuI(cr)	-69.5	20	CuI(cr) $\Leftrightarrow I^- + Cu^{2+} + e^-$	82.816	-14.509	present
HgI_2(cr)	-101.7	20	HgI_2(cr) $\Leftrightarrow 2\ I^- + Hg^{2+}$	162.919	-28.542	present
Hg_2I_2(cr)	-111.0	20	Hg_2I_2(cr) $\Leftrightarrow 2\ I^- + Hg_2^{2+}$	161.119	-28.227	present
LiI(cr)	-270.3	20	LiI(cr) $\Leftrightarrow I^- + Li^+$	-74.342	13.024	present
MgI_2(cr)	-358.2	20	MgI_2(cr) $\Leftrightarrow 2\ I^- + Mg^{2+}$	-200.623	35.147	present
NH_4I(cr)	-112.5	20	NH_4I(cr) $\Leftrightarrow I^- + NH_4^+$	-18.622	3.262	present
PbI_2(cr)	-173.6	20	PbI_2(cr) $\Leftrightarrow 2\ I^- + Pb^{2+}$	45.914	-8.044	present
RbI(cr)	-328.9	20	RbI(cr) $\Leftrightarrow I^- + Rb^+$	-6.833	1.197	present
SiI_4(cr)	-191.6	21	SiI_4(cr) $+ 4\ H_2O$(l) $\Leftrightarrow 4\ I^- + H_4SiO_4$(aq) $+ 4\ H^+$	-374.471	65.604	present
SrI_2(cr)	-560.7	21	SrI_2(cr) $\Leftrightarrow 2\ I^- + Sr^{2+}$	-106.612	18.678	present
TlI(cr)	-125.4	20	TlI(cr) $\Leftrightarrow I^- + Tl^+$	41.276	-7.231	present
ZnI_2(cr)	-209.0	20	ZnI_2(cr) $\Leftrightarrow 2\ I^- + Zn^{2+}$	-41.651	7.297	present
AlI_3(cr)	-300.8	20	AlI_3(cr) $\Leftrightarrow 3\ I^- + Al^{3+}$	-345.879	60.595	present
AsI_3(cr)	-59.4	20	AsI_3(cr) $+ 4\ H_2O$(l) $\Leftrightarrow 3\ I^- + AsO_4^{3-} + 8\ H^+ + 2\ e^-$	204.428	-35.814	present

under various conditions. Solubility-controlling solid phase was set to I_2(cr), which was a typical solid phase of iodine. The geochemical calculation program "PHREEQC" version 2.17 [5] was used for calculation.

Contribution of I^- was 100 % for FRHP and SRHP, while those of I^- and I_2OH^- were 42 % and 29 % (i.e. equivalent to 58 % of isolated iodine), respectively, for FOHP. The obtained results were different from those using the previous thermodynamic data. Although we did not succeed to review and select thermodynamic data on iodine, we believe the present results using more exhaustive data were more realistic than the previous ones.

3.6 Thorium

Some thermodynamic data on thorium aqueous species selected by the NEA [3] shown in Table 9, which were missing in the previous version of JAEA-TDB [1,2], were additionally selected.

Additionally calculated and selected thermodynamic data on thorium compounds and gaseous species are listed in Table 10. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [3].

Table 9 Additionally selected thermodynamic data for thorium aqueous species

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Th^{4+} + ClO_3^- \Leftrightarrow ThClO_3^{3+}$	-8.847 ± 0.742	1.550 ± 0.130
$Th^{4+} + Br^- \Leftrightarrow ThBr^{3+}$	-7.877 ± 0.742	1.380 ± 0.130
$Th^{4+} + BrO_3^- \Leftrightarrow ThBrO_3^{3+}$	-10.845 ± 0.571	1.900 ± 0.100
$Th^{4+} + IO_3^- \Leftrightarrow ThIO_3^{3+}$	-23.631 ± 0.571	4.140 ± 0.100
$Th^{4+} + 2\ IO_3^- \Leftrightarrow Th(IO_3)_2^{2+}$	-39.785 ± 0.685	6.970 ± 0.120
$Th^{4+} + 3\ IO_3^- \Leftrightarrow Th(IO_3)_3^+$	-56.338 ± 0.628	9.870 ± 0.110
$Th^{4+} + N_3^- \Leftrightarrow ThN_3^{3+}$	-25.344 ± 3.653	4.440 ± 0.640
$Th^{4+} + 2\ N_3^- \Leftrightarrow Th(N_3)_2^{2+}$	-49.032 ± 3.653	8.590 ± 0.640
$Th^{4+} + SCN^- \Leftrightarrow ThSCN^{3+}$	-11.416 ± 2.854	2.000 ± 0.500
$Th^{4+} + 2\ SCN^- \Leftrightarrow Th(SCN)_2^{2+}$	-19.407 ± 4.566	3.400 ± 0.800

Table 10 Additionally selected thermodynamic data for thorium compounds and gaseous species

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$Th(cr) \Leftrightarrow Th^{4+} + 4\ e^-$	-704.783 ± 5.298	123.472 ± 0.928
$Th(g) \Leftrightarrow Th^{4+} + 4\ e^-$	-1265.778 ± 8.006	221.753 ± 1.403
$ThO(g) + 2\ H^+ \Leftrightarrow Th^{4+} + H_2O(l) + 2\ e^-$	-890.624 ± 8.006	156.030 ± 1.403
$ThO_2(g) + 4\ H^+ \Leftrightarrow Th^{4+} + 2\ H_2O(l)$	-716.935 ± 16.314	125.601 ± 2.858
$ThH_2(cr) \Leftrightarrow Th^{4+} + 2\ H^+ + 6\ e^-$	-599.315 ± 5.665	104.995 ± 0.992
$ThH_{3.75}(cr) \Leftrightarrow Th^{4+} + 3.75\ H^+ + 7.75\ e^-$	-561.906 ± 9.596	98.441 ± 1.681
$ThF(g) \Leftrightarrow Th^{4+} + F^- + 3\ e^-$	-985.518 ± 16.321	172.654 ± 2.859
$ThF_2(g) \Leftrightarrow Th^{4+} + 2\ F^- + 2\ e^-$	-665.972 ± 20.950	116.673 ± 3.670
$ThF_3(g) \Leftrightarrow Th^{4+} + 3\ F^- + e^-$	-389.578 ± 16.318	68.251 ± 2.859
$ThF_4(g) \Leftrightarrow Th^{4+} + 4\ F^-$	-111.547 ± 11.837	19.542 ± 2.074
$ThOF(g) + 2\ H^+ \Leftrightarrow Th^{4+} + F^- + H_2O(l) + e^-$	-657.260 ± 13.471	115.146 ± 2.360
$ThOF_2(cr) + 2\ H^+ \Leftrightarrow Th^{4+} + 2\ F^- + H_2O(l)$	84.202 ± 9.652	-14.751 ± 1.691
$ThCl(g) \Leftrightarrow Th^{4+} + Cl^- + 3\ e^-$	-1051.688 ± 20.998	184.247 ± 3.679
$ThCl_2(g) \Leftrightarrow Th^{4+} + 2\ Cl^- + 2\ e^-$	-775.880 ± 22.827	135.928 ± 3.999
$ThCl_3(g) \Leftrightarrow Th^{4+} + 3\ Cl^- + e^-$	-534.670 ± 25.732	93.670 ± 4.508
$\beta\text{-}ThCl_4 \Leftrightarrow Th^{4+} + 4\ Cl^-$	-137.358 ± 5.677	24.064 ± 0.994
$ThCl_4(g) \Leftrightarrow Th^{4+} + 4\ Cl^-$	-306.695 ± 7.511	53.730 ± 1.316
$ThOCl_2(cr) + 2\ H^+ \Leftrightarrow Th^{4+} + 2\ F^- + H_2O(l)$	-351.405 ± 5.930	61.563 ± 1.039
$ThBr(g) \Leftrightarrow Th^{4+} + Br^- + 3\ e^-$	-1128.208 ± 20.998	197.652 ± 3.679
$ThBr_2(g) \Leftrightarrow Th^{4+} + 2\ Br^- + 2\ e^-$	-912.456 ± 20.907	159.854 ± 3.663
$ThBr_3(g) \Leftrightarrow Th^{4+} + 3\ Br^- + e^-$	-645.260 ± 16.194	113.044 ± 2.837
$\beta\text{-}ThBr_4 \Leftrightarrow Th^{4+} + 4\ Br^-$	-195.160 ± 5.898	34.190 ± 1.033
$ThBr_4(g) \Leftrightarrow Th^{4+} + 4\ Br^-$	-351.154 ± 7.733	61.519 ± 1.355
$ThI_4(g) \Leftrightarrow Th^{4+} + 4\ I^-$	-393.363 ± 7.834	68.914 ± 1.372
$ThS(cr) + H^+ \Leftrightarrow Th^{4+} + HS^- + 2\ e^-$	-300.678 ± 8.429	52.676 ± 1.477
$ThN(cr) + 3\ H_2O(l) \Leftrightarrow Th^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	249.481 ± 11.335	-43.707 ± 1.986
$Th_3N_4(cr) + 12\ H_2O(l) \Leftrightarrow 3\ Th^{4+} + 4\ NO_3^- + 24\ H^+ + 32\ e^-$	1488.206 ± 22.380	-260.721 ± 3.921
$Th(NO_3)_4 \cdot 5H_2O(cr) \Leftrightarrow Th^{4+} + 4\ NO_3^- + 5\ H_2O(l)$	-11.008 ± 6.230	1.929 ± 1.091
$ThC_{0.97}(cr) + 2.91\ H_2O(l) \Leftrightarrow Th^{4+} + 0.97\ CO_3^{2-} + 5.82\ H^+ + 7.88\ e^-$	-402.303 ± 8.247	70.480 ± 1.445
$ThC_{1.94}(s) + 5.82\ H_2O(l) \Leftrightarrow Th^{4+} + 1.94\ CO_3^{2-} + 11.64\ H^+ + 11.76\ e^-$	-222.049 ± 9.219	38.901 ± 1.615

3.7 Uranium

Additionally calculated and selected thermodynamic data on uranium compounds and gaseous species are listed in Table 11. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [14].

It should be noted that thermodynamic data on diuranate (e.g., $Na_2U_2O_7(cr)$) might control uranium(VI) solubility under oxic and highly alkaline conditions [27]. These thermodynamic data may be important for performance assessment of radioactive waste, especially for TRU and low-level wastes of which environment will be under oxic and highly

alkaline conditions.

Table 11 Additionally selected thermodynamic data for uranium compounds and gaseous species

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$UO(g) + 2\ H^+ \Leftrightarrow U^{4+} + H_2O(l) + 2\ e^-$	-772.327 ± 10.172	135.305 ± 1.782
$UO_2(g) + 4\ H^+ \Leftrightarrow U^{4+} + 2\ H_2O(l)$	-523.076 ± 20.114	91.638 ± 3.524
$\beta\text{-}UO_{2.25} + 4.5\ H^+ + 0.5\ e^- \Leftrightarrow U^{4+} + 2.25\ H_2O(l)$	5.658 ± 2.454	-0.991 ± 0.430
$UO_{2.25}(cr) + 4.5\ H^+ + 0.5\ e^- \Leftrightarrow U^{4+} + 2.25\ H_2O(l)$	5.700 ± 2.454	-0.999 ± 0.430
$\beta\text{-}UO_{2.3333} + 4.6666\ H^+ + 0.6666\ e^- \Leftrightarrow U^{4+} + 2.3333\ H_2O(l)$	-3.607 ± 2.671	0.632 ± 0.468
$UO_{2.6667}(cr) + 5.3334\ H^+ + 1.3334\ e^- \Leftrightarrow U^{4+} + 2.6667\ H_2O(l)$	-39.084 ± 1.943	6.847 ± 0.340
$UO_3(g) + 2\ H^+ \Leftrightarrow UO_2^{2+} + H_2O(l)$	-404.930 ± 15.113	70.940 ± 2.648
$\beta\text{-}UH_3 \Leftrightarrow U^{3+} + 3\ H^+ + 6\ e^-$	-403.917 ± 1.816	70.763 ± 0.318
$UF(g) \Leftrightarrow U^{4+} + F^- + 3\ e^-$	-734.507 ± 20.110	128.679 ± 3.523
$UF_2(g) \Leftrightarrow U^{4+} + 2\ F^- + 2\ e^-$	-534.209 ± 25.277	93.589 ± 4.428
$UF_3(cr) \Leftrightarrow U^{3+} + 3\ F^-$	111.489 ± 5.449	-19.532 ± 0.955
$UF_3(g) \Leftrightarrow U^{3+} + 3\ F^-$	-258.095 ± 20.408	45.216 ± 3.575
$UF_4(cr) \Leftrightarrow U^{4+} + 4\ F^-$	167.586 ± 5.332	-29.360 ± 0.934
$UF_4(g) \Leftrightarrow U^{4+} + 4\ F^-$	-79.101 ± 7.459	13.858 ± 1.307
$UF_4{\cdot}2.5H_2O(cr) \Leftrightarrow U^{4+} + 4\ F^- + 2.5\ H_2O(l)$	191.480 ± 7.006	-33.546 ± 1.227
$\alpha\text{-}UF_5 + 2\ H_2O(l) \Leftrightarrow UO_2^{+} + 5\ F^- + 4\ H^+$	74.332 ± 7.999	-13.022 ± 1.401
$\beta\text{-}UF_5 + 2\ H_2O(l) \Leftrightarrow UO_2^{+} + 5\ F^- + 4\ H^+$	76.239 ± 6.841	-13.356 ± 1.199
$UF_5(g) + 2\ H_2O(l) \Leftrightarrow UO_2^{+} + 5\ F^- + 4\ H^+$	-32.273 ± 15.778	5.654 ± 2.764
$UF_6(g) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ F^- + 4\ H^+$	-102.969 ± 4.887	18.039 ± 0.856
$U_2F_9(cr) + e^- \Leftrightarrow 2\ U^{4+} + 9\ F^-$	218.573 ± 18.446	-38.292 ± 3.232
$U_4F_{17}(cr) + e^- \Leftrightarrow 4\ U^{4+} + 17\ F^-$	558.669 ± 32.988	-97.874 ± 5.779
$UOF_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ F^- + H_2O(l)$	104.081 ± 6.804	-18.234 ± 1.192
$UOF_4(cr) + H_2O(l) \Leftrightarrow UO_2^{2+} + 4\ F^- + 2\ H^+$	-25.239 ± 5.380	4.422 ± 0.942
$UOF_4(g) + H_2O(l) \Leftrightarrow UO_2^{2+} + 4\ F^- + 2\ H^+$	-136.689 ± 20.406	23.947 ± 3.575
$UO_2F_2(cr) \Leftrightarrow UO_2^{2+} + 2\ F^-$	41.725 ± 2.584	-7.310 ± 0.453
$UO_2F_2(g) \Leftrightarrow UO_2^{2+} + 2\ F^-$	-197.516 ± 10.482	34.603 ± 1.836
$U_2O_3F_6(cr) + H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 6\ F^- + 2\ H^+$	15.630 ± 15.764	-2.738 ± 2.762
$U_3O_5F_8(cr) + H_2O(l) \Leftrightarrow 3\ UO_2^{2+} + 8\ F^- + 2\ H^+$	17.438 ± 12.393	-3.055 ± 2.171
$UOFOH(cr) \Leftrightarrow UO_2^{2+} + F^- + H^+$	102.856 ± 13.084	-18.019 ± 2.292
$UOFOH{\cdot}0.5H_2O(cr) \Leftrightarrow UO_2^{2+} + F^- + H^+ + 0.5\ H_2O(l)$	105.473 ± 7.219	-18.478 ± 1.265
$UOF_2{\cdot}H_2O(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ F^- + 2\ H_2O(l)$	107.288 ± 4.712	-18.796 ± 0.825
$UO_2FOH{\cdot}H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + F^- + 2\ H_2O(l)$	13.346 ± 7.732	-2.338 ± 1.355
$UO_2FOH{\cdot}2H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + F^- + 3\ H_2O(l)$	15.538 ± 8.616	-2.722 ± 1.510
$UO_2F_2{\cdot}3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ F^- + 3\ H_2O(l)$	42.641 ± 7.289	-7.470 ± 1.277
$UCl(g) \Leftrightarrow U^{4+} + Cl^- + 3\ e^-$	-817.022 ± 20.098	143.135 ± 3.521
$UCl_2(g) \Leftrightarrow U^{4+} + 2\ Cl^- + 2\ e^-$	-617.670 ± 20.299	108.210 ± 3.556
$UCl_3(cr) \Leftrightarrow U^{3+} + 3\ Cl^-$	-74.021 ± 2.725	12.968 ± 0.477
$UCl_3(g) \Leftrightarrow U^{3+} + 3\ Cl^-$	-348.472 ± 20.305	61.049 ± 3.557
$UCl_4(cr) \Leftrightarrow U^{4+} + 4\ Cl^-$	-125.123 ± 3.106	21.920 ± 0.544
$UCl_4(g) \Leftrightarrow U^{4+} + 4\ Cl^-$	-265.286 ± 5.273	46.476 ± 0.924

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$UCl_5(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Cl^- + 4\ H^+$	-212.711 ± 4.323	37.265 ± 0.757
$UCl_5(g) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Cl^- + 4\ H^+$	-293.274 ± 15.187	51.379 ± 2.661
$UCl_6(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ Cl^- + 4\ H^+$	-328.453 ± 3.579	57.542 ± 0.627
$UCl_6(g) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ Cl^- + 4\ H^+$	-363.985 ± 5.548	63.767 ± 0.972
$UOCl(cr) + 2\ H^+ \Leftrightarrow U^{3+} + Cl^- + H_2O(l)$	-59.176 ± 5.216	10.367 ± 0.914
$UOCl_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ Cl^- + H_2O(l)$	-30.956 ± 3.235	5.423 ± 0.567
$UOCl_3(cr) + H_2O(l) \Leftrightarrow UO_2^+ + 3\ Cl^- + 2\ H^+$	-71.956 ± 8.571	12.606 ± 1.502
$UO_2Cl(cr) \Leftrightarrow UO_2^+ + Cl^-$	3.015 ± 8.565	-0.528 ± 1.501
$UO_2Cl_2(cr) \Leftrightarrow UO_2^{2+} + 2\ Cl^-$	-69.147 ± 2.192	12.114 ± 0.384
$UO_2Cl_2(g) \Leftrightarrow UO_2^{2+} + 2\ Cl^-$	-276.001 ± 15.208	48.353 ± 2.664
$U_2O_2Cl_5(cr) + 2\ H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 5\ Cl^- + 4\ H^+ + e^-$	-49.601 ± 6.040	8.690 ± 1.058
$(UO_2)_2Cl_3(cr) + e^- \Leftrightarrow 2\ UO_2^{2+} + 3\ Cl^-$	-63.998 ± 4.574	11.212 ± 0.801
$U_5O_{12}Cl(cr) + 4\ H^+ \Leftrightarrow 5\ UO_2^{2+} + Cl^- + 2\ H_2O(l) + 5\ e^-$	149.699 ± 15.178	-26.226 ± 2.659
$UO_2Cl_2{\cdot}H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Cl^- + H_2O(l)$	-47.122 ± 3.714	8.255 ± 0.651
$UO_2ClOH{\cdot}2H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + Cl^- + 3\ H_2O(l)$	-12.969 ± 4.837	2.272 ± 0.847
$UO_2Cl_2{\cdot}3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Cl^- + 3\ H_2O(l)$	-31.789 ± 3.506	5.569 ± 0.614
$UCl_3F(cr) \Leftrightarrow U^{4+} + 3\ Cl^- + F^-$	-58.461 ± 5.504	10.242 ± 0.964
$UCl_2F_2(cr) \Leftrightarrow U^{4+} + 2\ Cl^- + 2\ F^-$	20.627 ± 6.030	-3.614 ± 1.056
$UClF_3(cr) \Leftrightarrow U^{4+} + Cl^- + 3\ F^-$	100.714 ± 5.832	-17.644 ± 1.022
$UBr(g) \Leftrightarrow U^{4+} + Br^- + 3\ e^-$	-833.333 ± 15.131	145.993 ± 2.651
$UBr_2(g) \Leftrightarrow U^{4+} + 2\ Br^- + 2\ e^-$	-650.664 ± 15.399	113.991 ± 2.698
$UBr_3(cr) \Leftrightarrow U^{3+} + 3\ Br^-$	-114.825 ± 4.605	20.116 ± 0.807
$UBr_3(g) \Leftrightarrow U^{3+} + 3\ Br^-$	-379.908 ± 20.580	66.557 ± 3.605
$UBr_4(cr) \Leftrightarrow U^{4+} + 4\ Br^-$	-177.781 ± 4.015	31.146 ± 0.703
$UBr_4(g) \Leftrightarrow U^{4+} + 4\ Br^-$	-310.656 ± 5.298	54.424 ± 0.928
$UBr_5(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Br^- + 4\ H^+$	-236.683 ± 9.408	41.465 ± 1.648
$UBr_5(g) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Br^- + 4\ H^+$	-337.779 ± 15.418	59.176 ± 2.701
$UOBr_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ Br^- + H_2O(l)$	-45.052 ± 8.591	7.893 ± 1.505
$UOBr_3(cr) + H_2O(l) \Leftrightarrow UO_2^+ + 3\ Br^- + 2\ H^+$	-133.933 ± 21.412	23.464 ± 3.751
$UO_2Br_2(cr) \Leftrightarrow UO_2^{2+} + 2\ Br^-$	-93.829 ± 2.536	16.438 ± 0.444
$UO_2Br_2{\cdot}H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Br^- + H_2O(l)$	-68.747 ± 3.081	12.044 ± 0.540
$UO_2BrOH{\cdot}2H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + Br^- + 3\ H_2O(l)$	-23.659 ± 4.713	4.145 ± 0.826
$UO_2Br_2{\cdot}3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Br^- + 3\ H_2O(l)$	-53.185 ± 5.851	9.318 ± 1.025
$UBr_2Cl(cr) \Leftrightarrow U^{3+} + 2\ Br^- + Cl^-$	-101.001 ± 9.938	17.695 ± 1.741
$UBr_3Cl(cr) \Leftrightarrow U^{4+} + 3\ Br^- + Cl^-$	-165.513 ± 9.938	28.996 ± 1.741
$UBrCl_2(cr) \Leftrightarrow U^{3+} + Br^- + 2\ Cl^-$	-82.442 ± 9.935	14.443 ± 1.741
$UBr_2Cl_2(cr) \Leftrightarrow U^{4+} + 2\ Br^- + 2\ Cl^-$	-149.098 ± 9.932	26.121 ± 1.740
$UBrCl_3(cr) \Leftrightarrow U^{4+} + Br^- + 3\ Cl^-$	-133.861 ± 9.378	23.451 ± 1.643
$UI(g) \Leftrightarrow U^{4+} + I^- + 3\ e^-$	-870.445 ± 25.107	152.494 ± 4.399
$UI_2(g) \Leftrightarrow U^{4+} + 2\ I^- + 2\ e^-$	-673.649 ± 25.240	118.018 ± 4.422
$UI_3(cr) \Leftrightarrow U^{3+} + 3\ I^-$	-165.523 ± 5.227	28.998 ± 0.916
$UI_3(g) \Leftrightarrow U^{3+} + 3\ I^-$	-432.991 ± 25.245	75.856 ± 4.423
$UI_4(cr) \Leftrightarrow U^{4+} + 4\ I^-$	-224.085 ± 4.179	39.258 ± 0.732
$UI_4(g) \Leftrightarrow U^{4+} + 4\ I^-$	-367.171 ± 6.471	64.325 ± 1.134
$UClI_3(cr) \Leftrightarrow U^{4+} + Cl^- + 3\ I^-$	-200.460 ± 11.492	35.119 ± 2.013
$UCl_2I_2(cr) \Leftrightarrow U^{4+} + 2\ Cl^- + 2\ I^-$	-172.386 ± 11.491	30.201 ± 2.013
$UCl_3I(cr) \Leftrightarrow U^{4+} + 3\ Cl^- + I^-$	-145.358 ± 8.950	25.465 ± 1.568
$US(cr) + H^+ \Leftrightarrow U^{4+} + HS^- + 2\ e^-$	-196.688 ± 12.898	34.458 ± 2.260

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
$US_{1.90}(cr) + 1.9\ H^+ \Leftrightarrow U^{4+} + 1.9\ HS^- + 0.2\ e^-$	2.872 ± 21.356	-0.503 ± 3.741
$US_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ HS^-$	13.867 ± 9.221	-2.429 ± 1.615
$US_3(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 3\ HS^- + H^+$	95.711 ± 14.215	-16.768 ± 2.490
$U_2S_3(cr) + 3\ H^+ \Leftrightarrow 2\ U^{3+} + 3\ HS^-$	-36.430 ± 67.399	6.382 ± 11.808
$U_3S_5(cr) + 5\ H^+ \Leftrightarrow 3\ U^{4+} + 5\ HS^- + 2\ e^-$	-103.289 ± 100.973	18.095 ± 17.690
$UO_2SO_3(cr) \Leftrightarrow UO_2^{2+} + SO_3^{2-}$	90.347 ± 13.461	-15.828 ± 2.358
$U(SO_3)_2(cr) \Leftrightarrow U^{4+} + 2\ SO_3^{2-}$	208.022 ± 22.715	-36.444 ± 3.979
$U(SO_4)_2(cr) \Leftrightarrow U^{4+} + 2\ SO_4^{2-}$	66.653 ± 14.205	-11.677 ± 2.489
$U(OH)_2SO_4(cr) + 2\ H^+ \Leftrightarrow U^{4+} + SO_4^{2-} + 2\ H_2O(l)$	18.079 ± 3.841	-3.167 ± 0.673
$UO_2SO_4 \cdot 3H_2O(cr) \Leftrightarrow UO_2^{2+} + SO_4^{2-} + 3\ H_2O(l)$	8.586 ± 2.554	-1.504 ± 0.447
$U(SO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow U^{4+} + 2\ SO_4^{2-} + 4\ H_2O(l)$	66.882 ± 11.600	-11.717 ± 2.032
$U(SO_4)_2 \cdot 8H_2O(cr) \Leftrightarrow U^{4+} + 2\ SO_4^{2-} + 8\ H_2O(l)$	72.910 ± 16.852	-12.773 ± 2.952
$USe(cr) + H^+ \Leftrightarrow U^{4+} + HSe^- + 2\ e^-$	-213.134 ± 18.205	37.339 ± 3.189
$\alpha\text{-}USe_2 + 2\ H^+ \Leftrightarrow U^{4+} + 2\ HSe^-$	-15.846 ± 42.232	2.776 ± 7.399
$\beta\text{-}USe_2 + 2\ H^+ \Leftrightarrow U^{4+} + 2\ HSe^-$	-14.946 ± 42.410	2.618 ± 7.430
$USe_3(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 3\ HSe^- + H^+$	104.139 ± 42.774	-18.244 ± 7.494
$U_2Se_3(cr) + 3\ H^+ \Leftrightarrow 2\ U^{3+} + 3\ HSe^-$	-101.339 ± 75.334	17.754 ± 13.198
$U_3Se_4(cr) + 4\ H^+ \Leftrightarrow 3\ U^{4+} + 4\ HSe^- + 4\ e^-$	-426.936 ± 86.296	74.796 ± 15.118
$U_3Se_5(cr) + 5\ H^+ \Leftrightarrow 3\ U^{4+} + 5\ HSe^- + 2\ e^-$	-241.614 ± 114.140	42.329 ± 19.996
$UN(cr) + 3\ H_2O(l) \Leftrightarrow U^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	335.848 ± 3.509	-58.838 ± 0.615
$\alpha\text{-}UN_{1.59} + 4.77\ H_2O(l) \Leftrightarrow U^{4+} + 1.59\ NO_3^- + 9.54\ H^+ + 11.95\ e^-$	763.337 ± 5.536	-133.730 ± 0.970
$\alpha\text{-}UN_{1.73} + 5.19\ H_2O(l) \Leftrightarrow U^{4+} + 1.73\ NO_3^- + 10.38\ H^+ + 12.65\ e^-$	862.976 ± 7.742	-151.186 ± 1.356
$UO_2(NO_3)_2(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^-$	-68.045 ± 5.996	11.921 ± 1.050
$UO_2(NO_3)_2 \cdot H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + H_2O(l)$	-48.314 ± 10.701	8.464 ± 1.875
$UO_2(NO_3)_2 \cdot 2H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + 2\ H_2O(l)$	-27.919 ± 2.785	4.891 ± 0.488
$UO_2(NO_3)_2 \cdot 3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + 3\ H_2O(l)$	-20.865 ± 2.761	3.655 ± 0.484
$UO_2(NO_3)_2 \cdot 6H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + 6\ H_2O(l)$	-12.766 ± 2.533	2.236 ± 0.444
$UP(cr) + 4\ H_2O(l) \Leftrightarrow U^{4+} + PO_4^{3-} + 8\ H^+ + 9\ e^-$	-340.870 ± 11.352	59.718 ± 1.989
$UP_2(cr) + 8\ H_2O(l) \Leftrightarrow U^{4+} + 2\ PO_4^{3-} + 16\ H^+ + 14\ e^-$	-389.167 ± 15.462	68.179 ± 2.709
$U_3P_4(cr) + 16\ H_2O(l) \Leftrightarrow U^{4+} + 4\ PO_4^{3-} + 32\ H^+ + 32\ e^-$	-1070.869 ± 27.294	187.607 ± 4.782
$UPO_5(cr) + H_2O(l) \Leftrightarrow UO_2^+ + PO_4^{3-} + 2\ H^+$	175.341 ± 5.519	-30.718 ± 0.967
$UP_2O_7(cr) + 3\ H_2O(l) \Leftrightarrow UO_2^{2+} + 2\ PO_4^{3-} + 6\ H^+ + 2\ e^-$	367.159 ± 6.467	-64.323 ± 1.133
$(UO_2)_2P_2O_7(cr) + H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 2\ PO_4^{3-} + 2\ H^+$	211.058 ± 8.320	-36.976 ± 1.458
$(UO_2)_3(PO_4)_2(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ PO_4^{3-}$	207.340 ± 8.193	-36.324 ± 1.435
$U(HPO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow U^{4+} + 2\ PO_4^{3-} + 4\ H_2O(l) + 2\ H^+$	315.051 ± 5.186	-55.194 ± 0.909
$(UO_2)_3(PO_4)_2 \cdot 6H_2O(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ PO_4^{3-} + 6\ H_2O(l)$	281.550 ± 14.724	-49.325 ± 2.580
$UAs(cr) + 4\ H_2O(l) \Leftrightarrow U^{4+} + AsO_4^{3-} + 8\ H^+ + 9\ e^-$	8.248 ± 9.143	-1.445 ± 1.602
$UAs_2(cr) + 8\ H_2O(l) \Leftrightarrow U^{4+} + 2\ AsO_4^{3-} + 16\ H^+ + 14\ e^-$	323.330 ± 15.382	-56.645 ± 2.695
$U_3As_4(cr) + 16\ H_2O(l) \Leftrightarrow 3\ U^{4+} + 4\ AsO_4^{3-} + 32\ H^+ + 32\ e^-$	336.608 ± 24.700	-58.971 ± 4.327
$UO_2(AsO_3)_2(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 2\ AsO_4^{3-} + 4\ H^+$	169.920 ± 14.542	-29.769 ± 2.548
$(UO_2)_2As_2O_7(cr) + H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 2\ AsO_4^{3-} + 2\ H^+$	165.572 ± 14.853	-29.007 ± 2.602
$(UO_2)_3(AsO_4)_2(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ AsO_4^{3-}$	156.416 ± 15.359	-27.403 ± 2.691
$UC(cr) + 3\ H_2O(l) \Leftrightarrow U^{4+} + CO_3^{2-} + 6\ H^+ + 8\ e^-$	-247.440 ± 3.505	43.349 ± 0.614
$\alpha\text{-}UC_{1.94} + 5.82\ H_2O(l) \Leftrightarrow U^{4+} + 1.94\ CO_3^{2-} + 11.64\ H^+ + 11.76\ e^-$	-86.431 ± 2.856	15.142 ± 0.500
$U_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ U^{4+} + 3\ CO_3^{2-} + 18\ H^+ + 20\ e^-$	-319.843 ± 10.677	56.034 ± 1.871
$USiO_4(cr) + 4\ H^+ \Leftrightarrow U^{4+} + H_4SiO_4(aq)$	46.005 ± 4.522	-8.060 ± 0.792
$MgUO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + Mg^{2+} + 2\ H_2O(l)$	-132.605 ± 2.664	23.231 ± 0.467
$CaUO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + Ca^{2+} + 2\ H_2O(l)$	-90.931 ± 3.166	15.930 ± 0.555

Reaction	$\Delta_r G°_m$ (kJ·mol^{-1})	$\log_{10} K°$
α-$SrUO_4 + 4\ H^+ \Leftrightarrow UO_2^{2+} + Sr^{2+} + 2\ H_2O(l)$	-109.340 ± 3.394	19.155 ± 0.595
$BaUO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + Ba^{2+} + 2\ H_2O(l)$	-100.682 ± 4.608	17.639 ± 0.807
$Ba_3UO_6(cr) + 8\ H^+ \Leftrightarrow UO_2^{2+} + 3\ Ba^{2+} + 4\ H_2O(l)$	-529.128 ± 12.151	92.699 ± 2.129
$BaU_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{2+} + Ba^{2+} + 3\ H_2O(l)$	-122.085 ± 7.998	21.388 ± 1.401
$Ba_2U_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{+} + 2\ Ba^{2+} + 3\ H_2O(l)$	-201.759 ± 9.946	35.346 ± 1.742
$Li_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Li^{+} + 2\ H_2O(l)$	-159.477 ± 2.831	27.939 ± 0.496
$NaUO_3(cr) + 2\ H^+ \Leftrightarrow UO_2^{+} + Na^{+} + H_2O(l)$	-47.619 ± 10.154	8.342 ± 1.779
α-$Na_2UO_4 + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Na^{+} + 2\ H_2O(l)$	-171.434 ± 3.923	30.034 ± 0.687
$Na_3UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{+} + 3\ Na^{+} + 2\ H_2O(l)$	-321.251 ± 8.198	56.280 ± 1.436
$Na_2U_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{2+} + 2\ Na^{+} + 3\ H_2O(l)$	-128.974 ± 5.327	22.595 ± 0.933
$K_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ K^{+} + 2\ H_2O(l)$	-193.352 ± 3.696	33.874 ± 0.648
$Rb_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Rb^{+} + 2\ H_2O(l)$	-194.708 ± 3.703	34.111 ± 0.649
$Cs_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Cs^{+} + 2\ H_2O(l)$	-204.373 ± 2.392	35.804 ± 0.419
$Cs_2U_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{2+} + 2\ Cs^{+} + 3\ H_2O(l)$	-176.553 ± 10.652	30.931 ± 1.866
$Cs_2U_4O_{12}(cr) + 8\ H^+ \Leftrightarrow 4\ UO_2^{2+} + 2\ Cs^{+} + 4\ H_2O(l) + 2\ e^-$	-90.618 ± 7.948	15.875 ± 1.392
$Na_4UO_2(CO_3)_3(cr) \Leftrightarrow UO_2^{2+} + 4\ Na^{+} + 3\ CO_3^{2-}$	155.143 ± 3.166	-27.180 ± 0.555

3.8 Neptunium

Additionally calculated and selected thermodynamic data on neptunium compounds and gaseous species are listed in Table 12. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [14].

Table 12 Additionally selected thermodynamic data for neptunium compounds and gaseous species

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$Np(cr) \Leftrightarrow Np^{4+} + 4\ e^-$	-491.774 ± 5.586	86.155 ± 0.979
$Np(g) \Leftrightarrow Np^{4+} + 4\ e^-$	-912.969 ± 6.345	159.944 ± 1.112
$NpO_2(cr) + 4\ H^+ \Leftrightarrow Np^{4+} + 2\ H_2O(l)$	55.677 ± 6.126	-9.754 ± 1.073
$Np_2O_5(cr) + 2\ H^+ \Leftrightarrow 2\ NpO_2^{+} + H_2O(l)$	-21.096 ± 15.898	3.696 ± 2.785
$NpO_2(OH)_2(cr) + 2\ H^+ \Leftrightarrow NpO_2^{2+} + 2\ H_2O(l)$	-31.219 ± 8.514	5.469 ± 1.492
$NpF(g) \Leftrightarrow Np^{4+} + F^- + 3\ e^-$	-663.737 ± 25.671	116.281 ± 4.497
$NpF_2(g) \Leftrightarrow Np^{4+} + 2\ F^- + 2\ e^-$	-464.689 ± 30.693	81.410 ± 5.377
$NpF_3(cr) \Leftrightarrow Np^{3+} + 3\ F^-$	103.066 ± 10.284	-18.056 ± 1.802
$NpF_3(g) \Leftrightarrow Np^{3+} + 3\ F^-$	-249.634 ± 25.892	43.734 ± 4.536
$NpF_4(cr) \Leftrightarrow Np^{4+} + 4\ F^-$	165.931 ± 17.215	-29.070 ± 3.016
$NpF_4(g) \Leftrightarrow Np^{4+} + 4\ F^-$	-82.579 ± 23.061	14.467 ± 4.040
$NpF_5(cr) + 2\ H_2O(l) \Leftrightarrow NpO_2^{+} + 5\ F^- + 4\ H^+$	-6.670 ± 26.243	1.169 ± 4.598
$NpF_6(cr) + 2\ H_2O(l) \Leftrightarrow NpO_2^{2+} + 6\ F^- + 4\ H^+$	-168.925 ± 21.186	29.594 ± 3.712
$NpF_6(g) + 2\ H_2O(l) \Leftrightarrow NpO_2^{2+} + 6\ F^- + 4\ H^+$	-173.272 ± 21.186	30.356 ± 3.712
$NpCl_3(cr) \Leftrightarrow Np^{3+} + 3\ Cl^-$	-76.706 ± 6.538	13.438 ± 1.145
$NpCl_3(g) \Leftrightarrow Np^{3+} + 3\ Cl^-$	-324.160 ± 12.222	56.790 ± 2.141
$NpCl_4(cr) \Leftrightarrow Np^{4+} + 4\ Cl^-$	-121.080 ± 6.357	21.212 ± 1.114

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$NpCl_4(g) \Leftrightarrow Np^{4+} + 4\ Cl^-$	-251.592 ± 7.844	44.077 ± 1.374
$NpOCl_2(cr) + 2\ H^+ \Leftrightarrow Np^{4+} + 2\ Cl^- + H_2O(l)$	-30.703 ± 9.876	5.379 ± 1.730
$NpBr_3(cr) \Leftrightarrow Np^{3+} + 3\ Br^-$	-118.895 ± 6.824	20.829 ± 1.195
$NpBr_4(cr) \Leftrightarrow Np^{4+} + 4\ Br^-$	-169.331 ± 6.623	29.665 ± 1.160
$NpOBr_2(cr) + 2\ H^+ \Leftrightarrow Np^{4+} + 2\ Br^- + H_2O(l)$	-29.681 ± 12.401	5.200 ± 2.173
$NpI_3(cr) \Leftrightarrow Np^{3+} + 3\ I^-$	-155.540 ± 6.786	27.249 ± 1.189
$NpN(cr) + 3\ H_2O(l) \Leftrightarrow Np^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	389.295 ± 11.474	-68.201 ± 2.010
$NpO_2(NO_3)_2{\cdot}6H_2O(cr) \Leftrightarrow NpO_2^{2+} + 2\ NO_3^- + 6\ H_2O(l)$	-12.298 ± 7.953	2.155 ± 1.393
$NpC_{0.91}(cr) + 2.73\ H_2O(l) \Leftrightarrow Np^{4+} + 0.91\ CO_3^{2-} + 5.46\ H^+ + 7.64\ e^-$	-248.747 ± 11.485	43.578 ± 2.012
$Np_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ Np^{4+} + 3\ CO_3^{2-} + 18\ H^+ + 20\ e^-$	-240.561 ± 22.452	42.144 ± 3.933
$Na_3NpF_8(cr) + e^- \Leftrightarrow 3\ Na^+ + Np^{4+} + 8\ F^-$	-8.578 ± 22.712	1.503 ± 3.979
$K_4NpO_2(CO_3)_3(s) \Leftrightarrow 4\ K^+ + NpO_2^{2+} + 3\ CO_3^{2-}$	150.716 ± 9.565	-26.404 ± 1.676
$Cs_2NpCl_6(cr) \Leftrightarrow 2\ Cs^+ + Np^{4+} + 6\ Cl^-$	-28.949 ± 7.521	5.072 ± 1.318
$Cs_2NpBr_6(cr) \Leftrightarrow 2\ Cs^+ + Np^{4+} + 6\ Br^-$	-77.665 ± 6.814	13.606 ± 1.194

3.9 Plutonium

Additionally calculated and selected thermodynamic data on plutonium compounds and gaseous species are listed in Table 13. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [14].

Table 13 Additionally selected thermodynamic data for plutonium compounds and gaseous species

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$Pu(cr) \Leftrightarrow Pu^{4+} + 4\ e^-$	-477.988 ± 2.705	83.739 ± 0.474
$Pu(g) \Leftrightarrow Pu^{4+} + 4\ e^-$	-790.403 ± 4.046	138.472 ± 0.709
$PuO_{1.61}(bcc) + 3.22\ H^+ \Leftrightarrow Pu^{4+} + 1.61\ H_2O(l) + 0.78\ e^-$	-25.012 ± 10.469	4.382 ± 1.834
$PuO_2(cr) + 4\ H^+ \Leftrightarrow Pu^{4+} + 2\ H_2O(l)$	45.845 ± 2.896	-8.032 ± 0.507
$Pu_2O_3(cr) + 6\ H^+ \Leftrightarrow 2\ Pu^{3+} + 3\ H_2O(l)$	-289.013 ± 11.366	50.633 ± 1.991
$Pu(OH)_3(cr) + 3\ H^+ \Leftrightarrow Pu^{3+} + 3\ H_2O(l)$	-90.186 ± 9.370	15.800 ± 1.641
$PuF(g) \Leftrightarrow Pu^{4+} + F^- + 3\ e^-$	-618.544 ± 10.491	108.364 ± 1.838
$PuF_2(g) \Leftrightarrow Pu^{4+} + 2\ F^- + 2\ e^-$	-414.883 ± 7.360	72.684 ± 1.289
$PuF_3(cr) \Leftrightarrow Pu^{3+} + 3\ F^-$	93.816 ± 5.029	-16.436 ± 0.881
$PuF_3(g) \Leftrightarrow Pu^{3+} + 3\ F^-$	-262.472 ± 5.846	45.983 ± 1.024
$PuF_4(cr) \Leftrightarrow Pu^{4+} + 4\ F^-$	152.661 ± 20.373	-26.745 ± 3.569
$PuF_4(g) \Leftrightarrow Pu^{4+} + 4\ F^-$	-86.206 ± 22.537	15.103 ± 3.948
$PuF_6(cr) + 2\ H_2O(l) \Leftrightarrow PuO_2^{2+} + 6\ F^- + 4\ H^+$	-247.355 ± 20.789	43.334 ± 3.642
$PuF_6(g) + 2\ H_2O(l) \Leftrightarrow PuO_2^{2+} + 6\ F^- + 4\ H^+$	-252.147 ± 20.721	44.174 ± 3.630
$PuOF(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + F^- + H_2O(l)$	-6.076 ± 20.412	1.064 ± 3.576
$PuCl_3(cr) \Leftrightarrow Pu^{3+} + 3\ Cl^-$	-80.829 ± 3.383	14.161 ± 0.593
$PuCl_3(g) \Leftrightarrow Pu^{3+} + 3\ Cl^-$	-331.336 ± 4.505	58.047 ± 0.789
$PuCl_4(cr) \Leftrightarrow Pu^{4+} + 4\ Cl^-$	-123.488 ± 6.440	21.634 ± 1.128

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$PuCl_4(g) \Leftrightarrow Pu^{4+} + 4\ Cl^-$	-238.173 ± 10.793	41.726 ± 1.891
$PuOCl(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + Cl^- + H_2O(l)$	-64.932 ± 3.315	11.376 ± 0.581
$PuCl_3 \cdot 6H_2O(cr) \Leftrightarrow Pu^{3+} + 3\ Cl^- + 6\ H_2O(l)$	-30.128 ± 3.755	5.278 ± 0.658
$PuBr_3(cr) \Leftrightarrow Pu^{3+} + 3\ Br^-$	-123.210 ± 3.841	21.585 ± 0.673
$PuBr_3(g) \Leftrightarrow Pu^{3+} + 3\ Br^-$	-360.726 ± 15.892	63.196 ± 2.784
$PuOBr(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + Br^- + H_2O(l)$	-81.620 ± 8.956	14.299 ± 1.569
$PuI_3(cr) \Leftrightarrow Pu^{3+} + 3\ I^-$	-155.156 ± 5.296	27.182 ± 0.928
$PuI_3(g) \Leftrightarrow Pu^{3+} + 3\ I^-$	-367.639 ± 15.888	64.407 ± 2.783
$PuOI(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + I^- + H_2O(l)$	-91.222 ± 20.671	15.981 ± 3.621
$PuN(cr) + 3\ H_2O(l) \Leftrightarrow Pu^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	396.357 ± 3.743	-69.438 ± 0.656
$PuP(cr) + 4\ H_2O(l) \Leftrightarrow Pu^{4+} + PO_4^{3-} + 8\ H^+ + 9\ e^-$	-241.162 ± 21.310	42.250 ± 3.733
$PuPO_4(s, hyd) \Leftrightarrow Pu^{3+} + PO_4^{3-}$	140.418 ± 6.346	-24.600 ± 1.112
$PuAs(cr) + 4\ H_2O(l) \Leftrightarrow Pu^{4+} + AsO_4^{3-} + 8\ H^+ + 9\ e^-$	63.625 ± 20.685	-11.147 ± 3.624
$PuC_{0.84}(cr) + 2.52\ H_2O(l) \Leftrightarrow Pu^{4+} + 0.84\ CO_3^{2-} + 5.04\ H^+ + 7.36\ e^-$	-274.004 ± 8.478	48.003 ± 1.485
$Pu_3C_2(cr) + 6\ H_2O(l) \Leftrightarrow 3\ Pu^{4+} + 2\ CO_3^{2-} + 12\ H^+ + 20\ e^-$	-943.447 ± 31.133	165.284 ± 5.454
$Pu_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ Pu^{4+} + 3\ CO_3^{2-} + 18\ H^+ + 20\ e^-$	-248.902 ± 17.625	43.605 ± 3.088
$Cs_2PuCl_6(cr) \Leftrightarrow 2\ Cs^+ + Pu^{4+} + 6\ Cl^-$	-9.959 ± 7.353	1.745 ± 1.288
$Cs_3PuCl_6(cr) \Leftrightarrow 3\ Cs^+ + Pu^{3+} + 6\ Cl^-$	-32.609 ± 10.019	5.713 ± 1.755
$CsPu_2Cl_7(cr) \Leftrightarrow Cs^+ + 2\ Pu^{3+} + 7\ Cl^-$	-132.824 ± 7.601	23.270 ± 1.332
$Cs_2PuBr_6(cr) \Leftrightarrow 2\ Cs^+ + Pu^{4+} + 6\ Br^-$	-49.674 ± 6.877	8.702 ± 1.205
$Cs_2NaPuCl_6(cr) \Leftrightarrow Na^+ + 2\ Cs^+ + Pu^{3+} + 6\ Cl^-$	-67.655 ± 5.979	11.853 ± 1.047

3.10 Americium

We focused selection of thermodynamic data on only americium(III) in the previous version of JAEA-TDB [1,2]. We additionally selected those on americium with other redox states shown in Table 14 selected by the NEA [14].

Additionally calculated and selected thermodynamic data on americium compounds and gaseous species are listed in Table 15. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [14]. Although the chemical similarity among trivalent samarium, actinium, plutonium, americium and curium was applied, selected values in Table 14 and Table 15 were not transferred to the other trivalent elements because most of the reactions contained a redox reaction which was not applicable to the other trivalent elements. Applicability of the chemical similarity should be further discussed.

3.11 Auxiliary Data

Additionally calculated and selected auxiliary data on compounds and gaseous species are listed in Table 16. Selected the Gibbs free energy of formation ($\Delta_f G°_m$) are listed elsewhere [3].

Table 14 Additionally selected thermodynamic data for americium aqueous species

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$Am^{3+} + e^- \Leftrightarrow Am^{2+}$	221.920 ± 14.476	-38.878 ± 2.536
$Am^{3+} \Leftrightarrow Am^{4+} + e^-$	252.340 ± 9.908	-44.208 ± 1.736
$Am^{4+} + 5\ CO_3^{2-} \Leftrightarrow Am(CO_3)_5^{6-}$	-224.369 ± 11.919	39.308 ± 2.088
$Am^{3+} + 2\ H_2O(l) \Leftrightarrow AmO_2^+ + 4\ H^+ + 2\ e^-$	333.182 ± 7.820	-58.371 ± 1.370
$AmO_2^+ + CO_3^{2-} \Leftrightarrow AmO_2CO_3^-$	-29.111 ± 2.854	5.100 ± 0.500 *
$AmO_2^+ + 2\ CO_3^{2-} \Leftrightarrow AmO_2(CO_3)_2^{3-}$	-38.244 ± 4.566	6.700 ± 0.800 *
$AmO_2^+ + 3\ CO_3^{2-} \Leftrightarrow AmO_2(CO_3)_3^{5-}$	-29.111 ± 5.708	5.100 ± 1.000 *
$Am^{3+} + 2\ H_2O(l) \Leftrightarrow AmO_2^{2+} + 4\ H^+ + 3\ e^-$	487.177 ± 7.435	-85.349 ± 1.303
$AmO_2^{2+} + 3\ CO_3^{2-} \Leftrightarrow AmO_2(CO_3)_3^{4-}$	-108.330 ± 10.874	18.978 ± 1.905

*Taken from $\log_{10} K°$ of the same chemical formula as neptunium.

Table 15 Additionally selected thermodynamic data for americium compounds and gaseous species

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$AmO_2OH(am) + H^+ \Leftrightarrow AmO_2^+ + H_2O(l)$	-30.253 ± 2.854	5.300 ± 0.500 *
$NaAmO_2CO_3(s) \Leftrightarrow AmO_2^+ + CO_3^{2-} + Na^+$	62.218 ± 2.283	-10.900 ± 0.400 *
$Am(cr) \Leftrightarrow Am^{3+} + 3\ e^-$	-598.698 ± 4.755	104.887 ± 0.833
$Am(g) \Leftrightarrow Am^{3+} + 3\ e^-$	-841.010 ± 5.021	147.338 ± 0.880
$AmO_2(cr) + 4\ H^+ \Leftrightarrow Am^{4+} + 2\ H_2O(l)$	57.045 ± 9.685	-9.994 ± 1.697
$Am_2O_3(cr) + 6\ H^+ \Leftrightarrow 2\ Am^{3+} + 3\ H_2O(l)$	-303.367 ± 12.613	53.147 ± 2.210
$AmH_2(cr) \Leftrightarrow Am^{2+} + 2\ H^+$	-242.119 ± 21.419	42.417 ± 3.752
$AmF_3(cr) \Leftrightarrow Am^{3+} + 3\ F^-$	76.498 ± 15.049	-13.402 ± 2.636
$AmF_3(g) \Leftrightarrow Am^{3+} + 3\ F^-$	-295.469 ± 17.555	51.764 ± 3.076
$AmF_4(cr) \Leftrightarrow Am^{4+} + 4\ F^-$	160.053 ± 19.449	-28.040 ± 3.407
$AmCl_3(cr) \Leftrightarrow Am^{3+} + 3\ Cl^-$	-87.244 ± 5.289	15.284 ± 0.927
$AmBr_3(cr) \Leftrightarrow Am^{3+} + 3\ Br^-$	-136.574 ± 8.254	23.927 ± 1.446
$AmOCl(cr) + 2\ H^+ \Leftrightarrow Am^{3+} + Cl^- + H_2O(l)$	-70.003 ± 8.238	12.264 ± 1.443
$AmOBr(cr) + 2\ H^+ \Leftrightarrow Am^{3+} + Br^- + H_2O(l)$	-91.203 ± 10.889	15.978 ± 1.908
$AmI_3(cr) \Leftrightarrow Am^{3+} + 3\ I^-$	-144.419 ± 11.139	25.301 ± 1.952
$Am_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ Am^{3+} + 8\ H^+ + 8\ e^- + 3\ CO_3^{2-}$	-490.773 ± 43.508	85.979 ± 7.622
$Cs_2NaAmCl_6(cr) \Leftrightarrow Am^{3+} + 2\ Cs^+ + Na^+ + 6\ Cl^-$	-71.714 ± 6.922	12.564 ± 1.213

*Taken from $\log_{10} K°$ of the same chemical formula as neptunium.

Table 16 Additionally selected auxiliary data for compounds and gaseous species

reaction	$\Delta_r G°_m$	$\log_{10} K°$
$Br_2(l) + 2\ e^- \Leftrightarrow 2\ Br^-$	-207.700 ± 0.334	36.387 ± 0.059
$As_4O_6(g) + 10\ H_2O(l) \Leftrightarrow 4\ AsO_4^{3-} + 20\ H^+ + 8\ e^-$	870.676 ± 22.736	-152.535 ± 3.983
$CO_3^{2-} + NO_3^- + 13\ H^+ + 10\ e^- \Leftrightarrow HCN(aq) + 6\ H_2O(l)$	-669.778 ± 2.593	117.339 ± 0.454
$HCN(g) + 6\ H_2O(l) \Leftrightarrow CO_3^{2-} + NO_3^- + 13\ H^+ + 10\ e^-$	664.629 ± 2.576	-116.437 ± 0.451
$Pb(g) \Leftrightarrow Pb^{2+} + 2\ e^-$	-186.470 ± 0.898	32.668 ± 0.157
$Al(cr) \Leftrightarrow Al^{3+} + 3\ e^-$	-491.507 ± 3.338	86.108 ± 0.585
$Al(g) \Leftrightarrow Al^{3+} + 3\ e^-$	-780.883 ± 5.210	136.804 ± 0.913
$Al_2O_3(corundum) + 6\ H^+ \Leftrightarrow 2\ Al^{3+} + 3\ H_2O(l)$	-112.177 ± 6.803	19.652 ± 1.192
$AlF_3(cr) \Leftrightarrow Al^{3+} + 3\ F^-$	95.020 ± 4.143	-16.647 ± 0.726
$Zn(cr) \Leftrightarrow Zn^{2+} + 2\ e^-$	-147.203 ± 0.254	25.789 ± 0.044
$Zn(g) \Leftrightarrow Zn^{2+} + 2\ e^-$	-242.016 ± 0.476	42.399 ± 0.083
$ZnO(cr) + 2\ H^+ \Leftrightarrow Zn^{2+} + H_2O(l)$	-63.864 ± 0.394	11.188 ± 0.069
$Cd(cr) \Leftrightarrow Cd^{2+} + 2\ e^-$	-77.733 ± 0.750	13.618 ± 0.131
$Cd(g) \Leftrightarrow Cd^{2+} + 2\ e^-$	-154.963 ± 0.778	27.148 ± 0.136
$CdO(cr) + 2\ H^+ \Leftrightarrow Cd^{2+} + H_2O(l)$	-86.212 ± 0.963	15.104 ± 0.169
$CdSO_4 \cdot 2.667H_2O(cr) \Leftrightarrow Cd^{2+} + SO_4^{2-} + 2.667\ H_2O(l)$	10.770 ± 1.185	-1.887 ± 0.208
$Hg(g) \Leftrightarrow Hg^{2+} + 2\ e^-$	132.825 ± 0.318	-23.270 ± 0.056
$Hg(l) \Leftrightarrow Hg^{2+} + 2\ e^-$	164.667 ± 0.313	-28.848 ± 0.055
$Hg_2Cl_2(cr) \Leftrightarrow 2\ Hg^{2+} + 2\ e^- + 2\ Cl^-$	277.625 ± 0.818	-48.638 ± 0.143
$Hg_2SO_4(cr) \Leftrightarrow 2\ Hg^{2+} + SO_4^{2-} + 2\ e^-$	211.110 ± 0.858	-36.985 ± 0.150
$HgO(montroydite,red) + 2\ H^+ \Leftrightarrow Hg^{2+} + H_2O(l)$	-13.950 ± 0.351	2.444 ± 0.062
$Cu(cr) \Leftrightarrow Cu^{2+} + 2\ e^-$	65.040 ± 1.557	-11.394 ± 0.273
$Cu(g) \Leftrightarrow Cu^{2+} + 2\ e^-$	-232.632 ± 1.966	40.755 ± 0.344
$CuSO_4(cr) \Leftrightarrow Cu^{2+} + SO_4^{2-}$	-16.779 ± 2.013	2.940 ± 0.353
$Ag(cr) \Leftrightarrow Ag^+ + e^-$	77.096 ± 0.156	-13.507 ± 0.027
$Ag(g) \Leftrightarrow Ag^+ + e^-$	-168.911 ± 0.817	29.592 ± 0.143
$AgCl(cr) \Leftrightarrow Ag^+ + Cl^-$	55.644 ± 0.218	-9.748 ± 0.038
$Mg(cr) \Leftrightarrow Mg^{2+} + 2\ e^-$	-455.375 ± 1.335	79.778 ± 0.234
$Mg(g) \Leftrightarrow Mg^{2+} + 2\ e^-$	-567.896 ± 1.557	99.491 ± 0.273
$CaCl(g) \Leftrightarrow Ca^{2+} + Cl^- + e^-$	-554.236 ± 5.111	97.097 ± 0.895
$CaF(g) \Leftrightarrow Ca^{2+} + F^- + e^-$	-532.211 ± 5.257	93.239 ± 0.921
$SrCl_2(cr) \Leftrightarrow Sr^{2+} + 2\ Cl^-$	-41.324 ± 1.084	7.240 ± 0.190
$Ba(g) \Leftrightarrow Ba^{2+} + 2\ e^-$	-710.508 ± 5.633	124.475 ± 0.987
$BaCl_2(cr) \Leftrightarrow Ba^{2+} + 2\ Cl^-$	-13.137 ± 3.611	2.301 ± 0.633
$BaF(g) \Leftrightarrow Ba^{2+} + F^- + e^-$	-489.610 ± 7.218	85.775 ± 1.265
$Li(cr) \Leftrightarrow Li^+ + e^-$	-292.918 ± 0.109	51.317 ± 0.019
$Li(g) \Leftrightarrow Li^+ + e^-$	-419.522 ± 1.008	73.497 ± 0.177
$NaCl(cr) \Leftrightarrow Na^+ + Cl^-$	-8.949 ± 0.211	1.568 ± 0.037
$NaF(cr) \Leftrightarrow Na^+ + F^-$	2.851 ± 0.992	-0.499 ± 0.174
$Rb(cr) \Leftrightarrow Rb^+ + e^-$	-284.009 ± 0.153	49.756 ± 0.027
$Rb(g) \Leftrightarrow Rb^+ + e^-$	-337.087 ± 0.819	59.055 ± 0.144
$CsBr(cr) \Leftrightarrow Cs^+ + Br^-$	-4.135 ± 0.638	0.724 ± 0.112
$CsCl(cr) \Leftrightarrow Cs^+ + Cl^-$	-8.866 ± 0.586	1.553 ± 0.103

4. Conclusions

We calculated additionally selected many equilibrium constant values using Gibbs free energy values of formation selected by the NEA. We also selected additional thermodynamic data on selenium, collected thermodynamic data on iodine and revised some thermodynamic data using the latest information. We carefully prepared the text files of JAEA-TDB available for the geochemical calculation programs of PHREEQC, EQ3/6 and Geochemist's Workbench. The prepared files are contained in the attached CD-ROM and will be uploaded onto JAEA's Website (http://migrationdb.jaea.go.jp/).

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Appendix 1. Revised Thermodynamic Data Compiled for JAEA-TDB

Selected equilibrium constants for JAEA-TDB are shown in Table A1 and Table A2.

Table A1 Selected equilibrium constants of aqueous species for JAEA-TDB ready to use for the geochemical calculation programs (revised from Table A1 in the previous TDB report [2)])

Reactions and $\log_{10} K°$ values written with bold letters are additionally selected or revised in the present report.

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$2\ H^+ + 2\ e^- \Leftrightarrow H_2(aq)$	-3.150	4	
$H_2O(l) \Leftrightarrow H^+ + OH^-$	-14.001 ± 0.015	3	
$2\ H_2O(l) \Leftrightarrow O_2(aq) + 4\ H^+ + 4\ e^-$	-86.080	4	
$Li^+ + SO_4^{2-} \Leftrightarrow LiSO_4^-$	0.640	4	
$B(OH)_3(aq) \Leftrightarrow H_2BO_3^- + H^+$	-9.240	4	
$B(OH)_3(aq) + F^- \Leftrightarrow BF(OH)_3^-$	-0.400	4	
$B(OH)_3(aq) + 2\ F^- + H^+ \Leftrightarrow BF_2(OH)_2^- + H_2O(l)$	7.628	4	
$B(OH)_3(aq) + 2\ H^+ + 3\ F^- \Leftrightarrow BF_3OH^- + 2\ H_2O(l)$	13.666	4	
$B(OH)_3(aq) + 3\ H^+ + 4\ F^- \Leftrightarrow BF_4^- + 3\ H_2O(l)$	20.274	4	
$CO_3^{2-} + H^+ \Leftrightarrow HCO_3^-$	10.329 ± 0.020	3	
$CO_3^{2-} + 2\ H^+ \Leftrightarrow CO_2(aq) + H_2O(l)$	16.683 ± 0.028	3	
$CO_3^{2-} + 10\ H^+ + 8\ e^- \Leftrightarrow CH_4(aq) + 3\ H_2O(l)$	41.071	4	
$CO_3^{2-} + NO_3^- + 12\ H^+ + 10\ e^- \Leftrightarrow CN^- + 6\ H_2O(l)$	108.129 ± 0.455	3	
$CO_3^{2-} + NO_3^- + 13\ H^+ + 10\ e^- \Leftrightarrow HCN(aq) + 6\ H_2O(l)$	**117.339 ± 0.454**	**present**	
$NO_3^- + 10\ H^+ + 8\ e^- \Leftrightarrow NH_4^+ + 3\ H_2O(l)$	119.134 ± 0.089	3	
$NO_3^- + 2\ H^+ + 2\ e^- \Leftrightarrow NO_2^- + H_2O(l)$	27.776 ± 0.075	3, 28	
$NO_2^- + H^+ \Leftrightarrow HNO_2(aq)$	3.210 ± 0.160	3	
$3\ NO_3^- + 18\ H^+ + 16\ e^- \Leftrightarrow N_3^- + 9\ H_2O(l)$	254.672 ± 0.418	3	
$3\ NO_3^- + 19\ H^+ + 16\ e^- \Leftrightarrow HN_3(aq) + 9\ H_2O(l)$	259.372 ± 0.382	3	
$NH_4^+ \Leftrightarrow H^+ + NH_3(aq)$	-9.237 ± 0.022	3	
$NH_4^+ + SO_4^{2-} \Leftrightarrow NH_4SO_4^-$	1.052	4	
$F^+ + H^- \Leftrightarrow HF(aq)$	3.180 ± 0.020	3	
$2\ F^- + H^+ \Leftrightarrow HF_2^-$	3.620 ± 0.122	3	
$Na^+ + CO_3^{2-} \Leftrightarrow NaCO_3^-$	1.268	4	
$Na^+ + CO_3^{2-} + H^+ \Leftrightarrow NaHCO_3(aq)$	10.080	4	
$Na^+ + SO_4^{2-} \Leftrightarrow NaSO_4^-$	0.700 ± 0.050	4, 29	
$Na^+ + H^+ + PO_4^{3-} \Leftrightarrow NaHPO_4^-$	12.636	4	
$Mg^{2+} + H_2O(l) \Leftrightarrow MgOH^+ + H^+$	-11.794	4	
$Mg^{2+} + CO_3^{2-} \Leftrightarrow MgCO_3(aq)$	2.981 ± 0.030	4, 29	
$Mg^{2+} + SO_4^{2-} \Leftrightarrow MgSO_4(aq)$	2.250	4	
$Mg^{2+} + PO_4^{3-} \Leftrightarrow MgPO_4^-$	6.589	4	
$Mg^{2+} + H^+ + PO_4^{3-} \Leftrightarrow MgHPO_4(aq)$	15.216	4	
$Mg^{2+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow MgH_2PO_4^+$	21.066	4	
$Mg^{2+} + F^- \Leftrightarrow MgF^+$	1.820	4	
$Al^{3+} + H_2O(l) \Leftrightarrow AlOH^{2+} + H^+$	-4.990 ± 0.020	4, 29	
$Al^{3+} + 2\ H_2O(l) \Leftrightarrow Al(OH)_2^+ + 2\ H^+$	-10.100 ± 0.200	4, 29	
$Al^{3+} + 3\ H_2O(l) \Leftrightarrow Al(OH)_3(aq) + 3\ H^+$	-16.000	4	
$Al^{3+} + 4\ H_2O(l) \Leftrightarrow Al(OH)_4^- + 4\ H^+$	-23.000	4	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Al^{3+} + F^- \Leftrightarrow AlF^{2+}$	7.010	4	
$Al^{3+} + 2\ F^- \Leftrightarrow AlF_2^+$	12.750	4	
$Al^{3+} + 3\ F^- \Leftrightarrow AlF_3(aq)$	17.020	4	
$Al^{3+} + 4\ F^- \Leftrightarrow AlF_4^-$	19.720	4	
$Al^{3+} + SO_4^{2-} \Leftrightarrow AlSO_4^+$	3.020	4	
$Al^{3+} + 2\ SO_4^{2-} \Leftrightarrow Al(SO_4)_2^-$	4.920	4	
$H_4SiO_4(aq) \Leftrightarrow H_2SiO_4^{2-} + 2\ H^+$	-23.140 ± 0.090	3	
$H_4SiO_4(aq) \Leftrightarrow H_3SiO_4^- + H^+$	-9.810 ± 0.020	3	
$2\ H_4SiO_4(aq) \Leftrightarrow H_4Si_2O_7^{2-} + H_2O(l) + 2\ H^+$	-19.000 ± 0.300	3	
$2\ H_4SiO_4(aq) \Leftrightarrow H_5Si_2O_7^- + H_2O(l) + H^+$	-8.100 ± 0.300	3	
$3\ H_4SiO_4(aq) \Leftrightarrow H_3Si_3O_9^{3-} + 3\ H_2O(l) + 3\ H^+$	-28.600 ± 0.300	3	
$3\ H_4SiO_4(aq) \Leftrightarrow H_5Si_3O_{10}^{3-} + 2\ H_2O(l) + 3\ H^+$	-27.500 ± 0.300	3	
$4\ H_4SiO_4(aq) \Leftrightarrow H_4Si_4O_{12}^{4-} + 4\ H_2O(l) + 4\ H^+$	-36.300 ± 0.500	3	
$4\ H_4SiO_4(aq) \Leftrightarrow H_5Si_4O_{12}^{3-} + 4\ H_2O(l) + 3\ H^+$	-25.500 ± 0.300	3	
$4\ H_4SiO_4(aq) \Leftrightarrow H_{13}Si_4O_{16}^{3-} + 3\ H^+$	-34.901	4	
$H_4SiO_4(aq) + 4\ H^+ + 6\ F^- \Leftrightarrow F_6Si^{2-} + 4\ H_2O(l)$	30.180	4	
$2\ PO_4^{3-} + 2\ H^+ \Leftrightarrow P_2O_7^{4-} + H_2O(l)$	21.314 ± 0.890	3	
$PO_4^{3-} + H^+ \Leftrightarrow HPO_4^{2-}$	12.350 ± 0.030	3	
$PO_4^{3-} + 2\ H^+ \Leftrightarrow H_2PO_4^-$	19.562 ± 0.033	3	
$PO_4^{3-} + 3\ H^+ \Leftrightarrow H_3PO_4(aq)$	21.702 ± 0.176	3	
$2\ PO_4^{3-} + 3\ H^+ \Leftrightarrow HP_2O_7^{3-} + H_2O(l)$	30.714 ± 0.660	3	
$2\ PO_4^{3-} + 4\ H^+ \Leftrightarrow H_2P_2O_7^{2-} + H_2O(l)$	37.364 ± 0.652	3	
$2\ PO_4^{3-} + 5\ H^+ \Leftrightarrow H_3P_2O_7^- + H_2O(l)$	39.614 ± 0.635	3	
$2\ PO_4^{3-} + 6\ H^+ \Leftrightarrow H_4P_2O_7(aq) + H_2O(l)$	40.614 ± 0.391	3	
$HS^- \Leftrightarrow S^{2-} + H^+$	-19.000 ± 2.000	3	
$SO_4^{2-} + 2\ H^+ + 2\ e^- \Leftrightarrow SO_3^{2-} + H_2O(l)$	-3.397 ± 0.701	3	
$2\ SO_4^{2-} + 10\ H^+ + 8\ e^- \Leftrightarrow S_2O_3^{2-} + 5\ H_2O(l)$	38.013 ± 1.985	3	
$SO_4^{2-} + 9\ H^+ + 8\ e^- \Leftrightarrow HS^- + 4\ H_2O(l)$	33.692 ± 0.378	3	
$HS^- + H^+ \Leftrightarrow H_2S(aq)$	6.990 ± 0.170	3	
$SO_3^{2-} + H^+ \Leftrightarrow HSO_3^-$	7.220 ± 0.080	3	
$S_2O_3^{2-} + H^+ \Leftrightarrow HS_2O_3^-$	1.590 ± 0.150	3	
$0.5\ S_2O_3^{2-} + 1.5\ H_2O(l) \Leftrightarrow H_2SO_3(aq) + H^+ + 2\ e^-$	-13.344 ± 0.710	3	
$SO_4^{2-} + H^+ \Leftrightarrow HSO_4^-$	1.980 ± 0.050	3	
$SO_4^{2-} + CO_3^{2-} + NO_3^- + 20\ H^+ + 16\ e^- \Leftrightarrow SCN^- + 10\ H_2O(l)$	156.972 ± 0.715	3	
$Cl^- + H_2O(l) \Leftrightarrow ClO^- + 2\ H^+ + 2\ e^-$	-57.933 ± 0.170	3	
$Cl^- + 2\ H_2O(l) \Leftrightarrow ClO_2^- + 4\ H^+ + 4\ e^-$	-107.874 ± 0.709	3	
$Cl^- + 3\ H_2O(l) \Leftrightarrow ClO_3^- + 6\ H^+ + 6\ e^-$	-146.238 ± 0.236	3	
$Cl^- + 4\ H_2O(l) \Leftrightarrow ClO_4^- + 8\ H^+ + 8\ e^-$	-187.785 ± 0.108	3	
$Cl^- + H_2O(l) \Leftrightarrow HClO(aq) + H^+ + 2\ e^-$	-50.513 ± 0.109	3	
$Cl^- + 2\ H_2O(l) \Leftrightarrow HClO_2(aq) + 3\ H^+ + 4\ e^-$	-105.913 ± 0.708	3	
$K^+ + SO_4^{2-} \Leftrightarrow KSO_4^-$	0.850 ± 0.050	4, 29	
$K^+ + H^+ + PO_4^{3-} \Leftrightarrow KHPO_4^-$	12.636	4	
$Ca^{2+} + H_2O(l) \Leftrightarrow CaOH^+ + H^+$	-12.850 ± 0.500	30	
$Ca^{2+} + SO_4^{2-} \Leftrightarrow CaSO_4(aq)$	2.309	4	
$Ca^{2+} + PO_4^{3-} \Leftrightarrow CaPO_4^-$	6.459	4	
$Ca^{2+} + H^+ + PO_4^{3-} \Leftrightarrow CaHPO_4(aq)$	15.085	4	
$Ca^{2+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow CaH_2PO_4^+$	20.961	4	
$Ca^{2+} + F^- \Leftrightarrow CaF^+$	0.940	4	
$Mn^{2+} + H_2O(l) \Leftrightarrow MnOH^+ + H^+$	-10.590 ± 0.040	4, 29	
$Mn^{2+} + 3\ H_2O(l) \Leftrightarrow Mn(OH)_3^- + 3\ H^+$	-34.800	4	
$Mn^{2+} \Leftrightarrow Mn^{3+} + e^-$	-25.507	4	
$Mn^{2+} + 4\ H_2O(l) \Leftrightarrow MnO_4^{2-} + 8\ H^+ + 4\ e^-$	-118.440	4	
$Mn^{2+} + 4\ H_2O(l) \Leftrightarrow MnO_4^- + 8\ H^+ + 5\ e^-$	-127.824	4	
$Mn^{2+} + F^- \Leftrightarrow MnF^+$	0.850	4	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Mn^{2+} + Cl^- \Leftrightarrow MnCl^+$	0.607	4	
$Mn^{2+} + 2\ Cl^- \Leftrightarrow MnCl_2(aq)$	0.041	4	
$Mn^{2+} + 3\ Cl^- \Leftrightarrow MnCl_3^-$	-0.305	4	
$Mn^{2+} + 2\ NO_3^- \Leftrightarrow Mn(NO_3)_2(aq)$	0.600	4	
$Mn^{2+} + SO_4^{2-} \Leftrightarrow MnSO_4(aq)$	2.260	4	
$Mn^{2+} + CO_3^{2-} + H^+ \Leftrightarrow MnHCO_3^+$	11.600	4	
$Fe^{2+} + H_2O(l) \Leftrightarrow FeOH^+ + H^+$	-9.500 ± 0.100	4, 29	
$Fe^{2+} + 2\ H_2O(l) \Leftrightarrow Fe(OH)_2(aq) + 2\ H^+$	-20.570 ± 1.000	4, 29	
$Fe^{2+} + 3\ H_2O(l) \Leftrightarrow Fe(OH)_3^- + 3\ H^+$	-31.000 ± 1.500	4, 29	
$Fe^{2+} + SO_4^{2-} \Leftrightarrow FeSO_4(aq)$	2.250	4	
$Fe^{2+} + 2\ HS^- \Leftrightarrow Fe(HS)_2(aq)$	8.864	4	
$Fe^{2+} + 3\ HS^- \Leftrightarrow Fe(HS)_3^-$	10.858	4	
$Fe^{2+} + H^+ + PO_4^{3-} \Leftrightarrow FeHPO_4(aq)$	15.946	4	
$Fe^{2+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow FeH_2PO_4^+$	22.253	4	
$Fe^{2+} \Leftrightarrow Fe^{3+} + e^-$	-13.032 ± 0.010	4, 29	
$Fe^{3+} + H_2O(l) \Leftrightarrow FeOH^{2+} + H^+$	-2.188 ± 0.020	4, 29	
$Fe^{3+} + 2\ H_2O(l) \Leftrightarrow Fe(OH)_2^+ + 2\ H^+$	-5.668 ± 0.100	4, 29	
$Fe^{3+} + 3\ H_2O(l) \Leftrightarrow Fe(OH)_3(aq) + 3\ H^+$	-13.598	4	
$Fe^{3+} + 4\ H_2O(l) \Leftrightarrow Fe(OH)_4^- + 4\ H^+$	-21.598 ± 0.200	4, 29	
$2\ Fe^{3+} + 2\ H_2O(l) \Leftrightarrow Fe_2(OH)_2^{4+} + 2\ H^+$	-2.946 ± 0.050	4, 29	
$3\ Fe^{3+} + 4\ H_2O(l) \Leftrightarrow Fe_3(OH)_4^{5+} + 4\ H^+$	-6.304 ± 0.100	4, 29	
$Fe^{3+} + Cl^- \Leftrightarrow FeCl^{2+}$	1.482	4	
$Fe^{3+} + 2\ Cl^- \Leftrightarrow FeCl_2^+$	2.132	4	
$Fe^{3+} + 3\ Cl^- \Leftrightarrow FeCl_3(aq)$	1.132	4	
$Fe^{3+} + SO_4^{2-} \Leftrightarrow FeSO_4^+$	3.922	4	
$Fe^{3+} + 2\ SO_4^{2-} \Leftrightarrow Fe(SO_4)_2^-$	5.422	4	
$Fe^{3+} + H^+ + PO_4^{3-} \Leftrightarrow FeHPO_4^+$	17.772	4	
$Fe^{3+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow FeH_2PO_4^{2+}$	24.982	4	
$Fe^{3+} + F^- \Leftrightarrow FeF^{2+}$	6.232	4	
$Fe^{3+} + 2\ F^- \Leftrightarrow FeF_2^+$	10.832	4	
$Fe^{3+} + 3\ F^- \Leftrightarrow FeF_3(aq)$	14.002	4	
$Co^{2+} + H_2O(l) \Leftrightarrow H^+ + CoOH^+$	-9.470 ± 0.020	31	
$Co^{2+} + 2\ H_2O(l) \Leftrightarrow 2\ H^+ + Co(OH)_2(aq)$	-18.000 ± 1.100	31	
$Co^{2+} + 3\ H_2O(l) \Leftrightarrow 3\ H^+ + Co(OH)_3^-$	-31.500 ± 0.500	31	
$2\ Co^{2+} + H_2O(l) \Leftrightarrow H^+ + Co_2OH^{3+}$	-10.548 ± 0.861	31	*
$4\ Co^{2+} + 4\ H_2O(l) \Leftrightarrow 4\ H^+ + Co_4(OH)_4^{4+}$	-27.371 ± 0.211	31	*
$Co^{2+} + F^- \Leftrightarrow CoF^+$	1.470 ± 0.040	31	
$Co^{2+} + Cl^- \Leftrightarrow CoCl^+$	0.810 ± 0.070	31	
$Co^{2+} + HS^{2-} \Leftrightarrow CoS(aq) + H^+$	0.600 ± 2.062	31	
$Co^{2+} + HS^- \Leftrightarrow CoHS^+$	5.141 ± 0.277	31	*
$Co^{2+} + SO_4^{2-} \Leftrightarrow CoSO_4(aq)$	2.200 ± 0.050	31	
$Co^{2+} + 2\ SO_4^{2-} \Leftrightarrow Co(SO_4)_2^{2-}$	2.870 ± 0.050	31	
$Co^{2+} + NO_3^- \Leftrightarrow CoNO_3^+$	-1.020 ± 0.060	31	
$Co^{2+} + NH_4^+ \Leftrightarrow CoNH_3^{2+} + H^+$	-7.037 ± 0.102	31, 3	
$Co^{2+} + 2\ NH_4^+ \Leftrightarrow Co(NH_3)_2^{2+} + 2\ H^+$	-14.574 ± 0.205	31, 3	
$Co^{2+} + 3\ NH_4^+ \Leftrightarrow Co(NH_3)_3^{2+} + 3\ H^+$	-22.311 ± 0.405	31, 3	
$Co^{2+} + 4\ NH_4^+ \Leftrightarrow Co(NH_3)_4^{2+} + 4\ H^+$	-30.548 ± 0.410	31, 3	
$Co^{2+} + 5\ NH_4^+ \Leftrightarrow Co(NH_3)_5^{2+} + 5\ H^+$	-39.485 ± 0.415	31, 3	
$Co^{2+} + 6\ NH_4^+ \Leftrightarrow Co(NH_3)_6^{2+} + 6\ H^+$	-49.522 ± 0.421	31, 3	
$Co^{2+} + H^+ + PO_4^{3-} \Leftrightarrow CoHPO_4(aq)$	15.300 ± 0.143	31, 3	
$Co^{2+} + 2\ H^+ + 2\ PO_4^{3-} \Leftrightarrow CoP_2O_7^{2-} + H_2O(l)$	29.985 ± 0.966	31, 3	*
$Co^{2+} + 3\ H^+ + 2\ PO_4^{3-} \Leftrightarrow HCoP_2O_7^- + H_2O(l)$	35.815 ± 0.737	31, 3	*
$Co^{2+} + H^+ + AsO_4^{3-} \Leftrightarrow CoHAsO_4(aq)$	14.477 ± 1.052	31, 3	*
$Co^{2+} + CO_3^{2-} \Leftrightarrow CoCO_3(aq)$	4.400 ± 0.100	31	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Co^{2+} + H^+ + CO_3^{2-} \Leftrightarrow CoHCO_3^+$	11.729 ± 0.201	31, 3	
$Co^{2+} + 4\ CO_3^{2-} + 4\ NO_3^- + 48\ H^+ + 40\ e^- \Leftrightarrow Co(CN)_4^{2-} + 24\ H_2O(l)$	462.533 ± 1.896	31, 3	*
$Co^{2+} + 5\ CO_3^{2-} + 5\ NO_3^- + 60\ H^+ + 50\ e^- \Leftrightarrow Co(CN)_5^{3-} + 30\ H_2O(l)$	568.972 ± 2.442	31, 3	*
$Co^{2+} + SO_4^{2-} + CO_3^{2-} + NO_3^- + 20\ H^+ + 16\ e^- \Leftrightarrow CoSCN^+ + 10\ H_2O(l)$	158.762 ± 0.719	31, 3	*
$Co^{2+} + 2\ SO_4^{2-} + 2\ CO_3^{2-} + 2\ NO_3^- + 40\ H^+ + 32\ e^- \Leftrightarrow Co(SCN)_2(aq) + 20\ H_2O(l)$	316.609 ± 1.435	31, 3	*
$Co^{2+} + 3\ SO_4^{2-} + 3\ CO_3^{2-} + 3\ NO_3^- + 60\ H^+ + 48\ e^- \Leftrightarrow Co(SCN)_3^- + 30\ H_2O(l)$	473.909 ± 2.157	31, 3	*
$Ni^{2+} + H_2O(l) \Leftrightarrow H^+ + NiOH^+$	-9.540 ± 0.140	10	
$Ni^{2+} + 2\ H_2O(l) \Leftrightarrow 2\ H^+ + Ni(OH)_2(aq)$	< -18.029	10	
$Ni^{2+} + 3\ H_2O(l) \Leftrightarrow 3\ H^+ + Ni(OH)_3^-$	-29.200 ± 1.700	10	
$2\ Ni^{2+} + H_2O(l) \Leftrightarrow H^+ + Ni_2OH^{3+}$	-10.600 ± 1.000	10	
$4\ Ni^{2+} + 4\ H_2O(l) \Leftrightarrow 4\ H^+ + Ni_4(OH)_4^{4+}$	-27.520 ± 0.150	10	
$Ni^{2+} + F^- \Leftrightarrow NiF^+$	1.430 ± 0.080	10	
$Ni^{2+} + Cl^- \Leftrightarrow NiCl^+$	0.080 ± 0.600	10	
$Ni^{2+} + HS^- \Leftrightarrow NiS(aq) + H^+$	0.723 ± 2.013	31, 3	*
$Ni^{2+} + HS^- \Leftrightarrow NiHS^+$	5.180 ± 0.200	10	
$Ni^{2+} + SO_4^{2-} \Leftrightarrow NiSO_4(aq)$	2.350 ± 0.030	10	
$Ni^{2+} + 2\ SO_4^{2-} \Leftrightarrow Ni(SO_4)_2^{2-}$	2.896 ± 0.002	10	*
$Ni^{2+} + NO_3^- \Leftrightarrow NiNO_3^+$	0.500 ± 1.000	10	
$Ni^{2+} + NH_4^+ \Leftrightarrow NiNH_3^{2+} + H^+$	-7.015 ± 0.065	31, 3	*
$Ni^{2+} + 2\ NH_4^+ \Leftrightarrow Ni(NH_3)_2^{2+} + 2\ H^+$	-14.542 ± 0.146	31, 3	*
$Ni^{2+} + 3\ NH_4^+ \Leftrightarrow Ni(NH_3)_3^{2+} + 3\ H^+$	-22.271 ± 0.327	31, 3	*
$Ni^{2+} + 4\ NH_4^+ \Leftrightarrow Ni(NH_3)_4^{2+} + 4\ H^+$	-30.502 ± 0.318	31, 3	*
$Ni^{2+} + 5\ NH_4^+ \Leftrightarrow Ni(NH_3)_5^{2+} + 5\ H^+$	-39.437 ± 0.321	31, 3	*
$Ni^{2+} + 6\ NH_4^+ \Leftrightarrow Ni(NH_3)_6^{2+} + 6\ H^+$	-49.479 ± 0.340	31, 3	*
$Ni^{2+} + H^+ + PO_4^{3-} \Leftrightarrow NiHPO_4(aq)$	15.400 ± 0.095	10, 3	
$Ni^{2+} + 2\ H^+ + 2\ PO_4^{3-} \Leftrightarrow NiP_2O_7^{2-} + H_2O(l)$	30.044 ± 0.924	10, 3	
$Ni^{2+} + 3\ H^+ + 2\ PO_4^{3-} \Leftrightarrow HNiP_2O_7^- + H_2O(l)$	35.854 ± 0.706	10, 3	
$Ni^{2+} + H^+ + AsO_4^{3-} \Leftrightarrow NiHAsO_4(aq)$	14.503 ± 1.037	10, 3	
$Ni^{2+} + CO_3^{2-} \Leftrightarrow NiCO_3(aq)$	4.200 ± 0.400	10	
$Ni^{2+} + H^+ + CO_3^{2-} \Leftrightarrow NiHCO_3^+$	11.746 ± 0.174	31, 3	*
$Ni^{2+} + 4\ NO_3^- + 4\ CO_3^{2-} + 48\ H^+ + 40\ e^- \Leftrightarrow Ni(CN)_4^{2-} + 24\ H_2O(l)$	462.716 ± 1.824	10, 3	
$Ni^{2+} + 5\ NO_3^- + 5\ CO_3^{2-} + 60\ H^+ + 50\ e^- \Leftrightarrow Ni(CN)_5^{3-} + 30\ H_2O(l)$	569.145 ± 2.329	10, 3	
$Ni^{2+} + NO_3^- + CO_3^{2-} + SO_4^{2-} + 20\ H^+ + 16\ e^- \Leftrightarrow NiSCN^+ + 10\ H_2O(l)$	158.782 ± 0.716	10, 3	
$Ni^{2+} + 2\ NO_3^- + 2\ CO_3^{2-} + 2\ SO_4^{2-} + 40\ H^+ + 32\ e^- \Leftrightarrow Ni(SCN)_2(aq) + 20\ H_2O(l)$	316.634 ± 1.432	10, 3	
$Ni^{2+} + 3\ NO_3^- + 3\ CO_3^{2-} + 3\ SO_4^{2-} + 60\ H^+ + 48\ e^- \Leftrightarrow Ni(SCN)_3^- + 30\ H_2O(l)$	473.936 ± 2.153	10, 3	
$AsO_4^{3-} + 4\ H^+ + 2\ e^- \Leftrightarrow AsO_2^- + 2\ H_2O(l)$	30.859 ± 0.993	3	
$AsO_4^{3-} + 5\ H^+ + 2\ e^- \Leftrightarrow HAsO_2(aq) + 2\ H_2O(l)$	40.092 ± 0.993	3	
$AsO_4^{3-} + 4\ H^+ + 2\ e^- \Leftrightarrow H_2AsO_3^- + H_2O(l)$	30.809 ± 0.993	3	
$AsO_4^{3-} + 5\ H^+ + 2\ e^- \Leftrightarrow H_3AsO_3(aq) + H_2O(l)$	40.024 ± 0.994	3	
$AsO_4^{3-} + H^+ \Leftrightarrow HAsO_4^{2-}$	11.603 ± 0.993	3	
$AsO_4^{3-} + 2\ H^+ \Leftrightarrow H_2AsO_4^-$	18.368 ± 0.994	3	
$AsO_4^{3-} + 3\ H^+ \Leftrightarrow H_3AsO_4(aq)$	20.630 ± 0.994	3	
$2\ SeO_4^{2-} + 16\ H^+ + 14\ e^- \Leftrightarrow Se_2^{2-} + 8\ H_2O(l)$	158.632 ± 1.213	11	
$3\ SeO_4^{2-} + 24\ H^+ + 20\ e^- \Leftrightarrow Se_3^{2-} + 12\ H_2O(l)$	249.934 ± 1.780	11	
$4\ SeO_4^{2-} + 32\ H^+ + 26\ e^- \Leftrightarrow Se_4^{2-} + 16\ H_2O(l)$	**340.074 ± 0.562**	**11, present**	
$SeO_4^{2-} + 2\ H^+ + 2\ e^- \Leftrightarrow SeO_3^{2-} + H_2O(l)$	28.039 ± 0.397	11	
$SeO_4^{2-} + 9\ H^+ + 8\ e^- \Leftrightarrow HSe^- + 4\ H_2O(l)$	81.570 ± 0.435	11	
$HSe^- + H^+ \Leftrightarrow H_2Se(aq)$	3.850 ± 0.050	11	
$HSe^- \Leftrightarrow Se^{2-} + H^+$	**-14.914 ± 0.634**	**present**	
$SeO_3^{2-} + H^+ \Leftrightarrow HSeO_3^-$	8.360 ± 0.230	11	
$SeO_4^{2-} + H^+ \Leftrightarrow HSeO_4^-$	1.750 ± 0.100	11	
$SeO_3^{2-} + 2\ H^+ \Leftrightarrow H_2SeO_3(aq)$	11.000 ± 0.269	11	
$2\ SeO_4^{2-} + 16\ H^+ + 10\ e^- + 2\ Cl^- \Leftrightarrow Se_2Cl_2(aq) + 8\ H_2O(l)$	140.427 ± 0.904	11	
$SeO_4^{2-} + 20\ H^+ + 16\ e^- + CO_3^{2-} + NO_3^- \Leftrightarrow SeCN^- + 10\ H_2O(l)$	202.726 ± 0.722	11	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$SeO_4^{2-} + 20\ H^+ + 16\ e^- + CO_3^{2-} + NO_3^- + Tl^+ \Leftrightarrow TlSeCN(aq) + 10\ H_2O(l)$	204.476 ± 0.778	11	
$SeO_4^{2-} + Zn^{2+} \Leftrightarrow ZnSeO_4(aq)$	2.160 ± 0.060	11	
$SeO_4^{2-} + 20\ H^+ + 16\ e^- + CO_3^{2-} + NO_3^- + Zn^{2+} \Leftrightarrow ZnSeCN^+ + 10\ H_2O(l)$	203.936 ± 0.724	11	
$2\ SeO_4^{2-}+40\ H^+ +32\ e^- +2\ CO_3^{2-} +2\ NO_3^- +Zn^{2+} \Leftrightarrow Zn(SeCN)_2(aq)+20\ H_2O(l)$	407.133 ± 1.448	11	
$Cd^{2+} + SeO_4^{2-} \Leftrightarrow CdSeO_4(aq)$	2.270 ± 0.060	11	
$SeO_4^{2-} + 20\ H^+ + 16\ e^- + CO_3^{2-} + NO_3^- + Cd^{2+} \Leftrightarrow CdSeCN^+ + 10\ H_2O(l)$	204.966 ± 0.724	11	
$2\ SeO_4^{2-}+40\ H^+ +32\ e^- +2\ CO_3^{2} +2\ NO_3^- +Cd^{2+} \Leftrightarrow Cd(SeCN)_2(aq)+20\ H_2O(l)$	408.793 ± 1.449	11	
$3\ SeO_4^{2-}+60\ H^+ +48\ e^- +3\ CO_3^{2-} +3\ NO_3^- +Cd^{2+} \Leftrightarrow Cd(SeCN)_3^- +30\ H_2O(l)$	611.989 ± 2.176	11	
$4\ SeO_4^{2-}+80\ H^+ +64\ e^- +4\ CO_3^{2-} +4\ NO_3^- +Cd^{2+} \Leftrightarrow Cd(SeCN)_4^{2-} +40\ H_2O(l)$	815.505 ± 2.890	11	
$2\ SeO_4^{2-} + 16\ H^+ + 16\ e^- + Hg^{2+} \Leftrightarrow HgSe_2^{2-} + 8\ H_2O(l)$	195.773 ± 1.111	11	
$2\ SeO_3^{2-} + Hg^{2+} \Leftrightarrow Hg(SeO_3)_2^{2-}$	14.850 ± 1.011	11	
$2\ SeO_4^{2-}+40\ H^+ +32\ e^- +2\ CO_3^{2-} +2\ NO_3^- +Hg^{2+} \Leftrightarrow Hg(SeCN)_2(aq)+20\ H_2O(l)$	427.753 ± 1.756	11	
$3\ SeO_4^{2-}+60\ H^+ +48\ e^- +3\ CO_3^{2-} +3\ NO_3^- +Hg^{2+} \Leftrightarrow Hg(SeCN)_3^- +30\ H_2O(l)$	634.979 ± 2.386	11	
$4\ SeO_4^{2-}+80\ H^+ +64\ e^- +4\ CO_3^{2-} +4\ NO_3^- +Hg^{2+} \Leftrightarrow Hg(SeCN)_4^{2-} +40\ H_2O(l)$	840.205 ± 2.931	11	
$3\ SeO_4^{2-}+60\ H^+ +48\ e^- +3\ CO_3^{2-} +3\ NO_3^- +Ag^+ \Leftrightarrow Ag(SeCN)_3^{2-} +30\ H_2O(l)$	622.029 ± 2.187	11	
$SeO_4^{2-} + Ni^{2+} \Leftrightarrow NiSeO_4(aq)$	2.670 ± 0.050	11	
$SeO_4^{2-} + 20\ H^+ + 16\ e^- + CO_3^{2-} + NO_3^- + Ni^{2+} \Leftrightarrow NiSeCN^+ + 10\ H_2O(l)$	204.496 ± 0.724	11	
$2\ SeO_4^{2-}+40\ H^+ +32\ e^- +2\ CO_3^{2-} +2\ NO_3^- +Ni^{2+} \Leftrightarrow Ni(SeCN)_2(aq)+20\ H_2O(l)$	407.693 ± 1.451	11	
$SeO_4^{2-} + UO_2^{2+} \Leftrightarrow UO_2SeO_4(aq)$	2.740 ± 0.250	11	
$SeO_4^{2-} + Mg^{2+} \Leftrightarrow MgSeO_4(aq)$	2.200 ± 0.200	11	
$SeO_4^{2-} + Ca^{2+} \Leftrightarrow CaSeO_4(aq)$	2.000 ± 0.100	11	
$SeO_4^{2-} + Mn^{2+} \Leftrightarrow MnSeO_4(aq)$	**2.430 ± 0.050**	**11**	
$SeO_4^{2-} + Co^{2+} \Leftrightarrow CoSeO_4(aq)$	**2.700 ± 0.050**	**11**	
$2\ Br^- \Leftrightarrow Br_2(aq) + 2\ e^-$	-37.246 ± 0.180	3	
$Br^- + H_2O(l) \Leftrightarrow BrO^- + 2\ H^+ + 2\ e^-$	-54.116 ± 0.271	3	
$Br^- + 3\ H_2O(l) \Leftrightarrow BrO_3^- + 6\ H^+ + 6\ e^-$	-146.169 ± 0.116	3	
$Br^- + H_2O(l) \Leftrightarrow HBrO(aq) + H^+ + 2\ e^-$	-45.486 ± 0.269	3	
$Sr^{2+} + H_2O(l) \Leftrightarrow SrOH^+ + H^+$	-13.290 ± 0.500	30	
$Sr^{2+} + SO_4^{2-} \Leftrightarrow SrSO_4(aq)$	1.860 ± 0.030	30	
$Sr^{2+} + NO_3^- \Leftrightarrow SrNO_3^+$	0.800	4	
$Sr^{2+} + PO_4^{3-} \Leftrightarrow SrPO_4^-$	4.200	4	
$Zr^{4+} + H_2O(l) \Leftrightarrow ZrOH^{3+} + H^+$	0.320 ± 0.220	13	
$Zr^{4+} + 2\ H_2O(l) \Leftrightarrow ZrOH)_2^{2+} + 2\ H^+$	0.980 ± 1.060	13	
$Zr^{4+} + 4\ H_2O(l) \Leftrightarrow Zr(OH)_4(aq) + 4\ H^+$	-2.190 ± 1.700	13	
$Zr^{4+} + 6\ H_2O(l) \Leftrightarrow Zr(OH)_6^{2-} + 6\ H^+$	-29.000 ± 0.700	13	
$3\ Zr^{4+} + 4\ H_2O(l) \Leftrightarrow Zr_3(OH)_4^{8+} + 4\ H^+$	0.400 ± 0.300	13	
$3\ Zr^{4+} + 9\ H_2O(l) \Leftrightarrow Zr_3(OH)_9^{3+} + 9\ H^+$	12.190 ± 0.080	13	
$4\ Zr^{4+} + 8\ H_2O(l) \Leftrightarrow Zr_4(OH)_8^{8+} + 8\ H^+$	6.520 ± 0.650	13	
$4\ Zr^{4+} + 15\ H_2O(l) \Leftrightarrow Zr_4(OH)_{15}^+ + 15\ H^+$	12.580 ± 0.240	13	
$4\ Zr^{4+} + 16\ H_2O(l) \Leftrightarrow Zr_4(OH)_{16}(aq) + 16\ H^+$	8.390 ± 0.800	13	
$Zr^{4+} + F^- \Leftrightarrow ZrF^{3+}$	10.120 ± 0.070	13	
$Zr^{4+} + 2\ F^- \Leftrightarrow ZrF_2^{2+}$	18.550 ± 0.310	13	
$Zr^{4+} + 3\ F^- \Leftrightarrow ZrF_3^+$	24.720 ± 0.380	13	
$Zr^{4+} + 4\ F^- \Leftrightarrow ZrF_4(aq)$	30.110 ± 0.400	13	
$Zr^{4+} + 5\ F^- \Leftrightarrow ZrF_5^-$	34.600 ± 0.420	13	
$Zr^{4+} + 6\ F^- \Leftrightarrow ZrF_6^{2-}$	38.110 ± 0.430	13	
$Zr^{4+} + Cl^- \Leftrightarrow ZrCl^{3+}$	1.590 ± 0.060	13	
$Zr^{4+} + 2\ Cl^- \Leftrightarrow ZrCl_2^{2+}$	2.170 ± 0.240	13	
$Zr^{4+} + 3\ Cl^- \Leftrightarrow ZrCl_3^+$	3.000 ± 0.450	32	
$Zr^{4+} + 4\ Cl^- \Leftrightarrow ZrCl_4(aq)$	-1.230 ± 0.500	32	
$Zr^{4+} + SO_4^{2-} \Leftrightarrow ZrSO_4^{2+}$	7.040 ± 0.090	13	
$Zr^{4+} + 2\ SO_4^{2-} \Leftrightarrow Zr(SO_4)_2(aq)$	11.540 ± 0.210	13	
$Zr^{4+} + 3\ SO_4^{2-} \Leftrightarrow Zr(SO_4)_3^{2-}$	14.300 ± 0.500	13	
$Zr^{4+} + NO_3^- \Leftrightarrow ZrNO_3^{3+}$	1.590 ± 0.080	13	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Zr^{4+} + 2\ NO_3^- \Leftrightarrow\ Zr(NO_3)_2^{2+}$	2.640 ± 0.170	13	
$Zr^{4+} + 3\ NO_3^- \Leftrightarrow\ Zr(NO_3)_3^+$	1.040 ± 1.500	32	*
$Zr^{4+} + 4\ CO_3^{2-} \Leftrightarrow\ Zr(CO_3)_4^{4-}$	42.900 ± 1.000	13	
$Zr^{4+} + 2\ Ca^{2+} + 6\ H_2O(l) \Leftrightarrow\ Ca_2[Zr(OH)_6]^{2+} + 6\ H^+$	-22.606 ± 0.313	33	
$Zr^{4+} + 3\ Ca^{2+} + 6\ H_2O(l) \Leftrightarrow\ Ca_3[Zr(OH)_6]^{4+} + 6\ H^+$	-23.206 ± 0.313	33	
$Nb(OH)_5(aq) + H_2O(l) \Leftrightarrow Nb(OH)_6^- + H^+$	> -6.758	1	
$MoO_4^{2-} + 8\ H^+ + 3\ e^- \Leftrightarrow Mo^{3+} + 4\ H_2O(l)$	29.390	35	
$MoO_4^{2-} + H^+ \Leftrightarrow HMoO_4^-$	4.100 ± 0.100	35	
$MoO_4^{2-} + 2\ H^+ \Leftrightarrow H_2MoO_4(aq)$	6.700 ± 0.200	35	
$7\ MoO_4^{2-} + 8\ H^+ \Leftrightarrow Mo_7O_{24}^{6-} + 4\ H_2O(l)$	53.000 ± 0.200	35	
$7\ MoO_4^{2-} + 9\ H^+ \Leftrightarrow HMo_7O_{24}^{5-} + 4\ H_2O(l)$	59.800 ± 0.500	35	
$Sm^{3+} + 2\ MoO_4^{2-} \Leftrightarrow Sm(MoO_4)_2^-$	11.200 ± 0.300	36	
$TcO_4^- + e^- \Leftrightarrow TcO_4^{2-}$	-10.800 ± 0.500	14	
$TcO_4^- + 6\ H^+ + 3\ e^- \Leftrightarrow\ TcO^{2+} + 3\ H_2O(l)$	**< 33.414**	**present**	
$TcO(OH)_2(aq) + H^+ \Leftrightarrow TcO(OH)^+ + H_2O(l)$	**4.563 ± 0.216**	**present**	
$TcO(OH)_2(aq) + 2\ H^+ \Leftrightarrow\ TcO^{2+} + 2\ H_2O(l)$	**< 4.000**	**present**	
$TcO(OH)_2(aq) + H_2O(l) \Leftrightarrow TcO(OH)_3^- + H^+$	**-10.900 ± 0.400**	**present**	
$TcO(OH)_2(aq) + 2\ H^+ + CO_3^{2-} \Leftrightarrow TcCO_3(OH)_2(aq) + H_2O(l)$	**19.255 ± 0.302**	**present**	
$TcO(OH)_2(aq) + H^+ + CO_3^{2-} \Leftrightarrow TcCO_3(OH)_3^-$	**10.955 ± 0.601**	**present**	
$Pd^{2+} + H_2O(l) \Leftrightarrow PdOH^+ + H^+$	-0.650 ± 0.640	37	
$Pd^{2+} + 2\ H_2O(l) \Leftrightarrow Pd(OH)_2(aq) + 2\ H^+$	-3.110 ± 0.630	37	
$Pd^{2+} + 3\ H_2O(l) \Leftrightarrow Pd(OH)_3^- + 3\ H^+$	-14.200 ± 0.630	37	
$Pd^{2+} + Cl^- \Leftrightarrow PdCl^+$	5.031 ± 0.200	1	
$Pd^{2+} + 2\ Cl^- \Leftrightarrow PdCl_2(aq)$	8.471 ± 0.283	1	
$Pd^{2+} + 3\ Cl^- \Leftrightarrow PdCl_3^-$	10.582 ± 0.346	1	
$Pd^{2+} + 4\ Cl^- \Leftrightarrow PdCl_4^{2-}$	11.464 ± 0.400	1	
$Pd^{2+} + NO_3^- \Leftrightarrow PdNO_3^+$	0.167 ± 0.024	1	*
$Pd^{2+} + 2\ NO_3^- \Leftrightarrow Pd(NO_3)_2(aq)$	-0.762 ± 0.039	1	*
$Pd^{2+} + 2\ NO_3^- + H_2O(l) \Leftrightarrow PdOHNO_3(aq) + H^+$	-0.650 ± 0.036	1	*
$Pd^{+2} + 3\ Cl^- + H_2O(l) \Leftrightarrow PdCl_3OH^{2-} + H^+$	2.500	9	
$Pd^{+2} + 2\ Cl^- + 2\ H_2O(l) \Leftrightarrow PdCl_2(OH)_2^{2-} + 2\ H^+$	-7.000	9	
$Pd^{+2} + NH_4^+ \Leftrightarrow PdNH_3^{2+} + H^+$	0.363	9	
$Pd^{+2} + 2\ NH_4^+ \Leftrightarrow Pd(NH_3)_2^{2+} + 2\ H^+$	0.026	9	
$Pd^{+2} + 3\ NH_4^+ \Leftrightarrow Pd(NH_3)_3^{2+} + 3\ H^+$	-1.711	9	
$Pd^{+2} + 4\ NH_4^+ \Leftrightarrow Pd(NH_3)_4^{2+} + 4\ H^+$	-4.148	9	
$Sn^{2+} + H_2O(l) \Leftrightarrow SnOH^+ + H^+$	-3.750	9	
$Sn^{2+} + 2\ H_2O(l) \Leftrightarrow Sn(OH)_2(aq) + 2\ H^+$	-7.710	9	
$Sn^{2+} + 3\ H_2O(l) \Leftrightarrow Sn(OH)_3^- + 3\ H^+$	-17.540	9	
$3\ Sn^{2+} + 4\ H_2O(l) \Leftrightarrow Sn_3(OH)_4^{2+} + 4\ H^+$	-6.510	9	
$Sn^{2+} + Cl^- \Leftrightarrow SnCl^+$	1.650	9	
$Sn^{2+} + 2\ Cl^- \Leftrightarrow SnCl_2(aq)$	2.310	9	
$Sn^{2+} + 3\ Cl^- \Leftrightarrow SnCl_3^-$	2.090	9	
$Sn^{2+} + H_2O(l) + Cl^- \Leftrightarrow SnClOH(aq) + H^+$	-2.270	9	
$Sn^{2+} + F^- \Leftrightarrow SnF^+$	4.460	9	
$Sn^{2+} + 2\ F^- \Leftrightarrow SnF_2(aq)$	7.740	9	
$Sn^{2+} + 3\ F^- \Leftrightarrow SnF_3^-$	9.610	9	
$Sn^{2+} + NO_3^- \Leftrightarrow SnNO_3^+$	1.250	9	
$Sn^{2+} + 2\ NO_3^- \Leftrightarrow Sn(NO_3)_2(aq)$	1.740	9	
$Sn^{2+} + 3\ NO_3^- \Leftrightarrow Sn(NO_3)_3^-$	1.370	9	
$Sn^{2+} + 4\ NO_3^- \Leftrightarrow Sn(NO_3)_4^{2-}$	0.300	9	
$Sn^{2+} + SO_4^{2-} \Leftrightarrow SnSO_4(aq)$	2.910	9	
$Sn^{2+} + 2\ SO_4^{2-} \Leftrightarrow Sn(SO_4)_2^{2-}$	2.830	9	
$Sn(OH)_4(aq) + 4\ H^+ + 2\ e^- \Leftrightarrow Sn^{2+} + 4\ H_2O(l)$	5.400	9	
$Sn(OH)_4(aq) + H_2O(l) - H^+ \Leftrightarrow Sn(OH)_5^-$	-7.970	9	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Sn(OH)_4(aq) + 2\ H_2O(l) \Leftrightarrow Sn(OH)_6^{2-} + 2\ H^+$	-18.400	9	
$Sn(OH)_4(aq) + 4\ H^+ \Leftrightarrow Sn^{4+} + 4\ H_2O(l)$	0.400	9	
$Sb(OH)_3(aq) + 3\ H^+ \Leftrightarrow Sb^{3+} + 3\ H_2O(l)$	-0.730	9	
$Sb(OH)_3(aq) + 2\ H^+ \Leftrightarrow SbOH^{2+} + 2\ H_2O(l)$	0.830	9	
$Sb(OH)_3(aq) + H^+ \Leftrightarrow Sb(OH)_2^+ + H_2O(l)$	1.300	9	
$Sb(OH)_3(aq) + H_2O(l) \Leftrightarrow Sb(OH)_4^- + H^+$	-11.930	9	
$2\ Sb(OH)_3(aq) + 2\ H^+ + 4\ HS^- \Leftrightarrow Sb_2S_4^{2-} + 6\ H_2O(l)$	42.530	9	
$2\ Sb(OH)_3(aq) + 3\ H^+ + 4\ HS^- \Leftrightarrow HSb_2S_4^- + 6\ H_2O(l)$	52.180	9	
$2\ Sb(OH)_3(aq) + 4\ H^+ + 4\ HS^- \Leftrightarrow H_2Sb_2S_4(aq) + 6\ H_2O(l)$	57.000	9	
$2\ Sb(OH)_3(aq) \Leftrightarrow Sb_2(OH)_6(aq)$	0.080	9	
$Sb(OH)_3(aq) + 3\ H^+ + Cl^- \Leftrightarrow SbCl^{2+} + 3\ H_2O(l)$	2.780	9	
$Sb(OH)_3(aq) + 3\ H^+ + 2\ Cl^- \Leftrightarrow SbCl_2^+ + 3\ H_2O(l)$	3.270	9	
$Sb(OH)_3(aq) + 3\ H^+ + F^- \Leftrightarrow SbF^{2+} + 3\ H_2O(l)$	6.480	9	
$Sb(OH)_3(aq) + 3\ H^+ + 2\ F^- \Leftrightarrow SbF_2^+ + 3\ H2O(l)$	12.650	9	
$Sb(OH)_3(aq) + 3\ H^+ + 3\ F^- \Leftrightarrow SbF_3(aq) + 3\ H_2O(l)$	18.360	9	
$Sb(OH)_3(aq) + 2\ H_2O(l) \Leftrightarrow Sb(OH)_5(aq) + 2\ H^+ + 2\ e^-$	-21.840	9	
$Sb(OH)_5(aq) + H_2O(l) \Leftrightarrow Sb(OH)_6^- + H^+$	-2.720	9	
$12\ Sb(OH)_5(aq) + 4\ H_2O(l) \Leftrightarrow Sb_{12}(OH)_{64}^{4-} + 4\ H^+$	20.340	9	
$12\ Sb(OH)_5(aq) + 5\ H_2O(l) \Leftrightarrow Sb_{12}(OH)_{65}^{5-} + 5\ H^+$	16.720	9	
$12\ Sb(OH)_5(aq) + 6\ H_2O(l) \Leftrightarrow Sb_{12}(OH)_{66}^{6-} + 6\ H^+$	11.890	9	
$12\ Sb(OH)_5(aq) + 7\ H_2O(l) \Leftrightarrow Sb_{12}(OH)_{67}^{7-} + 7\ H^+$	6.070	9	
$I^- + 3\ H_2O(l) \Leftrightarrow IO_3^- + 6\ H^+ + 6\ e^-$	-111.563 ± 0.138	present	
$IO_3^- + H^+ \Leftrightarrow HIO_3(aq)$	**0.788 ± 0.029**	3	
$2\ I^- \Leftrightarrow I_2(aq) + 2\ e^-$	**-20.996**	**present**	*
$3\ I^- \Leftrightarrow I_3^- + 2\ e^-$	**-18.180**	**present**	*
$I^- + H_2O(l) \Leftrightarrow IO^- + 2\ H^+ + 2\ e^-$	**-43.862**	**present**	*
$I^- + 4\ H_2O(l) \Leftrightarrow IO_4^- + 8\ H^+ + 8\ e^-$	**-164.992**	**present**	*
$2\ I^- + H_2O(l) \Leftrightarrow I_2O^{2-} + 2\ H^+ + 2\ e^-$	**-45.232**	**present**	*
$I^- + H^+ \Leftrightarrow HI(aq)$	**-0.027**	**present**	*
$I^- + H_2O(l) \Leftrightarrow HIO(aq) + H^+ + 2\ e^-$	**-33.245**	**present**	*
$I^- + H_2O(l) \Leftrightarrow H_2OI^+ + 2\ e^-$	**-31.914**	**present**	*
$2\ I^- + H_2O(l) \Leftrightarrow I_2OH^- + H^+ + 2\ e^-$	**-19.357**	**present**	*
$I^- + 2\ Cl^- \Leftrightarrow ICl_2^- + 2\ e^-$	**-26.832**	**present**	*
$2\ I^- + Cl^- \Leftrightarrow I_2Cl^- + 2\ e^-$	**-20.737**	**present**	*
$I^- + Br^- \Leftrightarrow IBr(aq) + 2\ e^-$	**-26.519**	**present**	*
$I^- + 2\ Br^- \Leftrightarrow IBr_2^- + 2\ e^-$	**-23.900**	**present**	*
$2\ I^- + Br^- \Leftrightarrow BrI_2^- + 2\ e^-$	**-17.046**	**present**	*
$2\ I^- + H^+ + Br^- \Leftrightarrow HBrI_2(aq) + 2\ e^-$	**-17.046**	**present**	*
$I^- + Cl^- + Br^- \Leftrightarrow IBrCl^- + 2\ e^-$	**-24.595**	**present**	*
$Ba^{2+} + H_2O(l) \Leftrightarrow BaOH^+ + H^+$	-13.470 ± 0.500	30	
$Ba^{2+} + SO_4^{2-} \Leftrightarrow BaSO_4(aq)$	2.720 ± 0.090	30	
$Sm^{3+} + H_2O(l) \Leftrightarrow SmOH^{2+} + H^+$	-7.200 ± 0.500	28	
$Sm^{3+} + 2\ H_2O(l) \Leftrightarrow Sm(OH)_2^+ + 2\ H^+$	-15.100 ± 0.700	28	
$Sm^{3+} + 3\ H_2O(l) \Leftrightarrow Sm(OH)_3(aq) + 3\ H^+$	-26.200 ± 0.500	28	
$Sm^{3+} + F^- \Leftrightarrow SmF^{2+}$	3.400 ± 0.400	28	
$Sm^{3+} + 2\ F^- \Leftrightarrow SmF_2^+$	5.800 ± 0.200	28	
$Sm^{3+} + Cl^- \Leftrightarrow SmCl^{2+}$	0.240 ± 0.030	28	
$Sm^{3+} + 2\ Cl^- \Leftrightarrow SmCl_2^+$	-0.740 ± 0.050	28	
$Sm^{3+} + SO_4^{2-} \Leftrightarrow SmSO_4^+$	3.300 ± 0.150	28	
$Sm^{3+} + 2\ SO_4^{2-} \Leftrightarrow Sm(SO_4)_2^-$	3.700 ± 0.150	28	
$Sm^{3+} + 3\ NO_3^- + 18\ H^+ + 16\ e^- \Leftrightarrow SmN_3^{2+} + 9\ H_2O(l)$	256.342 ± 0.430	28	
$Sm^{3+} + NO_2^- \Leftrightarrow SmNO_2^{2+}$	2.100 ± 0.200	28	
$Sm^{3+} + NO_3^- \Leftrightarrow SmNO_3^{2+}$	1.330 ± 0.200	28	
$Sm^{3+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow SmH_2PO_4^{2+}$	22.562 ± 0.501	28	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Sm^{3+} + CO_3^{2-} \Leftrightarrow SmCO_3^+$	8.000 ± 0.400	28	
$Sm^{3+} + 2\ CO_3^{2-} \Leftrightarrow Sm(CO_3)_2^-$	12.900 ± 0.600	28	
$Sm^{3+} + 3\ CO_3^{2-} \Leftrightarrow Sm(CO_3)_3^{3-}$	15.000 ± 1.000	28	
$Sm^{3+} + H^+ + CO_3^{2-} \Leftrightarrow SmHCO_3^{2+}$	13.429 ± 0.301	28	
$Sm^{3+} + H_4SiO_4(aq) \Leftrightarrow SmSiO(OH)_3^{2+} + H^+$	-1.680 ± 0.180	28	
$Sm^{3+} + NO_3^- + CO_3^{2-} + SO_4^{2-} + 20\ H^+ + 16\ e^- \Leftrightarrow SmSCN^{2+} + 10\ H_2O(l)$	158.272 ± 0.775	28	
$2\ Hg^{2+} + 2\ e^- \Leftrightarrow Hg_2^{2+}$	3.889 ± 0.224	3	
$Pb^{2+} + H_2O(l) \Leftrightarrow PbOH^+ + H^+$	-6.910 ± 0.360	38	
$Pb^{2+} + 2\ H_2O(l) \Leftrightarrow Pb(OH)2(aq) + 2\ H^+$	-16.110 ± 0.710	38	
$Pb^{2+} + 3\ H_2O(l) \Leftrightarrow Pb(OH)_3^- + 3\ H^+$	-26.270 ± 1.180	38	
$Pb^{2+} + 4\ H_2O(l) \Leftrightarrow Pb(OH)_4^{2-} + 4\ H^+$	-38.780 ± 0.390	38	
$2\ Pb^{2+} + H_2O(l) \Leftrightarrow Pb_2OH^{3+} + H^+$	-7.180	9	
$4\ Pb^{2+} + 4\ H_2O(l) \Leftrightarrow Pb_4(OH)_4^{4+} + 4\ H^+$	-20.630	9	
$3\ Pb^{2+} + 4\ H_2O(l) \Leftrightarrow Pb_3(OH)_4^{2+} + 4\ H^+$	-22.480	9	
$3\ Pb^{2+} + 5\ H_2O(l) \Leftrightarrow Pb_3(OH)_5^+ + 5\ H^+$	-30.720	9	
$6\ Pb^{2+} + 8\ H_2O(l) \Leftrightarrow Pb_6(OH)_8^{4+} + 8\ H^+$	-42.680	9	
$Pb^{2+} + CO_3^{2-} \Leftrightarrow PbCO_3(aq)$	7.300	9	
$Pb^{2+} + 2\ CO_3^{2-} \Leftrightarrow Pb(CO_3)_2^{-2}$	10.130	9	
$Pb^{2+} + NO_3^- \Leftrightarrow PbNO_3^+$	1.060	9	
$Pb^{2+} + 2\ NO_3^- \Leftrightarrow Pb(NO_3)_2(aq)$	1.480	9	
$Pb^{2+} + 3\ NO_3^- \Leftrightarrow Pb(NO_3)_3^-$	0.760	9	
$Pb^{2+} + PO_4^{-3} + H^+ \Leftrightarrow PbHPO_4(aq)$	15.450	9	
$Pb^{2+} + PO_4^{-3} + 2\ H^+ \Leftrightarrow PbH_2PO_4^+$	21.050	9	
$Pb^{2+} + SO_4^{2-} \Leftrightarrow PbSO_4(aq)$	2.820	9	
$Pb^{2+} + 2\ SO_4^{2-} \Leftrightarrow Pb(SO_4)_2^{2-}$	2.370	9	
$Pb^{2+} + 2\ HS^- \Leftrightarrow Pb(HS)_2(aq)$	12.340	9	
$Pb^{2+} + 3\ HS^- \Leftrightarrow Pb(HS)_3^-$	13.590	9	
$Pb^{2+} + Cl^- \Leftrightarrow PbCl^+$	1.480 ± 0.100	38	
$Pb^{2+} + 2\ Cl^- \Leftrightarrow PbCl_2(aq)$	2.070 ± 0.170	38	
$Pb^{2+} + 3\ Cl^- \Leftrightarrow PbCl_3^-$	1.800 ± 0.320	38	
$Pb^{2+} + 4\ Cl^- \Leftrightarrow PbCl_4^{2-}$	1.330 ± 0.830	38	*
$Pb^{2+} + F^- \Leftrightarrow PbF^+$	2.270	9	
$Pb^{2+} + 2\ F^- \Leftrightarrow PbF_2(aq)$	3.010	9	
$Pb^{2+} + F^- + Cl^- \Leftrightarrow PbFCl(aq)$	3.550	9	
$Bi^{3+} + H_2O \Leftrightarrow BiOH^{2+} + H^+$	-0.920	9	
$Bi^{3+} + 2\ H_2O \Leftrightarrow Bi(OH)_2^+ + 2\ H^+$	-2.560 ± 1.000	9	
$Bi^{3+} + 3\ H_2O \Leftrightarrow Bi(OH)_3(aq) + 3\ H^+$	-8.940 ± 0.500	39	
$Bi^{3+} + 4\ H_2O \Leftrightarrow Bi(OH)_4^- + 4\ H^+$	-21.660 ± 0.870	39	
$6\ Bi^{3+} + 12\ H_2O \Leftrightarrow Bi_6(OH)_{12}^{6+} + 12\ H^+$	1.340	9	
$9\ Bi^{3+} + 20\ H_2O \Leftrightarrow Bi_9(OH)_{20}^{7+} + 20\ H^+$	-1.360	9	
$9\ Bi^{3+} + 21\ H_2O \Leftrightarrow Bi_9(OH)_{21}^{6+} + 21\ H^+$	-3.250	9	
$9\ Bi^{3+} + 22\ H_2O \Leftrightarrow Bi_9(OH)_{22}^{5+} + 22\ H^+$	-4.860	9	
$3\ Bi^{3+} + 4\ H_2O \Leftrightarrow Bi_3(OH)_4^{5+} + 4\ H^+$	-0.800	9	
$Bi^{3+} + Cl^- \Leftrightarrow BiCl^{2+}$	3.610 ± 0.180	39	
$Bi^{3+} + 2\ Cl^- \Leftrightarrow BiCl_2^+$	5.560 ± 0.240	39	
$Bi^{3+} + 3\ Cl^- \Leftrightarrow BiCl_3(aq)$	6.980 ± 0.370	39	
$Bi^{3+} + 4\ Cl^- \Leftrightarrow BiCl_4^-$	8.040 ± 0.200	39	
$Bi^{3+} + 5\ Cl^- \Leftrightarrow BiCl_5^{2-}$	7.360 ± 0.370	39	
$Bi^{3+} + PO_4^{3-} \Leftrightarrow BiPO_4(aq)$	≤ 21.850	39	
$Bi^{3+} + NO_3^- \Leftrightarrow BiNO_3^{2+}$	1.970	9	
$Bi^{3+} + 2\ NO_3^- \Leftrightarrow Bi(NO_3)_2^+$	2.950	9	
$Bi^{3+} + 3\ NO_3^- \Leftrightarrow Bi(NO_3)_3(aq)$	3.620	9	
$Bi^{3+} + 4\ NO_3^- \Leftrightarrow Bi(NO_3)_4^-$	3.090	9	
$Bi^{3+} + Cl^- + NO_3^- \Leftrightarrow BiClNO_3^+$	5.160	9	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Bi^{3+} + Cl^- + 2\ NO_3^- \Leftrightarrow BiCl(NO_3)_2(aq)$	5.280	9	
$Bi^{3+} + 2\ Cl^- + NO_3^- \Leftrightarrow BiCl_2NO_3(aq)$	6.860	9	
$Bi^{3+} + 2\ Cl^- + 2\ NO_3^- \Leftrightarrow BiCl_2(NO_3)_2^-$	5.750	9	
$Bi^{3+} + 3\ Cl^- + NO_3^- \Leftrightarrow BiCl_3NO_3^-$	8.090	9	
$Ra^{2+} + H_2O \Leftrightarrow RaOH^+ + H^+$	-13.470 ± 0.500	30	
$Ra^{2+} + SO_4^{2-} \Leftrightarrow RaSO_4(aq)$	2.720 ± 0.090	30	
$Ac^{3+} + H_2O(l) \Leftrightarrow AcOH^{2+} + H^+$	-7.200 ± 0.700	28	*
$Ac^{3+} + 2\ H_2O(l) \Leftrightarrow Ac\ OH)_2^+ + 2\ H^+$	-15.100 ± 0.900	28	*
$Ac^{3+} + 3\ H_2O(l) \Leftrightarrow Ac(OH)_3(aq) + 3\ H^+$	-26.200 ± 0.700	28	*
$Ac^{3+} + F^- \Leftrightarrow AcF^{2+}$	3.400 ± 0.600	28	*
$Ac^{3+} + 2\ F^- \Leftrightarrow AcF_2^+$	5.800 ± 0.400	28	*
$Ac^{3+} + Cl^- \Leftrightarrow AcCl^{2+}$	0.240 ± 0.230	28	*
$Ac^{3+} + 2\ Cl^- \Leftrightarrow AcCl_2^+$	-0.740 ± 0.250	28	*
$Ac^{3+} + SO_4^{2-} \Leftrightarrow AcSO_4^+$	3.300 ± 0.350	28	*
$Ac^{3+} + 2\ SO_4^{2-} \Leftrightarrow Ac(SO_4)_2^-$	3.700 ± 0.350	28	*
$Ac^{3+} + 3\ NO_3^- + 18\ H^+ + 16\ e^- \Leftrightarrow AcN_3^{2+} + 9\ H_2O(l)$	256.342 ± 0.515	28, 3	*
$Ac^{3+} + NO_2^- \Leftrightarrow AcNO_2^{2+}$	2.100 ± 0.400	28	*
$Ac^{3+} + NO_3^- \Leftrightarrow AcNO_3^{2+}$	1.330 ± 0.400	28	*
$Ac^{3+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow AcH_2PO_4^{2+}$	22.562 ± 0.701	28, 3	*
$Ac^{3+} + CO_3^{2-} \Leftrightarrow AcCO_3^+$	8.000 ± 0.600	28	*
$Ac^{3+} + 2\ CO_3^{2-} \Leftrightarrow Ac(CO_3)_2^-$	12.900 ± 0.800	28	*
$Ac^{3+} + 3\ CO_3^{2-} \Leftrightarrow Ac(CO_3)_3^{3-}$	15.000 ± 1.200	28	*
$Ac^{3+} + H^+ + CO_3^{2-} \Leftrightarrow AcHCO_3^{2+}$	13.429 ± 0.500	28, 3	*
$Ac^{3+} + H_4SiO_4(aq) \Leftrightarrow AcSiO(OH)_3^{2+} + H^+$	-1.680 ± 0.380	28	*
$Ac^{3+} + NO_3^- + CO_3^{2-} + SO_4^{2-} + 20\ H^+ + 16\ e^- \Leftrightarrow AcSCN^{2+} + 10\ H_2O(l)$	158.272 ± 0.872	28, 3	*
$Th^{4+} + H_2O(l) \Leftrightarrow ThOH^{3+} + H^+$	-2.500 ± 0.500	3	
$Th^{4+} + 2\ H_2O(l) \Leftrightarrow Th(OH)_2^{2+} + 2\ H^+$	-6.200 ± 0.500	3	
$Th^{4+} + 4\ H_2O(l) \Leftrightarrow Th(OH)_4(aq) + 4\ H^+$	-17.400 ± 0.700	3	
$2\ Th^{4+} + 2\ H_2O(l) \Leftrightarrow Th_2(OH)_2^{6+} + 2\ H^+$	-5.900 ± 0.500	3	
$2\ Th^{4+} + 3\ H_2O(l) \Leftrightarrow Th_2(OH)_3^{5+} + 3\ H^+$	-6.800 ± 0.200	3	
$4\ Th^{4+} + 8\ H_2O(l) \Leftrightarrow Th_4(OH)_8^{8+} + 8\ H^+$	-20.400 ± 0.400	3	
$4\ Th^{4+} + 12\ H_2O(l) \Leftrightarrow Th_4(OH)_{12}^{4+} + 12\ H^+$	-26.600 ± 0.200	3	
$6\ Th^{4+} + 14\ H_2O(l) \Leftrightarrow Th_6(OH)_{14}^{10+} + 14\ H^+$	-36.800 ± 1.200	3	
$6\ Th^{4+} + 15\ H_2O(l) \Leftrightarrow Th_6(OH)_{15}^{9+} + 15\ H^+$	-36.800 ± 1.500	3	
$Th^{4+} + F^- \Leftrightarrow ThF^{3+}$	8.870 ± 0.150	3	
$Th^{4+} + 2\ F^- \Leftrightarrow ThF_2^{2+}$	15.630 ± 0.230	3	
$Th^{4+} + 3\ F^- \Leftrightarrow ThF_3^+$	20.670 ± 0.160	3	
$Th^{4+} + 4\ F^- \Leftrightarrow ThF_4(aq)$	25.580 ± 0.180	3	
$Th^{4+} + Cl^- \Leftrightarrow ThCl^{3+}$	1.700 ± 0.100	3	
$Th^{4+} + ClO_3^- \Leftrightarrow ThClO_3^{3+}$	**1.550 ± 0.130**	3	
$Th^{4+} + Br^- \Leftrightarrow ThBr^{3+}$	**1.380 ± 0.130**	3	
$Th^{4+} + BrO_3^- \Leftrightarrow ThBrO_3^{3+}$	**1.900 ± 0.100**	3	
$Th^{4+} + IO_3^- \Leftrightarrow ThIO_3^{3+}$	**4.140 ± 0.100**	3	
$Th^{4+} + 2\ IO_3^- \Leftrightarrow Th(IO_3)_2^{2+}$	**6.970 ± 0.120**	3	
$Th^{4+} + 3\ IO_3^- \Leftrightarrow Th(IO_3)_3^+$	**9.870 ± 0.110**	3	
$Th^{4+} + SO_4^{2-} \Leftrightarrow ThSO_4^{2+}$	6.170 ± 0.320	3	
$Th^{4+} + 2\ SO_4^{2-} \Leftrightarrow Th(SO_4)_2(aq)$	9.690 ± 0.270	3	
$Th^{4+} + 3\ SO_4^{2-} \Leftrightarrow Th(SO_4)_3^{2-}$	10.748 ± 0.076	3	
$Th^{4+} + N_3^- \Leftrightarrow ThN_3^{3+}$	**4.440 ± 0.640**	3	
$Th^{4+} + 2\ N_3^- \Leftrightarrow Th(N_3)_2^{2+}$	**8.590 ± 0.640**	3	
$Th^{4+} + NO_3^- \Leftrightarrow ThNO_3^{3+}$	1.300 ± 0.200	3	
$Th^{4+} + 2\ NO_3^- \Leftrightarrow Th(NO_3)_2^{2+}$	2.300 ± 0.400	3	
$Th^{4+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow ThH_2PO_4^{3+}$	25.152 ± 0.365	3	
$Th^{4+} + 3\ H^+ + PO_4^{3-} \Leftrightarrow ThH_3PO_4^{4+}$	23.592 ± 0.356	3	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Th^{4+} + 4\ H^+ + 2\ PO_4^{3-} \Leftrightarrow Th(H_2PO_4)_2^{2+}$	49.604 ± 0.476	3	
$Th^{4+} + 5\ H^+ + 2\ PO_4^{3-} \Leftrightarrow Th(H_3PO_4)(H_2PO_4)^{3+}$	48.824 ± 0.476	3	
$Th^{4+} + 5\ CO_3^{2-} \Leftrightarrow Th(CO_3)_5^{6-}$	31.000 ± 0.700	3	
$Th^{4+} + 2\ CO_3^{2-} + 2\ H_2O(l) \Leftrightarrow Th(CO_3)_2(OH)_2^{2-} + 2\ H^+$	8.798 ± 0.501	3	
$Th^{4+} + 4\ CO_3^{2-} + H_2O(l) \Leftrightarrow Th(CO_3)_4OH^{5-} + H^+$	21.599 ± 0.500	3	
$Th^{4+} + CO_3^{2-} + 4\ H_2O(l) \Leftrightarrow ThCO_3(OH)_4^{2-} + 4\ H^+$	-15.605 ± 0.603	3	
$Th^{4+} + SCN^- \Leftrightarrow ThSCN^{3+}$	**2.000 ± 0.500**	3	
$Th^{4+} + 2\ SCN^- \Leftrightarrow Th(SCN)_2^{2+}$	**3.400 ± 0.800**	3	
$Th^{4+} + 3\ H_4SiO_4(aq) + 3\ H_2O(l) \Leftrightarrow Th(OH)_3(H_3SiO_4)_3^{2-} + 6\ H^+$	-27.800 ± 0.700	33	
$Th^{4+} + 8\ H_2O(l) + 4\ Ca^{2+} \Leftrightarrow Ca_4[Th(OH)_8]^{4+} + 8\ H^+$	-62.708 ± 0.908	40	
$Pa^{4+} + H_2O(l) \Leftrightarrow PaOH^{3+} + H^+$	0.840	41	
$Pa^{4+} + 2\ H_2O(l) \Leftrightarrow Pa(OH)_2^{2+} + 2\ H^+$	-0.020	41	
$Pa^{4+} + 3\ H_2O(l) \Leftrightarrow Pa(OH)_3^{+} + 3\ H^+$	-1.500	41	
$PaOOH^{2+} + 2\ H_2O(l) \Leftrightarrow PaO(OH)_3(aq) + 2\ H^+$	-5.460	41	
$PaOOH^{2+} + H_2O(l) \Leftrightarrow PaO(OH)_2^{+} + H^+$	-1.240 ± 0.020	42, 43	
$PaOOH^{2+} + 3\ H_2O(l) \Leftrightarrow Pa(OH)_5(aq) + 2\ H^+$	-8.270 ± 0.151	42, 43	
$PaOOH^{2+} + Cl^- \Leftrightarrow PaOOHCl^+$	1.922 ± 0.020	1	
$PaOOH^{2+} + SO_4^{2-} + H^+ \Leftrightarrow PaOSO_4^{+} + H_2O(l)$	3.890 ± 0.180	44	
$PaOOH^{2+} + 2\ SO_4^{2-} + H^+ \Leftrightarrow PaO(SO_4)_2^{-} + H_2O(l)$	7.000 ± 0.200	44	
$PaOOH^{2+} + 3\ SO_4^{2-} + H^+ \Leftrightarrow PaO(SO_4)_3^{3-} + H_2O(l)$	8.590 ± 0.230	44	
$Pa^{4+} + 2\ H_2O(l) \Leftrightarrow PaOOH^{2+} + e^- + 3\ H^+$	1.860	41	
$U^{4+} + e^- \Leftrightarrow U^{3+}$	-9.353 ± 0.070	14	
$U^{4+} + H_2O(l) \Leftrightarrow UOH^{3+} + H^+$	-0.290 ± 0.310	45	
$U^{4+} + 2\ H_2O(l) \Leftrightarrow U(OH)_2^{2+} + 2\ H^+$	-1.780 ± 0.210	45	
$U^{4+} + 3\ H_2O(l) \Leftrightarrow U(OH)_3^{+} + 3\ H^+$	-5.150 ± 0.210	45	
$U^{4+} + 4\ H_2O(l) \Leftrightarrow U(OH)_4(aq) + 4\ H^+$	-10.800 ± 1.400	45	
$U^{4+} + F^- \Leftrightarrow UF^{3+}$	9.420 ± 0.510	14	
$U^{4+} + 2\ F^- \Leftrightarrow UF_2^{2+}$	16.560 ± 0.710	14	
$U^{4+} + 3\ F^- \Leftrightarrow UF_3^{+}$	21.890 ± 0.830	14	
$U^{4+} + 4\ F^- \Leftrightarrow UF_4$	26.340 ± 0.960	14	
$U^{4+} + 5\ F^- \Leftrightarrow UF_5^{-}$	27.730 ± 0.740	14	
$U^{4+} + 6\ F^- \Leftrightarrow UF_6^{2-}$	29.800 ± 0.700	14	
$U^{4+} + Cl^- \Leftrightarrow UCl^{3+}$	1.720 ± 0.130	14	
$U^{4+} + Br^- \Leftrightarrow UBr^{3+}$	1.460 ± 0.200	14	
$U^{4+} + I^- \Leftrightarrow UI^{3+}$	1.250 ± 0.300	14	
$U^{4+} + SO_4^{2-} \Leftrightarrow USO_4^{2+}$	6.580 ± 0.190	14	
$U^{4+} + 2\ SO_4^{2-} \Leftrightarrow U(SO_4)_2(aq)$	10.510 ± 0.200	14	
$U^{4+} + NO_3^- \Leftrightarrow UNO_3^{3+}$	1.470 ± 0.130	14	
$U^{4+} + 2\ NO_3^- \Leftrightarrow U(NO_3)_2^{2+}$	2.300 ± 0.350	14	
$U^{4+} + 4\ CO_3^{2-} \Leftrightarrow U(CO_3)_4^{4-}$	35.120 ± 0.934	14	
$U^{4+} + 5\ CO_3^{2-} \Leftrightarrow U(CO_3)_5^{6-}$	31.500 ± 1.000	14	
$U^{4+} + 2\ CO_3^{2-} + 2\ H_2O(l) \Leftrightarrow U(CO_3)_2(OH)_2^{2-} + 2\ H^+$	13.557 ± 1.000	45	
$U^{4+} + SO_4^{2-} + CO_3^{2-} + NO_3^- + 20\ H^+ + 16\ e^- \Leftrightarrow USCN^{3+} + 10\ H_2O(l)$	159.942 ± 0.718	14	
$U^{4+} + 2\ SO_4^{2-} + 2\ CO_3^{2-} + 2\ NO_3^- + 40\ H^+ + 32\ e^- \Leftrightarrow U(SCN)_2^{2+} + 20\ H_2O(l)$	318.204 ± 1.441	14	
$U^{4+} + 2\ H_2O(l) \Leftrightarrow UO_2^{+} + 4\ H^+ + e^-$	-7.554 ± 0.047	14	
$UO_2^{+} + 3\ CO_3^{2-} \Leftrightarrow UO_2(CO_3)_3^{5-}$	6.950 ± 0.360	14	
$U^{4+} + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 4\ H^+ + 2\ e^-$	-9.038 ± 0.041	14	
$UO_2^{2+} + H_2O(l) \Leftrightarrow UO_2OH^{+} + H^+$	-5.250 ± 0.240	14	
$UO_2^{2+} + 2\ H_2O(l) \Leftrightarrow UO_2(OH)_2(aq) + 2\ H^+$	-12.150 ± 0.070	14	
$UO_2^{2+} + 3\ H_2O(l) \Leftrightarrow UO_2(OH)_3^{-} + 3\ H^+$	-20.250 ± 0.420	14	
$UO_2^{2+} + 4\ H_2O(l) \Leftrightarrow UO_2(OH)_4^{2-} + 4\ H^+$	-32.400 ± 0.680	14	
$2\ UO_2^{2+} + H_2O(l) \Leftrightarrow (UO_2)_2OH^{3+} + H^+$	-2.700 ± 1.000	14	
$2\ UO_2^{2+} + 2\ H_2O(l) \Leftrightarrow (UO_2)_2OH_2^{2+} + 2\ H^+$	-5.620 ± 0.040	14	
$3\ UO_2^{2+} + 4\ H_2O(l) \Leftrightarrow (UO_2)_3(OH)_4^{2+} + 4\ H^+$	-11.900 ± 0.300	14	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$3\ UO_2^{2+} + 5\ H_2O(l) \Leftrightarrow (UO_2)_3(OH)_5^{+} + 5\ H^{+}$	-15.550 ± 0.120	14	
$3\ UO_2^{2+} + 7\ H_2O(l) \Leftrightarrow (UO_2)_3(OH)_7^{-} + 7\ H^{+}$	-32.200 ± 0.800	14	
$4\ UO_2^{2+} + 7\ H_2O(l) \Leftrightarrow (UO_2)_4(OH)_7^{+} + 7\ H^{+}$	-21.900 ± 1.000	14	
$UO_2^{2+} + F^{-} \Leftrightarrow UO_2F^{+}$	5.160 ± 0.060	14	
$UO_2^{2+} + 2\ F^{-} \Leftrightarrow UO_2F_2(aq)$	8.830 ± 0.080	14	
$UO_2^{2+} + 3\ F^{-} \Leftrightarrow UO_2F_3^{-}$	10.900 ± 0.100	14	
$UO_2^{2+} + 4\ F^{-} \Leftrightarrow UO_2F_4^{2-}$	11.840 ± 0.110	14	
$UO_2^{2+} + Cl^{-} \Leftrightarrow UO_2Cl^{+}$	0.170 ± 0.020	14	
$UO_2^{2+} + 2\ Cl^{-} \Leftrightarrow UO_2Cl_2(aq)$	-1.100 ± 0.400	14	
$UO_2^{2+} + Cl^{-} + 3\ H_2O(l) \Leftrightarrow UO_2ClO_3^{+} + 6\ H^{+} + 6\ e^{-}$	-145.738 ± 0.246	14	
$UO_2^{2+} + Br^{-} \Leftrightarrow UO_2Br^{+}$	0.220 ± 0.020	14	
$UO_2^{2+} + Br^{-} + 3\ H_2O(l) \Leftrightarrow UO_2BrO_3^{+} + 6\ H^{+} + 6\ e^{-}$	-145.539 ± 0.141	14	
$UO_2^{2+} + 2\ IO_3^{-} \Leftrightarrow UO_2(IO_3)_2(aq)$	**3.590 ± 0.150**	**14**	
$UO_2(IO_3)_2(cr) \Leftrightarrow UO_2^{2+} + 2\ IO_3^{-}$	**-7.880 ± 0.100**	**14**	
$UO_2^{2+} + SO_3^{2-} \Leftrightarrow UO_2SO_3(aq)$	6.600 ± 0.600	14	
$UO_2^{2+} + S_2O_3^{2-} \Leftrightarrow UO_2S_2O_3(aq)$	2.800 ± 0.300	14	
$UO_2^{2+} + SO_4^{2-} \Leftrightarrow UO_2SO_4(aq)$	3.150 ± 0.020	14	
$UO_2^{2+} + 2\ SO_4^{2-} \Leftrightarrow UO_2(SO_4)_2^{2-}$	4.140 ± 0.070	14	
$UO_2^{2+} + 3\ SO_4^{2-} \Leftrightarrow UO_2(SO_4)_3^{4-}$	3.020 ± 0.380	14	
$UO_2^{2+} + 3\ NO_3^{-} + 18\ H^{+} + 16\ e^{-} \Leftrightarrow UO_2N_3^{+} + 9\ H_2O(l)$	257.252 ± 0.428	14	
$UO_2^{2+} + 6\ NO_3^{-} + 36\ H^{+} + 32\ e^{-} \Leftrightarrow UO_2(N_3)_2(aq) + 18\ H_2O(l)$	513.674 ± 0.867	14	
$UO_2^{2+} + 9\ NO_3^{-} + 54\ H^{+} + 48\ e^{-} \Leftrightarrow UO_2(N_3)_3^{-} + 27\ H_2O(l)$	769.756 ± 1.273	14	
$UO_2^{2+} + 12\ NO_3^{-} + 72\ H^{+} + 64\ e^{-} \Leftrightarrow UO_2(N_3)_4^{2-} + 36\ H_2O(l)$	1023.608 ± 1.689	14	
$UO_2^{2+} + NO_3^{-} \Leftrightarrow UO_2NO_3^{+}$	0.300 ± 0.150	14	
$UO_2^{2+} + PO_4^{3-} \Leftrightarrow UO_2PO_4^{-}$	13.230 ± 0.150	14	
$UO_2^{2+} + H^{+} + PO_4^{3-} \Leftrightarrow UO_2HPO_4(aq)$	19.590 ± 0.262	14	
$UO_2^{2+} + 2\ H^{+} + PO_4^{3-} \Leftrightarrow UO_2H_2PO_4^{+}$	20.682 ± 0.068	14	
$UO_2^{2+} + 3\ H^{+} + PO_4^{3-} \Leftrightarrow UO_2H_3PO_4^{2+}$	22.462 ± 0.231	14	
$UO_2^{2+} + 4\ H^{+} + 2\ PO_4^{3-} \Leftrightarrow UO_2(H_2PO_4)_2(aq)$	44.044 ± 0.369	14	
$UO_2^{2+} + 5\ H^{+} + 2\ PO_4^{3-} \Leftrightarrow UO_2(H_2PO_4)(H_3PO_4)^{+}$	45.054 ± 0.369	14	
$UO_2^{2+} + AsO_4^{3-} + H^{+} \Leftrightarrow UO_2HAsO_4(aq)$	18.760 ± 0.310	14	
$UO_2^{2+} + AsO_4^{3-} + 2\ H^{+} \Leftrightarrow UO_2H_2AsO_4^{+}$	21.960 ± 0.240	14	
$UO_2^{2+} + 2\ AsO_4^{3-} + 4\ H^{+} \Leftrightarrow UO_2(H_2AsO_4)_2(aq)$	41.530 ± 0.200	14	
$UO_2^{2+} + CO_3^{2-} \Leftrightarrow UO_2CO_3(aq)$	9.940 ± 0.030	14	
$UO_2^{2+} + 2\ CO_3^{2-} \Leftrightarrow UO_2(CO_3)_2^{2-}$	16.610 ± 0.090	14	
$UO_2^{2+} + 3\ CO_3^{2-} \Leftrightarrow UO_2(CO_3)_3^{4-}$	21.840 ± 0.040	14	
$3\ UO_2^{2+} + 6\ CO_3^{2-} \Leftrightarrow (UO_2)_3(CO_3)_6^{6-}$	54.000 ± 1.000	14	
$2\ UO_2^{2+} + CO_3^{2-} + 3\ H_2O(l) \Leftrightarrow (UO_2)_2CO_3(OH)_3^{-} + 3\ H^{+}$	-0.855 ± 0.501	14	
$3\ UO_2^{2+} + CO_3^{2-} + 3\ H_2O(l) \Leftrightarrow (UO_2)_3O(OH)_2(HCO_3)^{+} + 3\ H^{+}$	0.655 ± 0.501	14	
$11\ UO_2^{2+} + 6\ CO_3^{2-} + 12\ H_2O(l) \Leftrightarrow (UO_2)_{11}(CO_3)_6(OH)_{12}^{2-} + 12\ H^{+}$	36.430 ± 2.011	14	
$UO_2^{2+} + CO_3^{2-} + F^{-} \Leftrightarrow UO_2CO_3F^{-}$	13.750 ± 0.090	14	
$UO_2^{2+} + CO_3^{2-} + 2\ F^{-} \Leftrightarrow UO_2CO_3F_2^{2-}$	15.570 ± 0.140	14	
$UO_2^{2+} + CO_3^{2-} + 3\ F^{-} \Leftrightarrow UO_2CO_3F_3^{3-}$	16.380 ± 0.110	14	
$UO_2^{2+} + SO_4^{2-} + CO_3^{2-} + NO_3^{-} + 20\ H^{+} + 16\ e^{-} \Leftrightarrow UO_2SCN^{+} + 10\ H_2O(l)$	158.372 ± 0.751	14	
$UO_2^{2+} + 2\ SO_4^{2-} + 2\ CO_3^{2-} + 2\ NO_3^{-} + 40\ H^{+} + 32\ e^{-} \Leftrightarrow UO_2(SCN)_2(aq) + 20\ H_2O(l)$	315.184 ± 1.532	14	
$UO_2^{2+} + 3\ SO_4^{2-} + 3\ CO_3^{2-} + 3\ NO_3^{-} + 60\ H^{+} + 48\ e^{-} \Leftrightarrow UO_2(SCN)_3^{-} + 30\ H_2O(l)$	473.016 ± 2.203	14	
$UO_2^{2+} + H_4SiO_4(aq) \Leftrightarrow UO_2SiO(OH)_3^{+} + H^{+}$	-1.840 ± 0.100	14	
$UO_2^{2+} + PuO_2^{2+} + 6\ CO_3^{2-} \Leftrightarrow (UO_2)_2PuO_2(CO_3)_6^{6-}$	53.480 ± 1.395	14	
$UO_2^{2+} + NpO_2^{2+} + 6\ CO_3^{2-} \Leftrightarrow (UO_2)_2NpO_2(CO_3)_6^{6-}$	54.053 ± 3.336	14	
$Np^{4+} + e^{-} \Leftrightarrow Np^{3+}$	3.695 ± 0.169	14	
$Np^{4+} + 3\ CO_3^{2-} + e^{-} \Leftrightarrow Np(CO_3)_3^{3-}$	20.279 ± 2.385	45, 14	
$Np^{3+} + H_2O(l) \Leftrightarrow NpOH^{2+} + H^{+}$	-6.800 ± 0.300	14	
$Np^{4+} + H_2O(l) \Leftrightarrow NpOH^{3+} + H^{+}$	-0.090 ± 0.300	45	
$Np^{4+} + 2\ H_2O(l) \Leftrightarrow Np(OH)_2^{2+} + 2\ H^{+}$	-0.870 ± 0.150	45	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Np^{4+} + 3\ H_2O(l) \Leftrightarrow Np(OH)_3^{+} + 3\ H^{+}$	-4.300 ± 0.300	45	
$Np^{4+} + 4\ H_2O(l) \Leftrightarrow Np(OH)_4(aq) + 4\ H^{+}$	-9.600 ± 1.100	45	
$Np^{4+} + F^{-} \Leftrightarrow NpF^{3+}$	8.960 ± 0.140	14	
$Np^{4+} + 2\ F^{-} \Leftrightarrow NpF_2^{2+}$	15.700 ± 0.300	14	
$Np^{4+} + Cl^{-} \Leftrightarrow NpCl^{3+}$	1.500 ± 0.300	14	
$Np^{4+} + I^{-} \Leftrightarrow NpI^{3+}$	1.500 ± 0.400	14	
$Np^{4+} + SO_4^{2-} \Leftrightarrow NpSO_4^{2+}$	6.850 ± 0.158	14	
$Np^{4+} + 2\ SO_4^{2-} \Leftrightarrow Np(SO_4)_2(aq)$	11.050 ± 0.269	14	
$Np^{4+} + NO_3^{-} \Leftrightarrow NpNO_3^{3+}$	1.900 ± 0.150	14	
$Np^{4+} + 4\ CO_3^{2-} \Leftrightarrow Np(CO_3)_4^{4-}$	37.610 ± 0.686	45, 14	
$Np^{4+} + 5\ CO_3^{2-} \Leftrightarrow Np(CO_3)_5^{6-}$	36.540 ± 0.748	45, 14	
$Np^{4+} + 2\ CO_3^{2-} + 2\ H_2O(l) \Leftrightarrow Np(CO_3)_2(OH)_2^{2-} + H^{+}$	16.387 ± 1.210	45	
$Np^{4+} + SO_4^{2-} + CO_3^{2-} + NO_3^{-} + 20\ H^{+} + 16\ e^{-} \Leftrightarrow NpSCN^{3+} + 10\ H_2O(l)$	159.972 ± 0.775	14	
$Np^{4+} + 2\ SO_4^{2-} + 2\ CO_3^{2-} + 2\ NO_3^{-} + 40\ H^{+} + 32\ e^{-} \Leftrightarrow Np(SCN)_2^{2+} + 20\ H_2O(l)$	318.044 ± 1.515	14	
$Np^{4+} + 3\ SO_4^{2-} + 3\ CO_3^{2-} + 3\ NO_3^{-} + 60\ H^{+} + 48\ e^{-} \Leftrightarrow Np(SCN)_3^{+} + 30\ H_2O(l)$	475.716 ± 2.203	14	
$Np^{4+} + 2\ H_2O(l) \Leftrightarrow NpO_2^{+} + 4\ H^{+} + e^{-}$	-10.212 ± 1.389	14	
$NpO_2^{+} + H_2O(l) \Leftrightarrow NpO_2OH(aq) + H^{+}$	-11.300 ± 0.700	14	
$NpO_2^{+} + 2\ H_2O(l) \Leftrightarrow NpO_2(OH)_2^{-} + 2\ H^{+}$	-23.600 ± 0.500	14	
$NpO_2^{+} + F^{-} \Leftrightarrow NpO_2F(aq)$	1.200 ± 0.300	14	
$NpO_2^{+} + IO_3^{-} \Leftrightarrow NpO_2IO_3(aq)$	**0.500 ± 0.300**	**14**	
$NpO_2^{+} + SO_4^{2-} \Leftrightarrow NpO_2SO_4^{-}$	0.440 ± 0.270	14	
$NpO_2^{+} + H^{+} + PO_4^{3-} \Leftrightarrow NpO_2HPO_4^{-}$	15.300 ± 0.104	14	
$NpO_2^{+} + CO_3^{2-} \Leftrightarrow NpO_2CO_3^{-}$	4.962 ± 0.061	14	
$NpO_2^{+} + 2\ CO_3^{2-} \Leftrightarrow NpO_2(CO_3)_2^{3-}$	6.534 ± 0.103	14	
$NpO_2^{+} + 3\ CO_3^{2-} \Leftrightarrow NpO_2(CO_3)_3^{5-}$	5.500 ± 0.151	14	
$3\ NpO_2^{+} + 6\ CO_3^{2-} \Leftrightarrow (NpO_2)_3(CO_3)_6^{6-} + 3\ e^{-}$	-8.492 ± 1.458	14	
$NpO_2^{+} + 2\ CO_3^{2-} + H_2O(l) \Leftrightarrow NpO_2(CO_3)_2OH^{4-} + H^{+}$	-5.306 ± 1.174	14	
$Np^{4+} + 2\ H_2O(l) \Leftrightarrow NpO_2^{2+} + 4\ H^{+} + 2\ e^{-}$	-29.803 ± 1.388	14	
$NpO_2^{2+} + H_2O(l) \Leftrightarrow NpO_2OH^{+} + H^{+}$	-5.100 ± 0.400	14	
$2\ NpO_2^{2+} + 2\ H_2O(l) \Leftrightarrow (NpO_2)_2(OH)_2^{2+} + 2\ H^{+}$	-6.270 ± 0.210	14	
$3\ NpO_2^{2+} + 5\ H_2O(l) \Leftrightarrow (NpO_2)_3(OH)_5^{+} + 5\ H^{+}$	-17.120 ± 0.220	14	
$NpO_2^{2+} + F^{-} \Leftrightarrow NpO_2F^{+}$	4.570 ± 0.070	14	
$NpO_2^{2+} + 2\ F^{-} \Leftrightarrow NpO_2F_2(aq)$	7.600 ± 0.080	14	
$NpO_2^{2+} + Cl^{-} \Leftrightarrow NpO_2Cl^{+}$	0.400 ± 0.170	14	
$NpO_2^{2+} + IO_3^{-} \Leftrightarrow NpO_2IO_3^{+}$	**1.200 ± 0.300**	**14**	
$NpO_2^{2+} + SO_4^{2-} \Leftrightarrow NpO_2SO_4(aq)$	3.280 ± 0.060	14	
$NpO_2^{2+} + 2\ SO_4^{2-} \Leftrightarrow NpO_2(SO_4)_2^{2-}$	4.700 ± 0.100	14	
$NpO_2^{2+} + H^{+} + PO_4^{3-} \Leftrightarrow NpO_2HPO_4(aq)$	18.550 ± 0.701	14	
$NpO_2^{2+} + 2\ H^{+} + PO_4^{3-} \Leftrightarrow NpO_2H_2PO_4^{+}$	22.882 ± 0.501	14	
$NpO_2^{2+} + 2\ H^{+} + 2\ PO_4^{3-} \Leftrightarrow NpO_2(HPO_4)_2^{2-}$	34.200 ± 1.001	14	
$NpO_2^{2+} + CO_3^{2-} \Leftrightarrow NpO_2CO_3(aq)$	9.320 ± 0.610	14	
$NpO_2^{2+} + 2\ CO_3^{2-} \Leftrightarrow NpO_2(CO_3)_2^{2-}$	16.516 ± 0.729	14	
$NpO_2^{2+} + 3\ CO_3^{2-} \Leftrightarrow NpO_2(CO_3)_3^{4-}$	19.371 ± 1.972	14	
$NpO_2^{2+} + CO_3^{2-} + 3\ H_2O(l) \Leftrightarrow (NpO_2)_2\ CO_3\ (OH)_3^{-}$	2.867 ± 4.254	14	
$Pu^{4+} + e^{-} \Leftrightarrow Pu^{3+}$	17.694 ± 0.668	14	
$Pu^{3+} + H_2O(l) \Leftrightarrow PuOH^{2+} + H^{+}$	-7.200 ± 0.500	28	
$Pu^{3+} + 2\ H_2O(l) \Leftrightarrow Pu(OH)_2^{+} + 2\ H^{+}$	-15.100 ± 0.700	28	
$Pu^{3+} + 3\ H_2O(l) \Leftrightarrow Pu(OH)_3(aq) + 3\ H^{+}$	-26.200 ± 0.500	28	
$Pu^{3+} + F^{-} \Leftrightarrow PuF^{2+}$	3.400 ± 0.400	28	
$Pu^{3+} + 2\ F^{-} \Leftrightarrow PuF_2^{+}$	5.800 ± 0.200	28	
$Pu^{3+} + Cl^{-} \Leftrightarrow PuCl^{2+}$	0.240 ± 0.030	28	
$Pu^{3+} + 2\ Cl^{-} \Leftrightarrow PuCl_2^{+}$	-0.740 ± 0.050	28	
$Pu^{3+} + SO_4^{2-} \Leftrightarrow PuSO_4^{+}$	3.300 ± 0.150	28	
$Pu^{3+} + 2\ SO_4^{2-} \Leftrightarrow Pu(SO_4)_2^{-}$	3.700 ± 0.150	28	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Pu^{3+} + 3\ NO_3^- + 18\ H^+ + 16\ e^- \Leftrightarrow PuN_3^{2+} + 9\ H_2O(l)$	256.342 ± 0.430	28, 3	
$Pu^{3+} + NO_2^- \Leftrightarrow PuNO_2^{2+}$	2.100 ± 0.200	28	
$Pu^{3+} + NO_3^- \Leftrightarrow PuNO_3^{2+}$	1.330 ± 0.200	28	
$Pu^{3+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow PuH_2PO_4^{2+}$	22.562 ± 0.501	28, 3	
$Pu^{3+} + CO_3^{2-} \Leftrightarrow PuCO_3^+$	8.000 ± 0.400	28	
$Pu^{3+} + 2\ CO_3^{2-} \Leftrightarrow Pu(CO_3)_2^-$	12.900 ± 0.600	28	
$Pu^{3+} + 3\ CO_3^{2-} \Leftrightarrow Pu(CO_3)_3^{3-}$	15.000 ± 1.000	28	
$Pu^{3+} + H^+ + CO_3^{2-} \Leftrightarrow PuHCO_3^{2+}$	13.429 ± 0.301	28, 3	
$Pu^{3+} + H_4SiO_4(aq) \Leftrightarrow PuSiO(OH)_3^{2+} + H^+$	-1.680 ± 0.180	28	
$Pu^{3+} + NO_3^- + CO_3^{2-} + SO_4^{2-} + 20\ H^+ + 16\ e^- \Leftrightarrow PuSCN^{2+} + 10\ H_2O(l)$	158.272 ± 0.775	28, 3	
$Pu^{4+} + H_2O(l) \Leftrightarrow PuOH^{3+} + H^+$	0.000 ± 0.200	45	
$Pu^{4+} + 2\ H_2O(l) \Leftrightarrow Pu(OH)_2^{2+} + 2\ H^+$	-1.200 ± 0.600	45	
$Pu^{4+} + 3\ H_2O(l) \Leftrightarrow Pu(OH)_3^+ + 3\ H^+$	-3.100 ± 0.900	45	
$Pu^{4+} + 4\ H_2O(l) \Leftrightarrow Pu(OH)_4(aq) + 4\ H^+$	-8.500 ± 0.500	45	
$Pu^{4+} + F^- \Leftrightarrow PuF^{3+}$	8.840 ± 0.100	14	
$Pu^{4+} + 2\ F^- \Leftrightarrow PuF_2^{2+}$	15.700 ± 0.200	14	
$Pu^{4+} + Cl^- \Leftrightarrow PuCl^{3+}$	1.800 ± 0.300	14	
$Pu^{4+} + Br^- \Leftrightarrow PuBr^{3+}$	1.600 ± 0.300	14	
$Pu^{4+} + SO_4^{2-} \Leftrightarrow PuSO_4^{2+}$	6.890 ± 0.226	14	
$Pu^{4+} + 2\ SO_4^{2-} \Leftrightarrow Pu(SO_4)_2(aq)$	11.140 ± 0.335	14	
$Pu^{4+} + NO_3^- \Leftrightarrow PuNO_3^{3+}$	1.950 ± 0.150	14	
$Pu^{4+} + 3\ H^+ + PO_4^{3-} \Leftrightarrow PuH_3PO_4^{4+}$	24.102 ± 0.348	14	
$Pu^{4+} + 4\ CO_3^{2-} \Leftrightarrow Pu(CO_3)_4^{4-}$	37.000 ± 1.100	14	
$Pu^{4+} + 5\ CO_3^{2-} \Leftrightarrow Pu(CO_3)_5^{6-}$	35.650 ± 1.130	14	
$Pu^{4+} + 2\ CO_3^{2-} + 2\ H_2O(l) \Leftrightarrow Pu(CO_3)_2(OH)_2^{2-} + 2\ H^+$	19.177 ± 1.250	45	
$Pu^{4+} + 2\ H_2O(l) \Leftrightarrow PuO_2^+ + 4\ H^+ + e^-$	-17.453 ± 0.691	14	
$PuO_2^+ + H_2O(l) \Leftrightarrow PuO_2OH(aq) + H^+$	≤ -9.730	14	
$PuO_2^+ + CO_3^{2-} \Leftrightarrow PuO_2CO_3^-$	5.120 ± 0.140	14	
$PuO_2^+ + 3\ CO_3^{2-} \Leftrightarrow PuO_2(CO_3)_3^{5-}$	5.025 ± 0.920	14	
$Pu^{4+} + 2\ H_2O(l) \Leftrightarrow PuO_2^{2+} + 4\ H^+ + 2\ e^-$	-33.272 ± 0.697	14	
$PuO_2^{2+} + H_2O(l) \Leftrightarrow PuO_2OH^+ + H^+$	-5.500 ± 0.500	14	
$PuO_2^{2+} + 2\ H_2O(l) \Leftrightarrow PuO_2OH_2(aq) + 2\ H^+$	-13.200 ± 1.500	14	
$2\ PuO_2^{2+} + 2\ H_2O(l) \Leftrightarrow (PuO_2)_2(OH)_2^{2+} + 2\ H^+$	-7.500 ± 1.000	14	
$PuO_2^{2+} + F^- \Leftrightarrow PuO_2F^+$	4.560 ± 0.200	14	
$PuO_2^{2+} + 2\ F^- \Leftrightarrow PuO_2F_2(aq)$	7.250 ± 0.450	14	
$PuO_2^{2+} + Cl^- \Leftrightarrow PuO_2Cl^+$	0.230 ± 0.030	14	
$PuO_2^{2+} + 2\ Cl^- \Leftrightarrow PuO_2Cl_2(aq)$	-1.150 ± 0.300	14	
$PuO_2^{2+} + SO_4^{2-} \Leftrightarrow PuO_2SO_4(aq)$	3.380 ± 0.200	14	
$PuO_2^{2+} + 2\ SO_4^{2-} \Leftrightarrow PuO_2(SO_4)_2^{2-}$	4.400 ± 0.200	14	
$PuO_2^{2+} + CO_3^{2-} \Leftrightarrow PuO_2CO_3(aq)$	9.500 ± 0.500	14	
$PuO_2^{2+} + 2\ CO_3^{2-} \Leftrightarrow PuO_2(CO_3)_2^{2-}$	14.700 ± 0.500	14	
$PuO_2^{2+} + 3\ CO_3^{2-} \Leftrightarrow PuO_2(CO_3)_3^{4-}$	18.000 ± 0.500	14	
$Am^{3+} + e^- \Leftrightarrow Am^{2+}$	**-38.878 ± 2.536**	**14**	
$Am^{3+} + H_2O(l) \Leftrightarrow AmOH^{2+} + H^+$	-7.200 ± 0.500	14	
$Am^{3+} + 2\ H_2O(l) \Leftrightarrow Am(OH)_2^+ + 2\ H^+$	-15.100 ± 0.700	14	
$Am^{3+} + 3\ H_2O(l) \Leftrightarrow Am(OH)_3(aq) + 3\ H^+$	-26.200 ± 0.500	14	
$Am^{3+} + F^- \Leftrightarrow AmF^{2+}$	3.400 ± 0.400	14	
$Am^{3+} + 2\ F^- \Leftrightarrow AmF_2^+$	5.800 ± 0.200	14	
$Am^{3+} + Cl^- \Leftrightarrow AmCl^{2+}$	0.240 ± 0.030	14	
$Am^{3+} + 2\ Cl^- \Leftrightarrow AmCl_2^+$	-0.740 ± 0.050	14	
$Am^{3+} + SO_4^{2-} \Leftrightarrow AmSO_4^+$	3.300 ± 0.150	14	
$Am^{3+} + 2\ SO_4^{2-} \Leftrightarrow Am(SO_4)_2^-$	3.700 ± 0.150	14	
$Am^{3+} + 3\ NO_3^- + 18\ H^+ + 16\ e^- \Leftrightarrow AmN_3^{2+} + 9\ H_2O(l)$	256.342 ± 0.430	14	
$Am^{3+} + NO_2^- \Leftrightarrow AmNO_2^{2+}$	2.100 ± 0.200	14	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Am^{3+} + NO_3^- \Leftrightarrow AmNO_3^{2+}$	1.330 ± 0.200	14	
$Am^{3+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow AmH_2PO_4^{2+}$	22.562 ± 0.501	14	
$Am^{3+} + CO_3^{2-} \Leftrightarrow AmCO_3^+$	8.000 ± 0.400	14	
$Am^{3+} + 2\ CO_3^{2-} \Leftrightarrow Am(CO_3)_2^-$	12.900 ± 0.600	14	
$Am^{3+} + 3\ CO_3^{2-} \Leftrightarrow Am(CO_3)_3^{3-}$	15.000 ± 1.000	14	
$Am^{3+} + H^+ + CO_3^{2-} \Leftrightarrow AmHCO_3^{2+}$	13.429 ± 0.301	14	
$Am^{3+} + H_4SiO_4(aq) \Leftrightarrow AmSiO(OH)_3^{2+} + H^+$	-1.680 ± 0.180	14	
$Am^{3+} + NO_3^- + CO_3^{2-} + SO_4^{2-} + 20\ H^+ + 16\ e^- \Leftrightarrow AmSCN^{2+} + 10\ H_2O(l)$	158.272 ± 0.775	14	
$Am^{3+} \Leftrightarrow Am^{4+} + e^-$	**-44.208 ± 1.736**	**present**	
$Am^{4+} + 5\ CO_3^{2-} \Leftrightarrow Am(CO_3)_5^{6-}$	**39.308 ± 2.088**	**present**	
$Am^{3+} + 2\ H_2O(l) \Leftrightarrow AmO_2^+ + 4\ H^+ + 2\ e^-$	**-58.371 ± 1.370**	**present**	
$AmO_2^+ + CO_3^{2-} \Leftrightarrow AmO_2CO_3^-$	**5.100 ± 0.500** *	**14**	
$AmO_2^+ + 2\ CO_3^{2-} \Leftrightarrow AmO_2(CO_3)_2^{3-}$	**6.700 ± 0.800** *	**14**	
$AmO_2^+ + 3\ CO_3^{2-} \Leftrightarrow AmO_2(CO_3)_3^{5-}$	**5.100 ± 1.000** *	**14**	
$Am^{3+} + 2\ H_2O(l) \Leftrightarrow AmO_2^{2+} + 4\ H^+ + 3\ e^-$	**-85.349 ± 1.303**	**present**	
$AmO_2^{2+} + 3\ CO_3^{2-} \Leftrightarrow AmO_2(CO_3)_3^{4-}$	**18.978 ± 1.905**	**present**	
$Cm^{3+} + H_2O(l) \Leftrightarrow CmOH^{2+} + H^+$	-7.200 ± 0.500	28	
$Cm^{3+} + 2\ H_2O(l) \Leftrightarrow Cm(OH)_2^+ + 2\ H^+$	-15.100 ± 0.700	28	
$Cm^{3+} + 3\ H_2O(l) \Leftrightarrow Cm(OH)_3(aq) + 3\ H^+$	-26.200 ± 0.500	28	
$Cm^{3+} + F^- \Leftrightarrow CmF^{2+}$	3.400 ± 0.400	28	
$Cm^{3+} + 2\ F^- \Leftrightarrow CmF_2^+$	5.800 ± 0.200	28	
$Cm^{3+} + Cl^- \Leftrightarrow CmCl^{2+}$	0.240 ± 0.030	28	
$Cm^{3+} + 2\ Cl^- \Leftrightarrow CmCl_2^+$	-0.740 ± 0.050	28	
$Cm^{3+} + SO_4^{2-} \Leftrightarrow CmSO_4^+$	3.300 ± 0.150	28	
$Cm^{3+} + 2\ SO_4^{2-} \Leftrightarrow Cm(SO_4)_2^-$	3.700 ± 0.150	28	
$Cm^{3+} + 3\ NO_3^- + 18\ H^+ + 16\ e^- \Leftrightarrow CmN_3^{2+} + 9\ H_2O(l)$	256.342 ± 0.430	28, 3	
$Cm^{3+} + NO_2^- \Leftrightarrow CmNO_2^{2+}$	2.100 ± 0.200	28	
$Cm^{3+} + NO_3^- \Leftrightarrow CmNO_3^{2+}$	1.330 ± 0.200	28	
$Cm^{3+} + 2\ H^+ + PO_4^{3-} \Leftrightarrow CmH_2PO_4^{2+}$	22.562 ± 0.501	28, 3	
$Cm^{3+} + CO_3^{2-} \Leftrightarrow CmCO_3^+$	8.000 ± 0.400	28	
$Cm^{3+} + 2\ CO_3^{2-} \Leftrightarrow Cm(CO_3)_2^-$	12.900 ± 0.600	28	
$Cm^{3+} + 3\ CO_3^{2-} \Leftrightarrow Cm(CO_3)_3^{3-}$	15.000 ± 1.000	28	
$Cm^{3+} + H^+ + CO_3^{2-} \Leftrightarrow CmHCO_3^{2+}$	13.429 ± 0.301	28, 3	
$Cm^{3+} + H_4SiO_4(aq) \Leftrightarrow CmSiO(OH)_3^{2+} + H^+$	-1.680 ± 0.180	28	
$Cm^{3+} + NO_3^- + CO_3^{2-} + SO_4^{2-} + 20\ H^+ + 16\ e^- \Leftrightarrow CmSCN^{2+} + 10\ H_2O(l)$	158.272 ± 0.775	28, 3	
$H^+ + ox^{2-} \Leftrightarrow Hox^-$	4.250 ± 0.010	46	
$2\ H^+ + ox^{2-} \Leftrightarrow H_2ox(aq)$	5.650 ± 0.032	46	
$Ni^{2+} + ox^{2-} \Leftrightarrow Ni(ox)(aq)$	5.190 ± 0.040	46	
$Ni^{2+} + 2\ ox^{2-} \Leftrightarrow Ni(ox)_2^{2-}$	7.640 ± 0.070	46	
$Am^{3+} + ox^{2-} \Leftrightarrow Am(ox)^+$	6.510 ± 0.150	46	
$Am^{3+} + 2\ ox^{2-} \Leftrightarrow Am(ox)_2^-$	10.710 ± 0.200	46	
$Am^{3+} + 3\ ox^{2-} \Leftrightarrow Am(ox)_3^{3-}$	13.000 ± 1.000	46	
$NpO_2^+ + ox^{2-} \Leftrightarrow NpO_2ox^-$	3.900 ± 0.100	46	
$NpO_2^+ + 2\ ox^{2-} \Leftrightarrow NpO_2(ox)_2^{3-}$	5.800 ± 0.200	46	
$UO_2^{2+} + ox^{2-} \Leftrightarrow UO_2ox(aq)$	7.130 ± 0.160	46	
$UO_2^{2+} + 2\ ox^{2-} \Leftrightarrow UO_2(ox)_2^{2-}$	11.650 ± 0.150	46	
$UO_2^{2+} + 3\ ox^{2-} \Leftrightarrow UO_2(ox)_3^{4-}$	13.800 ± 1.500	46	
$Mg^{2+} + ox^{2-} \Leftrightarrow Mg(ox)(aq)$	3.560 ± 0.040	46	
$Mg^{2+} + 2\ ox^{2-} \Leftrightarrow Mg(ox)_2^{2-}$	5.170 ± 0.080	46	
$Ca^{2+} + ox^{2-} \Leftrightarrow Ca(ox)(aq)$	3.190 ± 0.060	46	
$Ca^{2+} + 2\ ox^{2-} \Leftrightarrow Ca(ox)_2^{2-}$	4.020 ± 0.199	46	
$cit^{3-} + H^+ \Leftrightarrow Hcit^{2-}$	6.360 ± 0.020	46	
$cit^{3-} + 2\ H^+ \Leftrightarrow H_2cit^-$	11.140 ± 0.022	46	
$cit^{3-} + 3\ H^+ \Leftrightarrow H_3cit(aq)$	14.270 ± 0.024	46	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Ni^{2+} + cit^{3-} \Leftrightarrow Ni(cit)^{-}$	6.760 ± 0.080	46	
$Ni^{2+} + 2\ cit^{3-} \Leftrightarrow Ni(cit)_2^{4-}$	8.500 ± 0.400	46	
$Ni^{2+} + H^{+} + cit^{3-} \Leftrightarrow Ni(Hcit)(aq)$	10.520 ± 0.102	46	
$Ni^{2+} + 2\ H^{+} + cit^{3-} \Leftrightarrow Ni(H_2cit)^{+}$	13.190 ± 0.251	46	
$Am^{3+} + cit^{3-} \Leftrightarrow Am(cit)(aq)$	8.550 ± 0.200	46	
$Am^{3+} + 2\ cit^{3-} \Leftrightarrow Am(cit)_2^{3-}$	13.900 ± 1.000	46	
$Am^{3+} + H^{+} + cit^{3-} \Leftrightarrow Am(Hcit)^{+}$	12.860 ± 1.000	46	
$Am^{3+} + 2\ H^{+} + 2\ cit^{3-} \Leftrightarrow Am(Hcit)_2^{-}$	23.520 ± 1.001	46	
$NpO_2^{+} + cit^{3-} \Leftrightarrow NpO_2cit^{2-}$	3.680 ± 0.050	46	
$UO_2^{2+} + cit^{3-} \Leftrightarrow UO_2cit^{-}$	8.960 ± 0.170	46	
$2\ UO_2^{2+} + 2\ cit^{3-} \Leftrightarrow (UO_2)_2(cit)_2^{2-}$	21.300 ± 0.500	46	
$UO_2^{2+} + H^{+} + cit^{3-} \Leftrightarrow UO_2(Hcit)(aq)$	11.360 ± 1.000	46	
$Mg^{2+} + cit^{3-} \Leftrightarrow Mg(cit)^{-}$	4.810 ± 0.030	46	
$Mg^{2+} + H^{+} + cit^{3-} \Leftrightarrow Mg(Hcit)(aq)$	8.960 ± 0.073	46	
$Mg^{2+} + 2\ H^{+} + cit^{3-} \Leftrightarrow Mg(H_2cit)^{+}$	12.450 ± 0.162	46	
$Ca^{2+} + cit^{3-} \Leftrightarrow Ca(cit)^{-}$	4.800 ± 0.030	46	
$Ca^{2+} + H^{+} + cit^{3-} \Leftrightarrow Ca(Hcit)(aq)$	9.280 ± 0.073	46	
$Ca^{2+} + 2\ H^{+} + cit^{3-} \Leftrightarrow Ca(H_2cit)^{+}$	12.670 ± 0.162	46	
$edta^{4-} + H^{+} \Leftrightarrow Hedta^{3-}$	11.240 ± 0.030	46	
$edta^{4-} + 2\ H^{+} \Leftrightarrow H_2edta^{2-}$	18.040 ± 0.036	46	
$edta^{4-} + 3\ H^{+} \Leftrightarrow H_3edta^{-}$	21.190 ± 0.041	46	
$edta^{4-} + 4\ H^{+} \Leftrightarrow H_4edta(aq)$	23.420 ± 0.065	46	
$edta^{4-} + 5\ H^{+} \Leftrightarrow H_5edta^{+}$	24.720 ± 0.119	46	
$edta^{4-} + 6\ H^{+} \Leftrightarrow H_6edta^{2+}$	24.220 ± 0.233	46	
$Ni^{2+} + edta^{4-} \Leftrightarrow Ni(edta)^{2-}$	20.540 ± 0.130	46	
$Ni^{2+} + edta^{4-} + H^{+} \Leftrightarrow Ni(Hedta)^{-}$	24.200 ± 0.206	46	
$Am^{3+} + edta^{4-} \Leftrightarrow Am(edta)^{-}$	19.670 ± 0.110	46	
$Am^{3+} + edta^{4-} + H^{+} \Leftrightarrow Am(Hedta)(aq)$	21.840 ± 0.273	46	
$Pu^{3+} + edta^{4-} \Leftrightarrow Pu(edta)^{-}$	20.180 ± 0.370	46	
$Pu^{3+} + edta^{4-} + H^{+} \Leftrightarrow Pu(Hedta)(aq)$	22.020 ± 0.454	46	
$Np^{4+} + edta^{4-} \Leftrightarrow Np(edta)(aq)$	31.200 ± 0.600	46	
$NpO_2^{+} + edta^{4-} \Leftrightarrow NpO_2edta^{3-}$	9.230 ± 0.130	46	
$NpO_2^{+} + edta^{4-} + H^{+} \Leftrightarrow NpO_2(Hedta)^{2-}$	17.060 ± 0.114	46	
$NpO_2^{+} + edta^{4-} + 2\ H^{+} \Leftrightarrow NpO_2(H_2edta)^{-}$	22.510 ± 0.145	46	
$U^{4+} + edta^{4-} \Leftrightarrow Uedta(aq)$	29.500 ± 0.200	46	
$UO_2^{2+} + edta^{4-} \Leftrightarrow UO_2edta^{2-}$	13.700 ± 0.200	46	
$2\ UO_2^{2+} + edta^{4-} \Leftrightarrow (UO_2)_2edta(aq)$	20.600 ± 0.400	46	
$UO_2^{2+} + edta^{4-} + H^{+} \Leftrightarrow UO_2(Hdta)^{-}$	19.610 ± 0.104	46	
$Mg^{2+} + edta^{4-} \Leftrightarrow Mg(edta)^{2-}$	10.900 ± 0.100	46	
$Mg^{2+} + edta^{4-} + H^{+} \Leftrightarrow Mg(Hedta)^{-}$	15.400 ± 0.224	46	
$Ca^{2+} + edta^{4-} \Leftrightarrow Ca(edta)^{2-}$	12.690 ± 0.060	46	
$Ca^{2+} + edta^{4-} + H^{+} \Leftrightarrow Ca(Hedta)^{-}$	16.230 ± 0.108	46	
$Na^{+} + edta^{4-} \Leftrightarrow Na(edta)^{3-}$	2.800 ± 0.200	46	
$K^{+} + edta^{4-} \Leftrightarrow Na(edta)^{3-}$	1.800 ± 0.300	46	
$H^{+} + isa^{-} \Leftrightarrow Hisa(aq)$	4.000 ± 0.500	46	
$Ca^{2+} + isa^{-} \Leftrightarrow Ca(isa)^{+}$	1.700 ± 0.300	46	
$Na^{+} + (ox)^{2-} \Leftrightarrow Na(ox)^{-}$	1.000	47	*
$K^{+} + (ox)^{2-} \Leftrightarrow K(ox)^{-}$	0.900	47	*
$Sr^{2+} + (ox)^{2-} \Leftrightarrow Sr(ox)$	2.330	48	*
$Sr^{2+} + 2\ (ox)^{2-} \Leftrightarrow Sr(ox)_2^{2-}$	2.980	48	*
$Ra^{2+} + (ox)^{2-} \Leftrightarrow Ra(ox)$	2.780	49	*
$Ra^{2+} + 2\ (ox)^{2-} \Leftrightarrow Ra(ox)_2^{2-}$	3.440	49	*
$Fe^{2+} + (ox)^{2-} \Leftrightarrow Fe(ox)$	4.130	48	*
$Fe^{2+} + 2\ (ox)^{2-} \Leftrightarrow Fe(ox)_2^{2-}$	6.230	48	*

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Co^{2+} + (ox)^{2-} \Leftrightarrow Co(ox)$	4.720	48	*
$Co^{2+} + 2\ (ox)^{2-} \Leftrightarrow Co(ox)_2^{2-}$	7.000	48	*
$Pb^{+} + 2\ (ox)^{2-} \Leftrightarrow Pb(ox)$	4.910	48	*
$Pb + 2\ (ox)^{2-} \Leftrightarrow Pb(ox)_2^{2-}$	6.760	48	*
$Al^{3+} + (ox)^{2-} \Leftrightarrow Al(ox)^{+}$	7.720	48	*
$Al^{3+} + 2\ (ox)^{2-} \Leftrightarrow Al(ox)_2^{-}$	13.200	48	*
$Al^{3+} + 3\ (ox)^{2-} \Leftrightarrow Al(ox)_3^{3-}$	16.740	48	*
$Zr^{4+} + (ox)^{2-} \Leftrightarrow Zr(ox)^{2+}$	10.520	49	*
$Zr^{4+} + 2\ (ox)^{2-} \Leftrightarrow Zr(ox)_2$	18.150	49	*
$TcO(OH)_2(aq) + 2\ H^{+} + (cit)^{3-} \Leftrightarrow TcO(cit)^{-} + 2\ H_2O(l)$	**< 15.999**	**49, present**	*
$TcO(OH)_2(aq) + 3\ H^{+} + (cit)^{3-} \Leftrightarrow TcOH(cit)(aq) + 2\ H_2O(l)$	**< 18.110**	**49, present**	*
$Sm^{3+} + (ox)^{2-} \Leftrightarrow Sm(ox)^{+}$	6.300	49	*
$Sm^{3+} + 2\ (ox)^{2-} \Leftrightarrow Sm(ox)_2^{-}$	10.130	49	*
$Ac^{3+} + (ox)^{2-} \Leftrightarrow Ac(ox)^{+}$	5.650	48	*
$Ac^{3+} + 2\ (ox)^{2-} \Leftrightarrow Ac(ox)_2^{-}$	8.800	48	*
$Cm^{3+} + (ox)^{2-} \Leftrightarrow Cm(ox)^{+}$	6.540	48	*
$Cm^{3+} + 2\ (ox)^{2-} \Leftrightarrow Cm(ox)_2^{-}$	10.570	48	*
$Th^{4+} + (ox)^{2-} \Leftrightarrow Th(ox)^{2+}$	10.600	48	*
$Th^{4+} + 2\ (ox)^{2-} \Leftrightarrow Th(ox)_2(aq)$	20.200	48	*
$Th^{4+} + 3\ (ox)^{2-} \Leftrightarrow Th(ox)_3^{2-}$	26.400	48	*
$Pu^{4+} + (ox)^{2-} \Leftrightarrow Pu(ox)^{2+}$	10.340	49	*
$Pu^{4+} + 2\ (ox)^{2-} \Leftrightarrow Pu(ox)_2(aq)$	17.800	49	*
$U^{4+} + (ox)^{2-} \Leftrightarrow U(ox)^{2+}$	10.180	49	*
$U^{4+} + 2\ (ox)^{2-} \Leftrightarrow U(ox)_2(aq)$	17.500	49	*
$Np^{4+} + (ox)^{2-} \Leftrightarrow Np(ox)^{2+}$	10.290	49	*
$Np^{4+} + 2\ (ox)^{2-} \Leftrightarrow Np(ox)_2(aq)$	17.710	49	*
$PuO_2^{2+} + (ox)^{2-} \Leftrightarrow PuO_2(ox)\ (aq)$	7.250	49	*
$PuO_2^{2+} + 2\ (ox)^{2-} \Leftrightarrow PuO_2(ox)_2^{2-}$	11.940	49	*
$Na^{+} + (cit)^{3-} \Leftrightarrow Na(cit)^{2-}$	1.340	48	*
$K^{+} + (cit)^{3-} \Leftrightarrow K(cit)^{2-}$	1.230	48	*
$Sr^{2+} + (cit)^{3-} \Leftrightarrow Sr(cit)^{-}$	4.110	48	*
$Sr^{2+} + H^{+} + (cit)^{3-} \Leftrightarrow SrH(cit)(aq)$	9.080	49	*
$Ra^{2+} + (cit)^{3-} \Leftrightarrow Ra(cit)^{-}$	3.590	49	*
$Ra^{2+} + H^{+} + (cit)^{3-} \Leftrightarrow Ra(H(cit)(aq)$	9.000	49	*
$Fe^{2+} + (cit)^{3-} \Leftrightarrow Fe(cit)^{-}$	5.690	48	*
$Fe^{2+} + H^{+} + (cit)^{3-} \Leftrightarrow FeH(cit)(aq)$	9.870	48	*
$Co^{2+} + (cit)^{3-} \Leftrightarrow Co(cit)^{-}$	6.290	48	*
$Co^{2+} + H^{+} + (cit)^{3-} \Leftrightarrow CoH(cit)(aq)$	10.270	48	*
$Pb^{2+} + (cit)^{3-} \Leftrightarrow Pb(cit)^{-}$	5.700	48	*
$Pb^{2+} + 2\ (cit)^{3-} \Leftrightarrow Pb(cit)_2^{4-}$	9.910	48	*
$Pb^{2+} + 3\ (cit)^{3-} \Leftrightarrow Pb(cit)_3^{7-}$	4.550	48	*
$Pb^{2+} + H^{+} + (cit)^{3-} \Leftrightarrow PbH(cit)(aq)$	10.410	48	*
$Al^{3+} + (cit)^{3-} \Leftrightarrow Al(cit)$	9.910	47	*
$Al^{3+} + 2\ (cit)^{3-} \Leftrightarrow Al(cit)_2^{3-}$	14.120	47	*
$Al^{3+} + H^{+} + (cit)^{3-} \Leftrightarrow AlH(cit)^{+}$	12.860	47	*
$Zr^{4+} + (cit)^{3-} \Leftrightarrow Zr(cit)^{+}$	13.270	49	*
$Zr^{4+} + H^{+} + (cit)^{3-} \Leftrightarrow ZrH(cit)^{2+}$	14.880	49	*
$TcO^{2+} + (cit)^{3-} \Leftrightarrow TcO(cit)^{-}$	11.990	49	*
$TcO^{2+} + H^{+} + (cit)^{3-} \Leftrightarrow TcOH(cit)(aq)$	14.110	49	*
$Sm^{3+} + (cit)^{3-} \Leftrightarrow Sm(cit)(aq)$	7.990	49	*
$Sm^{3+} + H^{+} + (cit)^{3-} \Leftrightarrow SmH(cit)^{+}$	11.670	49	*
$Ac^{3+} + (cit)^{3-} \Leftrightarrow Ac(cit)(aq)$	7.990	49	*
$Ac^{3+} + H^{+} + (cit)^{3-} \Leftrightarrow AcH(cit)^{+}$	11.670	49	*
$Cm^{3+} + (cit)^{3-} \Leftrightarrow Cm(cit)(aq)$	7.990	49	*

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Cm^{3+} + H^+ + (cit)^{3-} \Leftrightarrow CmH(cit)^+$	11.670	49	*
$Pu^{3+} + (cit)^{3-} \Leftrightarrow Pu(cit)(aq)$	7.990	49	*
$Pu^{3+} + H^+ + (cit)^{3-} \Leftrightarrow PuH(cit)^+$	11.670	49	*
$Th^{4+} + (cit)^{3-} \Leftrightarrow Th(cit)^+$	11.290	49	*
$Th^{4+} + H^+ + (cit)^{3-} \Leftrightarrow ThH(cit)^{2+}$	13.680	49	*
$Pu^{4+} + (cit)^{3-} \Leftrightarrow Pu(cit)^+$	13.040	49	*
$Pu^{4+} + H^+ + (cit)^{3-} \Leftrightarrow PuH(cit)^{2+}$	14.750	49	*
$U^{4+} + (cit)^{3-} \Leftrightarrow U(cit)^+$	12.840	49	*
$U^{4+} + H^+ + (cit)^{3-} \Leftrightarrow UH(cit)^{2+}$	14.620	49	*
$Np^{4+} + (cit)^{3-} \Leftrightarrow Np(cit)^+$	12.980	49	*
$Np^{4+} + H^+ + (cit)^{3-} \Leftrightarrow NpH(cit)^{2+}$	14.710	49	*
$NpO_2^+ + H^+ + (cit)^{3-} \Leftrightarrow NpH(cit)^-$	9.920	49	*
$PuO_2^{2+} + (cit)^{3-} \Leftrightarrow PuO_2(cit)^-$	9.180	49	*
$PuO_2^{2+} + H^+ + (cit)^{3-} \Leftrightarrow PuO_2H(cit)(aq)$	12.400	49	*
$Sr^{2+} + (edta)^{4-} \Leftrightarrow Sr(edta)^{2-}$	10.460	47	*
$Sr^{2+} + H^+ + (edta)^{4-} \Leftrightarrow SrH(edta)^-$	14.820	47	*
$Fe^{2+} + (edta)^{4-} \Leftrightarrow Fe(edta)^{2-}$	16.020	47	*
$Fe^{2+} + H^+ + (edta)^{4-} \Leftrightarrow FeH(edta)^-$	19.250	47	*
$Co^{2+} + (edta)^{4-} \Leftrightarrow Co(edta)^{2-}$	18.170	47	*
$Co^{2+} + H^+ + (edta)^{4-} \Leftrightarrow CoH(edta)^-$	21.600	47	*
$Co^{2+} + 2\ H^+ + (edta)^{4-} \Leftrightarrow CoH_2(edta)(aq)$	23.570	47	*
$Pb^{2+} + (edta)^{4-} \Leftrightarrow Pb(edta)^{2-}$	19.680	47	*
$Pb^{2+} + H^+ + (edta)^{4-} \Leftrightarrow PbH(edta)^-$	22.610	47	*
$Pb^{2+} + 2\ H^+ + (edta)^{4-} \Leftrightarrow PbH_2(edta)(aq)$	24.570	47	*
$Pb^{2+} + 3\ H^+ + (edta)^{4-} \Leftrightarrow PbH_3(edta)^+$	25.770	47	*
$Th^{4+} + (edta)^{4-} \Leftrightarrow Th(edta)(aq)$	26.630	47	*
$Th^{4+} + H^+ + (edta)^{4-} \Leftrightarrow ThH(edta)^+$	28.610	47	*
$Pu^{4+} + (edta)^{4-} + H_2O \Leftrightarrow PuOH(edta)^- + H^+$	24.200	50	*
$Pu^{4+} + (edta)^{4-} + 2\ H_2O \Leftrightarrow Pu(OH)_2(edta)^{2-} + 2\ H^+$	19.220	50	*
$Pu^{4+} + (edta)^{4-} + 3\ H_2O \Leftrightarrow Pu(OH)_3(edta)^{3-} + 3\ H^+$	9.710	50	*
$Mg^{2+} + (isa)^- \Leftrightarrow Mg(isa)^+$	0.600	49	*
$Sr^{2+} + (isa)^- \Leftrightarrow Sr(isa)^+$	0.910	49	*
$Fe^{2+} + (isa)^- \Leftrightarrow Fe(isa)^+$	0.940	49	*
$Ni^{2+} + (isa)^- \Leftrightarrow Ni(isa)^+$	2.200	51	*
$Pb^{2+} + (isa)^- \Leftrightarrow Pb(isa)^+$	2.440	49	*
$Am^{3+} + 3\ H_2O(l) + (isa)^- \Leftrightarrow Am(OH)_3(isa)^- + 3\ H^+$	-47.700	51	*
$Pu^{4+} + 4\ H_2O(l) + (isa)^- \Leftrightarrow Pu(OH)_4(isa)^- + 4\ H^+$	-12.300	51	*
$Pu^{4+} + 4\ H_2O(l) + 2\ (isa)^- \Leftrightarrow Pu(OH)_4(isa)_2^{2-} + 4\ H^+$	-8.100	51	*
$Np^{4+} + 4\ H_2O(l) + (isa)^- \Leftrightarrow Np(OH)_4(isa)^- + 4\ H^+$	-13.660	51	*
$Np^{4+} + 4\ H_2O(l) + 2\ (isa)^- \Leftrightarrow Np(OH)_4(isa)_2^{2-} + 4\ H^+$	-11.800	51	*
$U^{4+} + 4\ H_2O(l) + (isa)^- \Leftrightarrow U(OH)_4(isa)^- + 4\ H^+$	-17.600	51	*
$U^{4+} + 4\ H_2O(l) + 2(isa)^- \Leftrightarrow U(OH)_4(isa)_2^{2-} + 4\ H^+$	-15.700	51	*
$Th^{4+} + H_2O(l) + (isa)^- \Leftrightarrow ThOH(isa)^{2+} + H^+$	-6.200	52	*
$Th^{4+} + 3\ H_2O(l) + 2\ (isa)^- \Leftrightarrow Th(OH)_3(isa)_2^- + 3\ H^+$	-70.300	52	*
$Th^{4+} + 4\ H_2O(l) + 2\ (isa)^- \Leftrightarrow Th(OH)_4(isa)_2^{2-} + 4\ H^+$	-105.900	52	*

[*1] Tentative values.

Table A2 Selected equilibrium constants of solid phases for JAEA-TDB ready to use for the geochemical calculation programs (revised from Table A2 in the previous TDB report [2])

Reactions and $\log_{10} K°$ values written with bold letters are additionally selected or revised in the present report.

Reaction	$\log_{10} K°$	ref.	t.v. [*1]
$H(g) \Leftrightarrow H^+ + e^-$	35.612 ± 0.001	3	
$H_2(g) \Leftrightarrow 2\ H^+ + 2\ e^-$	0.000	3, 4	
$H_2O(g) \Leftrightarrow H_2O(l)$	1.499 ± 0.010	3	
$Li(cr) \Leftrightarrow Li^+ + e^-$	**51.317 ± 0.019**	**present**	
$Li(g) \Leftrightarrow Li^+ + e^-$	**73.497 ± 0.177**	**present**	
$B(cr) + 3\ H_2O(l) \Leftrightarrow B(OH)_3(aq) + 3\ H^+ + 3\ e^-$	45.173 ± 0.145	3	
$B(g) + 3\ H_2O(l) \Leftrightarrow B(OH)_3(aq) + 3\ H^+ + 3\ e^-$	136.450 ± 0.888	3	
$B_2O_3(cr) + 3\ H_2O(l) \Leftrightarrow 2\ B(OH)_3(aq)$	5.745 ± 0.379	3	
$B(OH)_3(cr) \Leftrightarrow B(OH)_3(aq)$	-0.070 ± 0.203	3	
$BF_3(g) + 3\ H_2O(l) \Leftrightarrow B(OH)_3(aq) + 3\ F^- + 3\ H^+$	-2.976 ± 0.416	3	
$C(cr) + 3\ H_2O(l) \Leftrightarrow CO_3^{2} + 6\ H^+ + 4\ e^-$	-32.151 ± 0.069	3	
$C(g) + 3\ H_2O(l) \Leftrightarrow CO_3^{2} + 6\ H^+ + 4\ e^-$	85.447 ± 0.105	3	
$CO(g) + 2\ H_2O(l) \Leftrightarrow CO_3^{2-} + 4\ H^+ + 2\ e^-$	-14.637 ± 0.075	3	
$CO_2(g) + H_2O(l) \Leftrightarrow CO_3^{2-} + 2\ H^+$	-18.155 ± 0.035	3	
$CH_4(g) + 3\ H_2O(l) \Leftrightarrow CO_3^{2-} + 10\ H^+ + 8\ e^-$	-43.931	1	
$HCN(g) + 6\ H_2O(l) \Leftrightarrow CO_3^{2-} + NO_3^- + 13\ H^+ + 10\ e^-$	**-116.437 ± 0.451**	**present**	
$N(g) + 3\ H_2O(l) \Leftrightarrow NO_3^- + 6\ H^+ + 5\ e^-$	-25.418 ± 0.102	3	
$N_2(g) + 6\ H_2O(l) \Leftrightarrow 2\ NO_3^- + 12\ H^+ + 10\ e^-$	-210.449 ± 0.105	3	
$NH_3(g) + 3\ H_2O(l) \Leftrightarrow NO_3^- + 9\ H^+ + 8\ e^-$	-108.099 ± 0.096	3	
$O(g) + 2\ H^+ + 2\ e^- \Leftrightarrow H_2O(l)$	82.144 ± 0.019	3	
$O_2(g) + 4\ H^+ + 4\ e^- \Leftrightarrow 2\ H_2O(l)$	83.090 ± 0.010	3	
$F(g) + e^- \Leftrightarrow F^-$	60.231 ± 0.132	3	
$F_2(g) + 2\ e^- \Leftrightarrow 2\ F^-$	98.641 ± 0.171	3	
$HF(g) \Leftrightarrow F^- + H^+$	1.073 ± 0.172	3	
$Na(cr) \Leftrightarrow Na^+ + e^-$	45.892 ± 0.017	3	
$Na(g) \Leftrightarrow Na^+ + e^-$	59.375 ± 0.124	3	
$NaCl(cr) \Leftrightarrow Na^+ + Cl^-$	**1.568 ± 0.037**	**present**	
$NaF(cr) \Leftrightarrow Na^+ + F^-$	**-0.499 ± 0.174**	**present**	
$Na_2Al_{14}Si_{22}O_{60}(OH)_{12}(montmorillonite,Na) + 16\ H_2O(l) + 44\ H^+$	58.540	4	
$NaAl_3Si_3O_{10}(OH)_2(plagioclase) + 10\ H^+ \Leftrightarrow Na^+ + 3\ Al^{3+} + 3\ H_4SiO_4(aq)$	18.870	4	
$NaAlSi_3O_8(albite) + 4\ H_2O(l) + 4\ H^+ \Leftrightarrow Na^+ + Al^{3+} + 3\ H_4SiO_4(aq)$	3.540	4	
$Mg(cr) \Leftrightarrow Mg^{2+} + 2\ e^-$	**79.778 ± 0.234**	**present**	
$Mg(g) \Leftrightarrow Mg^{2+} + 2\ e^-$	**99.491 ± 0.273**	**present**	
$Mg_{26}Fe_8Al_{20}Si_{24}O_{80}(OH)_{64}(clinochlore) + 128\ H^+$	447.610	4	
$Mg_2Si_2O_6(s) + 2\ H_2O(l) + 4\ H^+ \Leftrightarrow 2\ Mg^{2+} + 2\ H_4SiO_4(aq)$	23.260	4	
$Mg_3Si_4O_{10}(OH)_2(talc) + 4\ H_2O(l) + 6\ H^+ \Leftrightarrow 3\ Mg^{2+} + 4\ H_4SiO_4(aq)$	20.600 ± 2.000	4, 29	
$Mg_{40}Al_{16}Si_{24}O_{80}(OH)_{64}(clinochlore,Mg\text{-}rich) + 128\ H^+$	546.830	4	
$Mg_4Si_6O_9(OH)_{14}(sepiolite) + H_2O(l) + 8\ H^+ \Leftrightarrow 4\ Mg^{2+} + 6\ H_4SiO_4(aq)$	32.830	4	
$Mg_8Fe_{26}Al_{25}Si_{20}O_{80}(OH)_{64}(clinochlore,Fe\text{-}rich) + 144\ H^+ + e^-$	178.370	4	
$MgAl_{14}Si_{22}O_{60}(OH)_{12}(montmorillonite,Mg) + 16\ H_2O(l) + 44\ H^+$	57.040	4	
$MgFe_2O_4(magnesio\text{-}ferrite) + 8\ H^+ + 2\ e^- \Leftrightarrow Mg^{2+} + 2\ Fe^{2+} + 4\ H_2O(l)$	42.820	4	
$MgO(periclase) + 2\ H^+ \Leftrightarrow Mg^{2+} + H_2O(l)$	21.580	4	
$Al(OH)_3(gibbsite) + 3\ H^+ \Leftrightarrow Al^{3+} + 3\ H_2O(l)$	8.770	4	
$Al_2SiO_4(OH)_2(topaz,O) + 6\ H^+ \Leftrightarrow 2\ Al^{3+} + H_4SiO_4(aq) + 2\ H_2O(l)$	12.810	4	
$Al_2Si_2O_5(OH)_4(kaolinite)\ 6\ H^+ \Leftrightarrow + 2\ H_4SiO_4(aq) + 2\ Al^{3+} + H_2O(l)$	9.080	4	
$Al(cr) \Leftrightarrow Al^{3+} + 3\ e^-$	**86.108 ± 0.585**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Al(g) \Leftrightarrow Al^{3+} + 3\ e^-$	**136.804 ± 0.913**	**present**	
Al_2O_3(corundum) + 6 $H^+ \Leftrightarrow 2\ Al^{3+} + 3\ H_2O(l)$	**19.652 ± 1.192**	**present**	
$AlF_3(cr) \Leftrightarrow Al^{3+} + 3\ F^-$	**-16.647 ± 0.726**	**present**	
SiO_2(chalcedony) + 2 $H_2O(l) \Leftrightarrow H_4SiO_4(aq)$	-3.490	4	
SiO_2(quartz) + 2 $H_2O(l) \Leftrightarrow H_4SiO_4(aq)$	-3.780	4	
SiO_2(silica-gel) + 2 $H_2O(l) \Leftrightarrow H_4SiO_4(aq)$	-2.700	4	
$SiO_2 \cdot H_2O$(silica-glass) + $H_2O(l) \Leftrightarrow H_4SiO_4(aq)$	-3.020	4	
SiO_2(am) + 2 $H_2O(l) \Leftrightarrow H_4SiO_4(aq)$	-2.710	4	
Si(cr) + 4 $H_2O(l) \Leftrightarrow H_4SiO_4(aq) + 4\ H^+ + 4\ e^-$	62.924 ± 0.205	3	
Si(g) + 4 $H_2O(l) \Leftrightarrow H_4SiO_4(aq) + 4\ H^+ + 4\ e^-$	133.969 ± 1.416	3	
SiO_2(α-quartz) + 2 $H_2O(l) \Leftrightarrow H_4SiO_4(aq)$	-4.000 ± 0.268	3	
$SiF_4(g)$ + 4 $H_2O(l) \Leftrightarrow H_4SiO_4(aq) + 4\ F^- + 4\ H^+$	-15.330 ± 0.545	3	
P(am) + 4 $H_2O(l) \Leftrightarrow PO_4^{3-} + 8\ H^+ + 5\ e^-$	13.478 ± 0.276	3	
P(cr) + 4 $H_2O(l) \Leftrightarrow PO_4^{3-} + 8\ H^+ + 5\ e^-$	13.478 ± 0.276	3	
P(g) + 4 $H_2O(l) \Leftrightarrow PO_4^{3-} + 8\ H^+ + 5\ e^-$	62.548 ± 0.328	3	
$P_2(g)$ + 8 $H_2O(l) \Leftrightarrow 2\ PO_4^{3-} + 16\ H^+ + 10\ e^-$	45.082 ± 0.526	3	
$P_4(g)$ + 16 $H_2O(l) \Leftrightarrow 4\ PO_4^{3-} + 32\ H^+ + 20\ e^-$	58.189 ± 0.558	3	
S(cr) + 4 $H_2O(l) \Leftrightarrow SO_4^{2-} + 8\ H^+ + 6\ e^-$	-35.836 ± 0.075	3	
S(g) + 4 $H_2O(l) \Leftrightarrow SO_4^{2-} + 8\ H^+ + 6\ e^-$	5.629 ± 0.079	3	
$S_2(g)$ + 8 $H_2O(l) \Leftrightarrow 2\ SO_4^{2-} + 16\ H^+ + 12\ e^-$	-57.713 ± 0.118	3	
$SO_2(g)$ + 2 $H_2O(l) \Leftrightarrow SO_4^{2-} + 4\ H^+ + 2\ e^-$	-5.321 ± 0.082	3	
$H_2S(g)$ + 4 $H_2O(l) \Leftrightarrow SO_4^{2-} + 10\ H^+ + 8\ e^-$	-41.695 ± 0.115	3	
Cl(g) + $e^- \Leftrightarrow Cl^-$	41.437 ± 0.021	3	
$Cl_2(g)$ + 2 $e^- \Leftrightarrow 2\ Cl^-$	45.976 ± 0.029	3	
HCl(g) $\Leftrightarrow Cl^- + H^+$	6.293 ± 0.027	3	
K(cr) $\Leftrightarrow K^+ + e^-$	49.493 ± 0.020	3	
K(g) $\Leftrightarrow K^+ + e^-$	60.089 ± 0.142	3	
$KAl_2(AlSi_3O_{10})(OH)_2$(muscovite) + $H^+ \Leftrightarrow 3\ Al^{3+} + 3\ H_4SiO_4(aq) + K^+$	14.600	4	
$K_2Al_{10}Si_{14}O_{40}(OH)_8$(illite,idealized2) + 8 $H_2O(l)$ + 32 H^+	28.540	4	
$K_2Al_{14}Si_{22}O_{60}(OH)_{12}$(montmorillonite,K) + 16 $H_2O(l)$ + 44 H^+	57.510	4	
$KAl_3(SO_4)_2(OH)_6$(alunite) + 6 $H^+ \Leftrightarrow 3\ Al^{3+} + 2\ SO_4^{2-} + K^+ + 6\ H_2O(l)$	1.610	4	
$KAlSi_3O_8$(microcline) + 4 $H_2O(l)$ + 4 $H^+ \Leftrightarrow Al^{3+}$ +3 $H_4SiO_4(aq) + K^+$	1.780	4	
$KAlSi_3O_8$(orthoclase) + 4 $H_2O(l)$ + 4 $H^+ \Leftrightarrow Al^{3+}$ +3 $H_4SiO_4(aq) + K^+$	0.860	4	
$KFe_3AlSi_3O_{10}(OH)_2$(annite) + 10 $H^+ \Leftrightarrow Al^{3+} + 3\ H_4SiO_4(aq) + K^+ + 3\ Fe^{2+}$	22.330	4	
$K_3MgAl_9Si_{14}O_{40}(OH)_8$(illite,idealized) + 8 $H_2O(l)$ + 32 H^+	67.150	4	
$KMg_3AlSi_3O_{10}(OH)_2$(phlogopite)+10 $H^+ \Leftrightarrow 3\ Mg^{2+}+Al^{3+}+3\ H_4SiO_4(aq)+K^+$	36.330	4	
$KAlSi_3O_8$(feldspar,K) + 4 $H_2O(l)$ + 4 $H^+ \Leftrightarrow 3\ H_4SiO_4(aq) + K^+ + Al^{3+}$	0.0832	4	
Ca(cr) $\Leftrightarrow Ca^{2+} + 2\ e^-$	96.847 ± 0.184	3	
Ca(g) $\Leftrightarrow Ca^{2+} + 2\ e^-$	122.078 ± 0.232	3	
CaO(cr) + 2 $H^+ \Leftrightarrow Ca^{2+} + H_2O(l)$	32.699 ± 0.244	3	
$CaCl(g) \Leftrightarrow Ca^{2+} + Cl^- + e^-$	**97.097 ± 0.895**	**present**	
$CaF(g) \Leftrightarrow Ca^{2+} + F^- + e^-$	**93.239 ± 0.921**	**present**	
$CaCO_3$(calcite) $\Leftrightarrow Ca^{2+} + CO_3^{2-}$	-8.460 ± 0.010	30	
$CaCO_3$(aragonite) $\Leftrightarrow Ca^{2+} + CO_3^{2-}$	-8.340 ± 0.020	4, 29	
$CaMg(CO_3)_2$(dolomite) $\Leftrightarrow Ca^{2+} + Mg^{2+} + 2\ CO_3^{2-}$	-17.090	4	
$CaSO_4 \cdot 2H_2O$(gypsum) $\Leftrightarrow Ca^{2+} + SO_4^{2-} + 2\ H_2O(l)$	-4.600 ± 0.020	4, 29	
$CaSO_4$(anhydrite) $\Leftrightarrow Ca^{2+} + SO_4^{2-}$	-4.380	4	
$Ca_5(PO_4)_3(OH)$(hydroxyapatite) + $H^+ \Leftrightarrow H_2O(l) + 3\ PO_4^{3-} + 5\ Ca^{2+}$	-40.470	4	
CaF_2(fluorite) $\Leftrightarrow Ca^{2+} + 2\ F^-$	-10.960	4	
$Ca_2Al_3(SiO_4)_3OH$(clinozoisite)+13 $H^+ \Leftrightarrow 3\ Al^{3+}$+3 $H_4SiO_4(aq)$+2 Ca^{2+} $H_2O(l)$	43.610	4	
$Ca_2Al_2Fe(SiO_4)(Si_2O_7)OOH$(epidote) + 13 $H^+ + e^-$	45.430	4	
$Ca_2Mg_5Si_8O_{22}(OH)_2$(tremolite)+8$H_2O(l)$+14$H^+ \Leftrightarrow 5Mg^{2+}$+8$H_4SiO_4(aq)$+2$Ca^{2+}$	57.700	4	
$Ca_3Fe_2(SiO_4)_3$(andradite) + 12 $H^+ + 2\ e^- \Leftrightarrow 3\ H_4SiO_4(aq)$ +3 Ca^{2+} +2 Fe^{2+}	55.100	4	
$CaAl_{14}Si_{22}O_{60}(OH)_{12}$ (montmorillonite,Ca) + 16 $H_2O(l)$ + 44 H^+	41.880	4	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$CaAl_2Si_2O_8$(anorthite,hexagonal) + 8 $H^+ \Leftrightarrow$ 2 Al^{3+} + 2 H_4SiO_4(aq) + Ca^{2+}	26.700	4	
$CaAl_2Si_2O_8$(anorthite,triclinic) + 8 $H^+ \Leftrightarrow$ 2 Al^{3+} + 2 H_4SiO_4(aq) + Ca^{2+}	26.370	4	
CaO(s) + 2 $H^+ \Leftrightarrow$ Ca^{2+} + H_2O(l)	32.700	4	
MnO_2(birnessite-type) + 2 e^- + 4 $H^+ \Leftrightarrow$ Mn^{2+} + 2 H_2O(l)	43.597	4	
MnOOH(manganite) + e^- + 3 $H^+ \Leftrightarrow$ Mn^{2+} + 2 H_2O(l)	25.267	4	
$MnCO_3$(rhodochrosite) $\Leftrightarrow$ CO_3^{2-} + Mn^{2+}	-10.540	4	
MnO_2(pyrolusite) + 4 H^+ + 2 e^- $\Leftrightarrow$ Mn^{2+} +2 H_2O(l)	41.550	4	
MnS(alabandite) + 4 H_2O(l) $\Leftrightarrow$ SO_4^{2-} + Mn^{2+} + 8 H^+ + 8 e^-	-34.110	4	
$Fe(OH)_3$(s) + 3 $H^+ \Leftrightarrow$ Fe^{3+} + 3 H_2O(l)	4.890	4	
$FeCO_3$(siderite) $\Leftrightarrow$ Fe^{2+} + CO_3^{2-}	-10.570	4	
Fe_2O_3(hematite) + 6 H^+ + 2 e^- $\Leftrightarrow$ 2 Fe^{2+} + 3 H_2O(l)	22.400	4	
FeS(mackinawite) + 4 H_2O(l) $\Leftrightarrow$ Fe^{2+} + SO_4^{2-} + H^+ + 8 e^-	-38.323	4	
FeS(s) + 4 H_2O(l) $\Leftrightarrow$ Fe^{2+} +SO_4^{2-}+8 H^+ +8 e^-	-37.603	4	
$Fe_3(PO_4)_2 \cdot 8H_2O$ (vivianite) $\Leftrightarrow$ 3 Fe^{2+} + 2 PO_4^{3-} + 8 H_2O(l)	-36.000	4, 29	
$Fe_2Si_2O_6$(s) + 2 H_2O(l) + 4 $H^+ \Leftrightarrow$ 2 H_4SiO_4(aq) + 2 Fe^{2+}	10.600	4	
$Fe_3Al_2(SiO_4)_3$(almandine) + 12 $H^+ \Leftrightarrow$ 2 Al^{3+} + 3 H_4SiO_4(aq) +3 Fe^{2+}	33.410	4	
Fe_3O_4(magnetite) + 8 H^+ + 2 e^- $\Leftrightarrow$ 3 Fe^{2+} + 4 H_2O(l)	30.650	4	
Fe_7S_8(pyrrhotite) + 32 H_2O(l) $\Leftrightarrow$ 8 SO_4^{-2} + 7 Fe^{2+} + 64 H^+ + 62 e^-	-321.280	4	
$FeCl_2$(lawrencite) $\Leftrightarrow$ 2 Cl^- + Fe^{2+}	6.820	4	
$FeCl_3$(molysite) + e^- $\Leftrightarrow$ 3 Cl^- + Fe^{2+}	24.560	4	
FeOOH(goethite) + 3 H^+ + e^- $\Leftrightarrow$ Fe^{2+} + 2 H_2O(l)	11.290	4	
FeS_2(pyrite) + 8 H_2O(l) $\Leftrightarrow$ 2 SO_4^{2-} + Fe^{2+} + 16 H^+ + 14 e^-	-85.950	4	
$FeSiO_3$(ferrosilite) + H_2O(l) + 2 $H^+ \Leftrightarrow$ Fe^{2+} + H_4SiO_4(aq)	7.420	4	
$Fe_3Si_2O_5(OH)_4$(greenalite) + 6 $H^+ \Leftrightarrow$ 3 Fe^{2+} + 2 H_4SiO_4(aq) + H_2O(l)	22.590	4	
Fe_2SiO_4(fayalite) + 4 $H^+ \Leftrightarrow$ 2 Fe^{2+} + H_4SiO_4(aq)	19.050	4	
Co(cr) $\Leftrightarrow$ Co^{2+} + 2 e^-	9.530 ± 0.175	31	
CoO(cr) + 2 $H^+ \Leftrightarrow$ Co^{2+} + H_2O(l)	12.399 ± 0.326	31	*
β-$Co(OH)_2$ +2 $H^+ \Leftrightarrow$ Co^{2+} + 2 H_2O(l)	12.430 ± 0.170	31	
$CoCl_2 \cdot 6H_2O$(cr) $\Leftrightarrow$ 2 Co^{2+} + 2 Cl^- + 6 H_2O(l)	3.037 ± 0.018	31	*
β-$Co(IO_3)_2$ + 12 H^+ + 12 e^- $\Leftrightarrow$ Co^{2+} + 2 I^- + 6 H_2O(l)	218.731 ± 0.293	31	*
$Co(IO_3)_2 \cdot 2H_2O$(cr) + 12 H^+ + 12 e^- $\Leftrightarrow$ Co^{2+} + 8 H_2O(l) + 2 I^-	218.025 ± 0.328	31	*
α-CoS + $H^+ \Leftrightarrow$ Co^{2+} + HS^-	-7.440 ± 0.120	31	
β-CoS + $H^+ \Leftrightarrow$ Co^{2+} + HS^-	-11.100 ± 1.700	31	
α-$CoSO_4 \cdot 6H_2O$ $\Leftrightarrow$ Co^{2+} + 6 H_2O(l) + SO_4^{2-}	-2.229 ± 0.279	31	*
β-$CoSO_4 \cdot 6H_2O$ $\Leftrightarrow$ Co^{2+} + 6 H_2O(l) + SO_4^{2-}	-2.124 ± 0.467	31	*
$CoSO_4 \cdot 7H_2O$(cr) $\Leftrightarrow$ Co^{2+} + 7 H_2O(l) + SO_4^{2-}	-2.245 ± 0.058	31	
$Co_3(AsO_3)_2$(cr,hyd) + 2 H_2O(l) + 4 e^- $\Leftrightarrow$ 3 Co^{2+} + 4 H^+ + 2 AsO_4^{3-}	-51.640 ± 2.012	31	*
$Co_3(AsO_4)_2 \cdot 8H_2O$(cr) $\Leftrightarrow$ 3 Co^{2+} + 2 AsO_4^{3-} + 8 H_2O(l)	-27.929 ± 0.883	31	*
$CoCO_3$(cr) $\Leftrightarrow$ Co^{2+} + CO_3^{2-}	-11.027 ± 0.098	31	*
$CoCO_3 \cdot 5.5H_2O$(cr) $\Leftrightarrow$ Co^{2+} + CO_3^{2-} + 5.5 H_2O(l)	-7.577 ± 0.049	31	*
Ni(cr) $\Leftrightarrow$ Ni^{2+} + 2 e^-	8.019 ± 0.135	10	
NiO(cr) + 2 $H^+ \Leftrightarrow$ Ni^{2+} + H_2O(l)	12.483 ± 0.154	31	*
β-$Ni(OH)_2$ + 2 $H^+ \Leftrightarrow$ Ni^{2+} + 2 H_2O(l)	11.029 ± 0.280	31	*
$NiCl_2 \cdot 6H_2O$(cr) $\Leftrightarrow$ 2 Ni^{2+} + 2 Cl^- + 6 H_2O(l)	3.045 ± 0.014	10	
β-$Ni(IO_3)_2$ + 12 H^+ + 12 e^- $\Leftrightarrow$ Ni^{2+} + 2 I^- + 6 H_2O(l)	218.696 ± 0.277	10	
$Ni(IO_3)_2 \cdot 2H_2O$(cr) + 12 H^+ + 12 e^- $\Leftrightarrow$ Ni^{2+} + 8 H_2O(l) + 2 I^-	217.986 ± 0.294	10	
α-NiS + $H^+ \Leftrightarrow$ Ni^{2+} + HS^-	-9.508 ± 0.464	31	*
β-NiS + $H^+ \Leftrightarrow$ Ni^{2+} + HS^-	-10.128 ± 0.464	31	*
$NiSO_4 \cdot 7H_2O$(cr) $\Leftrightarrow$ Ni^{2+} + 7 H_2O(l) + SO_4^{2-}	-2.267 ± 0.019	10	
$Ni_3(AsO_3)_2$(cr,hyd) + 2 H_2O(l) + 4 e^- $\Leftrightarrow$ 3 Ni^{2+} + 4 H^+ + 2 $HAsO_4^{3-}$	-51.484 ± 2.106	10	
$Ni_3(AsO_4)_2 \cdot 8H_2O$(cr) $\Leftrightarrow$ 3 Ni^{2+} + 2 AsO_4^{3-} + 8 H_2O(l)	-28.100 ± 0.500	10	
$NiCO_3$(cr) $\Leftrightarrow$ Ni^{2+} + CO_3^{2-}	-10.995 ± 0.183	10	
$NiCO_3 \cdot 5.5H_2O$(cr) $\Leftrightarrow$ Ni^{2+} + CO_3^{2-} + 5.5 H_2O(l)	-7.525 ± 0.106	10	
Ni(g) $\Leftrightarrow$ Ni^{2+} + 2 e^-	**75.413 ± 1.478**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$NiF_2(cr) \Leftrightarrow Ni^{2+} + 2\ F^-$	**-0.181 ± 1.429**	**present**	
$NiCl_2(cr) \Leftrightarrow Ni^{2+} + 2\ Cl^-$	**8.666 ± 0.144**	**present**	
$NiCl_2{\cdot}2H_2O(cr) \Leftrightarrow Ni^{2+} + 2\ Cl^- + 2\ H_2O(l)$	**4.924 ± 0.262**	**present**	
$NiCl_2{\cdot}4H_2O(cr) \Leftrightarrow Ni^{2+} + 2\ Cl^- + 4\ H_2O(l)$	**3.823 ± 0.232**	**present**	
$NiBr_2(cr) \Leftrightarrow Ni^{2+} + 2\ Br^-$	**10.172 ± 0.449**	**present**	
$NiI_2(cr) \Leftrightarrow Ni^{2+} + 2\ I^-$	**9.611 ± 0.211**	**present**	
$NiS_2(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow Ni^{2+} + 2\ HS^-$	**-17.965 ± 1.499**	**present**	
$Ni_3S_2(cr) + 2\ H^+ \Leftrightarrow 3\ Ni^{2+} + 2\ HS^- + 2\ e^-$	**-17.228 ± 0.891**	**present**	
$Ni_9S_8(cr) + 8\ H^+ \Leftrightarrow 9\ Ni^{2+} + 8\ HS^- + 2\ e^-$	**-75.821 ± 3.591**	**present**	
$NiSO_4(cr) \Leftrightarrow Ni^{2+} + SO_4^{2-}$	**4.746 ± 0.315**	**present**	
α-$NiSO_4{\cdot}6H_2O \Leftrightarrow Ni^{2+} + SO_4^{2-} + 6\ H_2O(l)$	**-2.251 ± 0.245**	**present**	
β-$NiSO_4{\cdot}6H_2O \Leftrightarrow Ni^{2+} + SO_4^{2-} + 6\ H_2O(l)$	**-2.155 ± 0.356**	**present**	
$NiAs(cr) + 4\ H_2O(l) \Leftrightarrow Ni^{2+} + AsO_4^{3-} + 8\ H^+ + 7\ e^-$	**-56.238 ± 1.079**	**present**	
$Ni_5As_2(cr) + 8\ H_2O(l) \Leftrightarrow 5\ Ni^{2+} + 2\ AsO_4^{3-} + 6\ H^+ + 20\ e^-$	**-106.722 ± 4.144**	**present**	
$Ni_{11}As_8(cr) + 32\ H_2O(l) \Leftrightarrow 11\ Ni^{2+} + 8\ AsO_4^{3-} + 64\ H^+ + 62\ e^-$	**-457.925 ± 9.017**	**present**	
$Ni_2SiO_4(oliv) + 4\ H^+ \Leftrightarrow 2\ Ni^{2+} + H_4SiO_4(aq)$	**19.418 ± 0.939**	**present**	
$Cu(cr) \Leftrightarrow Cu^{2+} + 2\ e^-$	**-11.394 ± 0.273**	**present**	
$Cu(g) \Leftrightarrow Cu^{2+} + 2\ e^-$	**40.755 ± 0.344**	**present**	
$CuSO_4(cr) \Leftrightarrow Cu^{2+} + SO_4^{2-}$	**2.940 ± 0.353**	**present**	
$Zn(cr) \Leftrightarrow Zn^{2+} + 2\ e^-$	**25.789 ± 0.044**	**present**	
$Zn(g) \Leftrightarrow Zn^{2+} + 2\ e^-$	**42.399 ± 0.083**	**present**	
$ZnO(cr) + 2\ H^+ \Leftrightarrow Zn^{2+} + H_2O(l)$	**11.188 ± 0.069**	**present**	
$As(cr) + 4\ H_2O(l) \Leftrightarrow AsO_4^{3-} + 8\ H^+ + 5\ e^-$	-52.592 ± 0.703	3	
$As_2O_5(cr) + 3\ H_2O(l) \Leftrightarrow 2\ AsO_4^{3--} + 6\ H^+$	-34.539 ± 1.986	3	
$As_4O_6(cubic) + 10\ H_2O(l) \Leftrightarrow 4\ AsO_4^{3-} + 20\ H^+ + 8\ e^-$	-162.999 ± 3.973	3	
$As_4O_6(monoclinic) + 10\ H_2O(l) \Leftrightarrow 4\ AsO_4^{3-} + 20\ H^+ + 8\ e^-$	-163.273 ± 3.974	3	
$As_4O_6(g) + 10\ H_2O(l) \Leftrightarrow 4\ AsO_4^{3-} + 20\ H^+ + 8\ e^-$	**-152.535 ± 3.983**	**present**	
$Se(cr,trigonal) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	-7.616 ± 0.355	11	
$Se(mono) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	**-7.391 ± 0.356**	**present**	
$Se(am) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	**-6.570 ± 0.150**	**12**	
$PbSeO_3(cr) \Leftrightarrow Pb^{2+} + SeO_3^{2-}$	-12.500 ± 1.000	11	
$PbSeO_4(cr) \Leftrightarrow Pb^{2+} + SeO_4^{2-}$	-6.900 ± 0.250	11	
$Tl_2SeO_4(cr) \Leftrightarrow 2\ Tl^+ + SeO_4^{2-}$	-3.900 ± 0.150	11	
$ZnSeO_4{\cdot}6H_2O(cr) \Leftrightarrow Zn^{2+} + 6H_2O(l) + SeO_4^{2-}$	-1.538 ± 0.068	11	
$Cd(SeCN)_2(cr)+20\ H_2O(l) \Leftrightarrow Cd^{2+}+2\ SeO_4^{2-}+40\ H^++32\ e^-+2\ CO_3^{2-}+2\ NO_3^-$	-411.153 ± 1.528	11	
$Ag_2SeO_3(cr) \Leftrightarrow 2\ Ag^+ + SeO_3^{2-}$	-15.800 ± 0.300	11	
$Ag_2SeO_4(cr) \Leftrightarrow 2\ Ag^+ + SeO_4^{2-}$	-7.860 ± 0.500	11	
$AgSeCN(cr) + 10\ H_2O(l) \Leftrightarrow SeO_4^{2-} + 20\ H^+ + 16\ e^- + CO_3^{2-} + NO_3^- + Ag^+$	-216.724 ± 0.883	11	
$NiSeO_3{\cdot}2H_2O(cr) \Leftrightarrow Ni^{2+} + 2\ H_2O(l) + SeO_3^{2-}$	-5.800 ± 1.000	11	
$NiSeO_4{\cdot}6H_2O(cr) \Leftrightarrow Ni^{2+} + 6\ H_2O(l) + SeO_4^{2-}$	-1.381 ± 0.045	11	
$CuSeO_4{\cdot}5H_2O(cr) \Leftrightarrow Cu^{2+} + 5\ H_2O(l) + SeO_4^{2-}$	-2.440 ± 0.200	11	
$MgSeO_3{\cdot}6H_2O(cr) \Leftrightarrow Mg^{2+} + 6\ H_2O(l) + SeO_3^{2-}$	-5.820 ± 0.250	11	
$MgSeO_4{\cdot}6H_2O(cr) \Leftrightarrow Mg^{2+} + 6\ H_2O(l) + SeO_4^{2-}$	-1.133 ± 0.044	11	
$CaSeO_3{\cdot}H_2O(cr) \Leftrightarrow Ca^{2+} + H_2O(l) + SeO_3^{2-}$	-6.400 ± 0.250	11	
$CaSeO_4{\cdot}2H_2O(cr) \Leftrightarrow Ca^{2+} + 2\ H_2O(l) + SeO_4^{2-}$	-2.680 ± 0.250	11	
$SrSeO_3(cr) \Leftrightarrow Sr^{2+} + SeO_3^{2-}$	-6.300 ± 0.500	11	
$BaSeO_3(cr) \Leftrightarrow Ba^{2+} + SeO_3^{2-}$	-6.500 ± 0.250	11	
$BaSeO_4(cr) \Leftrightarrow Ba^{2+} + SeO_4^{2-}$	-7.560 ± 0.100	11	
$NH_4HSe(cr) + 7\ H_2O(l) \Leftrightarrow SeO_4^{2-} + NO_3^- + 19\ H^+ + 16\ e^-$	-198.643 ± 0.973	11	
$(NH_4)_2SeO_4(cr) \Leftrightarrow 2\ NH_4^+ + SeO_4^{2-}$	0.911 ± 0.065	11	
$Li_2SeO_4{\cdot}H_2O(cr) \Leftrightarrow 2\ Li^+ + H_2O(l) + SeO_4^{2-}$	1.762 ± 0.065	11	
$Na_2SeO_4{\cdot}10H_2O(cr) \Leftrightarrow 2\ Na^+ + 10H_2O(l) + SeO_4^{2-}$	-0.681 ± 0.087	11	
$K_2SeO_4(cr) \Leftrightarrow 2\ K^+ + SeO_4^{2-}$	0.904 ± 0.065	11	
$Cs_2SeO_4(cr) \Leftrightarrow 2\ Cs^+ + SeO_4^{2-}$	0.636 ± 0.065	11	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$FeSe_2(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow Fe^{2+} + 2\ HSe^-$	-17.220 ± 2.754	53	*
$\beta\text{-}Fe_{1.04}Se + H^+ \Leftrightarrow 1.04\ Fe^{2+} + HSe^- + 0.08\ e^-$	-3.503 ± 0.870	53	*
$\gamma\text{-}Fe_3Se_4 + 4\ H^+ + 2\ e^- \Leftrightarrow 3\ Fe^{2+} + 4\ HSe^-$	-25.908 ± 5.547	53	*
$\alpha\text{-}Fe_7Se_8 + 8\ H^+ + 2\ e^- \Leftrightarrow 7\ Fe^{2+} + 8\ HSe^-$	-36.274 ± 5.175	53	*
$HgSeO_3(cr) \Leftrightarrow Hg^{2+} + SeO_3^{2-}$	-16.200 ± 1.000	11	
$Hg_2SeO_3(cr) \Leftrightarrow Hg_2^{2+} + SeO_3^{2-}$	-15.200 ± 1.000	11	
$SeO_2(cr) + H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ H^+$	**-8.154 ± 0.326**	**present**	
$SeO_3(cr) + H_2O(l) \Leftrightarrow SeO_4^{2-} + 2\ H^+$	**20.356 ± 0.463**	**present**	
$SeCl_4(cr) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 4\ Cl^- + 6\ H^+$	**15.756 ± 0.632**	**present**	
$PbSe(cr) + H^+ \Leftrightarrow HSe^- + Pb^{2+}$	**-20.527 ± 1.396**	**present**	
$\alpha\text{-}ZnSe + H^+ \Leftrightarrow HSe^- + Zn^{2+}$	**-12.045 ± 0.789**	**present**	
$\alpha\text{-}CdSe + H^+ \Leftrightarrow HSe^- + Cd^{2+}$	**-18.682 ± 0.506**	**present**	
$CdSeO_3(cr) \Leftrightarrow SeO_3^{2-} + Cd^{2+}$	**-9.339 ± 1.181**	**present**	
$\alpha\text{-}HgSe + H^+ \Leftrightarrow HSe^- + Hg^{2+}$	**-45.434 ± 0.787**	**present**	
$\alpha\text{-}CuSe + H^+ \Leftrightarrow HSe^- + Cu^{2+}$	**-25.463 ± 0.458**	**present**	
$\beta\text{-}CuSe + H^+ \Leftrightarrow HSe^- + Cu^{2+}$	**-25.126 ± 0.458**	**present**	
$\alpha\text{-}Ag_2Se + H^+ \Leftrightarrow HSe^- + 2\ Ag^+$	**-42.845 ± 0.425**	**present**	
$Ni_{0.88}Se(cr) + H^+ + 0.24\ e^- \Leftrightarrow HSe^- + 0.88\ Ni^{2+}$	**-12.757 ± 0.470**	**present**	
$NiSe_2(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow 2\ HSe^- + Ni^{2+}$	**-26.896 ± 1.426**	**present**	
$Co_{0.84}Se(cr) + H^+ + 0.32\ e^- \Leftrightarrow HSe^- + 0.84\ Co^{2+}$	**-9.473 ± 1.202**	**present**	
$USe(cr) + H^+ \Leftrightarrow HSe^- + U^{4+} + 2\ e^-$	**37.339 ± 3.189**	**present**	
$Na_2SeO_3(cr) \Leftrightarrow SeO_3^{2-} + 2\ Na^+$	**3.087 ± 0.353**	**present**	
$Rb_2SeO_4(cr) \Leftrightarrow SeO_4^{2-} + 2\ Rb^+$	**0.421 ± 0.367**	**present**	
$Ga_2(SeO_3)_3 \cdot 6H_2O(cr) \Leftrightarrow 3\ SeO_3^{2-} + 2\ Ga^{3+} + 6\ H_2O(l)$	**-37.000 ± 2.000**	**present**	
$In_2(SeO_3)_3 \cdot 6H_2O(cr) \Leftrightarrow 3\ SeO_3^{2-} + 2\ In^{3+} + 6\ H_2O(l)$	**-39.000 ± 2.000**	**present**	
$CoSeO_3 \cdot 2H_2O(cr) \Leftrightarrow SeO_3^{2-} + Co^{2+} + 2\ H_2O(l)$	**-7.900 ± 0.400**	**present**	
$CoSeO_4 \cdot 6H_2O(cr) \Leftrightarrow SeO_4^{2-} + Co^{2+} + 6\ H_2O(l)$	**-1.759 ± 0.043**	**present**	
$FeSeO_3^+ \Leftrightarrow SeO_3^{2-} + Fe^{3+}$	**-11.150 ± 0.110**	**present**	
$Fe_2(SeO_3)_3 \cdot 6H_2O(cr) \Leftrightarrow 3\ SeO_3^{2-} + 2\ Fe^{3+} + 6\ H_2O(l)$	**-41.580 ± 0.110**	**present**	
$MnSeO_3 \cdot 2H_2O(cr) \Leftrightarrow SeO_3^{2-} + Mn^{2+} + 2\ H_2O(l)$	**-7.600 ± 1.000**	**present**	
$Se(g) + H^+ + 2\ e^- \Leftrightarrow HSe^-$	**26.709 ± 0.444**	**present**	
$Se_2(g) + 2\ H^+ + 4\ e^- \Leftrightarrow 2\ HSe^-$	**0.964 ± 0.884**	**present**	
$Se_3(g) + 3\ H^+ + 6\ e^- \Leftrightarrow 3\ HSe^-$	**-1.203 ± 2.116**	**present**	
$Se_4(g) + 4\ H^+ + 8\ e^- \Leftrightarrow 4\ HSe^-$	**-10.903 ± 2.744**	**present**	
$Se_5(g) + 5\ H^+ + 10\ e^- \Leftrightarrow 5\ HSe^-$	**-22.593 ± 1.998**	**present**	
$Se_6(g) + 6\ H^+ + 12\ e^- \Leftrightarrow 6\ HSe^-$	**-31.042 ± 2.292**	**present**	
$Se_7(g) + 7\ H^+ + 14\ e^- \Leftrightarrow 7\ HSe^-$	**-37.045 ± 2.626**	**present**	
$Se_8(g) + 8\ H^+ + 16\ e^- \Leftrightarrow 8\ HSe^-$	**-43.353 ± 2.905**	**present**	
$SeO(g) + 2\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 4\ H^+ + 2\ e^-$	**-14.196 ± 1.132**	**present**	
$SeO_2(g) + H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ H^+$	**1.767 ± 0.550**	**present**	
$H_2Se(g) \Leftrightarrow HSe^- + H^+$	**-4.950 ± 0.051**	**present**	
$SeF_4(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 4\ F^- + 6\ H^+$	**2.017 ± 4.252**	**present**	
$SeF_6(g) + 4\ H_2O(l) \Leftrightarrow SeO_4^{2-} + 6\ F^- + 8\ H^+$	**28.489 ± 0.774**	**present**	
$SeOF_2(g) + 2\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ F^- + 4\ H^+$	**-11.258 ± 2.836**	**present**	
$SeCl_2(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ Cl^- + 6\ H^+ + 2\ e^-$	**-19.716 ± 0.843**	**present**	
$Se_2Cl_2(g) + 6\ H_2O(l) \Leftrightarrow 2\ SeO_3^{2-} + 2\ Cl^- + 12\ H^+ + 6\ e^-$	**-82.438 ± 1.858**	**present**	
$SeOCl_2(g) + 2\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ Cl^- + 4\ H^+$	**6.363 ± 0.537**	**present**	
$SeBr_2(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + 2\ Br^- + 6\ H^+ + 2\ e^-$	**-25.562 ± 3.557**	**present**	
$SeS(g) + 3\ H_2O(l) \Leftrightarrow SeO_3^{2-} + HS^- + 5\ H^+ + 2\ e^-$	**-47.112 ± 1.297**	**present**	
$CSe(g) + 3\ H_2O(l) \Leftrightarrow HSe^- + CO_3^{2-} + 5\ H^+ + 2\ e^-$	**14.516 ± 1.652**	**present**	
$CSe_2(g) + 3\ H_2O(l) \Leftrightarrow 2\ HSe^- + CO_3^{2-} + 4\ H^+$	**-11.655 ± 1.512**	**present**	
$SiSe(g) + 4\ H_2O(l) \Leftrightarrow HSe^- + H_4SiO_4(aq) + 3\ H^+ + 2\ e^-$	**72.498 ± 1.885**	**present**	
$SnSe(g) + H^+ \Leftrightarrow HSe^- + Sn^{2+}$	**8.061 ± 2.785**	**present**	
$PbSe(g) + H^+ \Leftrightarrow HSe^- + Pb^{2+}$	**11.148 ± 1.565**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$BSe_2(g) + 3\ H_2O(l) + e^- \Leftrightarrow 2\ HSe^- + B(OH)_3(aq) + H^+$	**52.961 ± 3.727**	**present**	
$AlSe(g) + H^+ \Leftrightarrow HSe^- + Al^{3+} + e^-$	**114.681 ± 6.170**	**present**	
$Br(g) + e^- \Leftrightarrow Br^-$	32.626 ± 0.037	3	
$Br_2(g) + 2\ e^- \Leftrightarrow 2\ Br^-$	36.931 ± 0.048	3	
$HBr(g) \Leftrightarrow Br^- + H^+$	8.845 ± 0.041	3	
$Br_2(l) + 2\ e^- \Leftrightarrow 2\ Br^-$	**36.387 ± 0.059**	**present**	
$Rb(cr) \Leftrightarrow Rb^+ + e^-$	**49.756 ± 0.027**	**present**	
$Rb(g) \Leftrightarrow Rb^+ + e^-$	**59.055 ± 0.144**	**present**	
$Sr(cr) \Leftrightarrow Sr^{2+} + 2\ e^-$	98.784 ± 0.137	3	
$SrO(cr) + 2\ H^+ \Leftrightarrow Sr^{2+} + H_2O(l)$	42.233 ± 0.211	3	
$SrCl_2(cr) \Leftrightarrow Sr^{2+} + 2\ Cl^-$	**7.240 ± 0.190**	**present**	
$SrCO_3(strontianite) \Leftrightarrow Sr^{2+} + CO_3^{2-}$	-9.250 ± 0.010	30	
$SrSO_4(celestite) \Leftrightarrow Sr^{2+} + SO_4^{2-}$	-6.620 ± 0.020	30	
$Sr_3(PO_4)_2(s) \Leftrightarrow 3\ Sr^{2+} + 2\ PO_4^{3-}$	-27.800	4	
$SrHPO_4(s) \Leftrightarrow Sr^{2+} + P\ O_4^{3-} + H^+$	-19.310	4	
$Sr(OH)_2(s) + 2\ H^+ \Leftrightarrow Sr^{2+} + 2\ H_2O(l)$	24.980	4	
$Sr(NO_3)_2(cr) \Leftrightarrow Sr^{2+} + 2\ NO_3^-$	0.404 ± 0.268	3	
$ZrO_2(mono) + 4\ H^+ \Leftrightarrow Zr^{4+} + 2\ H_2O(l)$	-7.000 ± 1.600	13	
$Zr(OH)_4(am,fresh) + 4\ H^+ \Leftrightarrow Zr^{4+} + 4\ H_2O(l)$	-3.240 ± 0.100	13	
$\beta\text{-}ZrF_4 \Leftrightarrow Zr^{4+} + 4\ F^-$	-31.830 ± 0.408	13	
$Zr(SO_4)_2 \cdot 9H_2O(cr) \Leftrightarrow Zr^{4+} + 9\ H_2O(l) + 2\ SO_4^{2-}$	-11.250 ± 0.096	13	
$ZrSiO_4(cr) + 4\ H^+ \Leftrightarrow Zr^{4+} + H_4SiO_4(aq)$	-14.623 ± 1.718	13	
$Zr(cr) \Leftrightarrow Zr^{4+} + 4\ e^-$	**92.590 ± 1.616**	**present**	
$Zr(g) \Leftrightarrow Zr^{4+} + 4\ e^-$	**191.903 ± 1.635**	**present**	
$ZrO(g) + 2\ H^+ \Leftrightarrow Zr^{4+} + H_2O(l) + 2\ e^-$	**139.492 ± 5.019**	**present**	
$ZrO_2(g) + 4\ H^+ \Leftrightarrow Zr^{4+} + 2\ H_2O(l)$	**123.405 ± 8.398**	**present**	
$ZrH(cr) \Leftrightarrow Zr^{4+} + H^+ + 5\ e^-$	**81.258 ± 1.623**	**present**	
$\varepsilon\text{-}ZrH_2 \Leftrightarrow Zr^{4+} + 2\ H^+ + 6\ e^-$	**70.817 ± 1.644**	**present**	
$ZrF(g) \Leftrightarrow Zr^{4+} + F^- + 3\ e^-$	**149.155 ± 1.634**	**present**	
$ZrF_2(g) \Leftrightarrow Zr^{4+} + 2\ F^- + 2\ e^-$	**104.902 ± 1.654**	**present**	
$ZrF_3(g) \Leftrightarrow Zr^{4+} + 3\ F^- + e^-$	**53.848 ± 1.683**	**present**	
$ZrF_4(g) \Leftrightarrow Zr^{4+} + 4\ F^-$	**3.508 ± 1.698**	**present**	
$ZrCl(cr) \Leftrightarrow Zr^{4+} + Cl^- + 3\ e^-$	**69.244 ± 1.655**	**present**	
$ZrCl(g) \Leftrightarrow Zr^{4+} + Cl^- + 3\ e^-$	**150.690 ± 4.436**	**present**	
$ZrCl_2(cr) \Leftrightarrow Zr^{4+} + 2\ Cl^- + 2\ e^-$	**51.645 ± 2.796**	**present**	
$ZrCl_2(g) \Leftrightarrow Zr^{4+} + 2\ Cl^- + 2\ e^-$	**111.532 ± 3.838**	**present**	
$ZrCl_3(cr) \Leftrightarrow Zr^{4+} + 3\ Cl^- + e^-$	**40.718 ± 1.702**	**present**	
$ZrCl_3(g) \Leftrightarrow Zr^{4+} + 3\ Cl^- + e^-$	**72.107 ± 2.283**	**present**	
$ZrCl_4(cr) \Leftrightarrow Zr^{4+} + 4\ Cl^-$	**28.596 ± 1.632**	**present**	
$ZrCl_4(g) \Leftrightarrow Zr^{4+} + 4\ Cl^-$	**38.008 ± 1.627**	**present**	
$ZrBr_4(g) \Leftrightarrow Zr^{4+} + 4\ Br^-$	**48.920 ± 1.750**	**present**	
$ZrI(cr) \Leftrightarrow Zr^{4+} + I^- + 3\ e^-$	**75.300 ± 1.630**	**present**	
$ZrI(g) \Leftrightarrow Zr^{4+} + I^- + 3\ e^-$	**162.849 ± 2.520**	**present**	
$ZrI_2(cr) \Leftrightarrow Zr^{4+} + 2\ I^- + 2\ e^-$	**62.746 ± 2.384**	**present**	
$ZrI_2(g) \Leftrightarrow Zr^{4+} + 2\ I^- + 2\ e^-$	**124.337 ± 3.247**	**present**	
$ZrI_3(cr) \Leftrightarrow Zr^{4+} + 3\ I^- + e^-$	**52.225 ± 3.086**	**present**	
$ZrI_3(g) \Leftrightarrow Zr^{4+} + 3\ I^- + e^-$	**87.211 ± 1.789**	**present**	
$ZrI_4(cr) \Leftrightarrow Zr^{4+} + 4\ I^-$	**44.594 ± 1.744**	**present**	
$ZrI_4(g) \Leftrightarrow Zr^{4+} + 4\ I^-$	**57.716 ± 1.745**	**present**	
$ZrS_{1.5}(cr) + 1.5\ H^+ \Leftrightarrow 1.5\ HS^-$	**-91.182 ± 0.879**	**present**	
$ZrS_2(cr) + 2\ H^+ \Leftrightarrow 2\ HS^-$	**-103.404 ± 2.232**	**present**	
$ZrS_3(cr) + 3\ H^+ \Leftrightarrow 3\ HS^-$	**-111.886 ± 1.398**	**present**	
$Zr(SO_3)_2(cr) \Leftrightarrow Zr^{4+} + 2\ SO_3^{2-}$	**-58.061 ± 2.772**	**present**	
$Zr(SO_4)_2(cr) \Leftrightarrow Zr^{4+} + 2\ SO_4^{2-}$	**1.237 ± 1.668**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Zr(SO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow Zr^{4+} + 2\ SO_4^{2-} + 4\ H_2O(l)$	**-7.653 ± 1.686**	**present**	
$ZrN(cr) + 3\ H_2O(l) \Leftrightarrow Zr^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	**-72.524 ± 1.654**	**present**	
α-$Zr(HPO_4)_2 \Leftrightarrow Zr^{4+} + 2\ PO_4^{3-} + 2\ H^+$	**-71.392 ± 4.377**	**present**	
$Zr(HPO_4)_2 \cdot H_2O(cr) \Leftrightarrow Zr^{4+} + 2\ PO_4^{3-} + 2\ H^+ + H_2O(l)$	**-66.204 ± 3.930**	**present**	
$ZrC(cr) + 3\ H_2O(l) \Leftrightarrow Zr^{4+} + CO_3^{2-} + 6\ H^+ + 8\ e^-$	**24.792 ± 1.680**	**present**	
$Ca_2ZrSi_3O_{12}(cr) + 12\ H^+ + 4\ e^- \Leftrightarrow 2\ Ca^{2+} + Zr^{4+} + 3\ H_4SiO_4(aq)$	**-69.048 ± 3.177**	**present**	
$Ca_3ZrSi_2O_9(cr) + 10\ H^+ \Leftrightarrow 3\ Ca^{2+} + Zr^{4+} + 2\ H_4SiO_4(aq) + H_2O(l)$	**47.344 ± 2.486**	**present**	
$SrZrSi_2O_7(cr) + H_2O(l) + 6\ H^+ \Leftrightarrow Sr^{2+} + Zr^{4+} + 2\ H_4SiO_4(aq)$	**4.680 ± 1.827**	**present**	
$Na_2ZrSiO_5(cr) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + H_4SiO_4(aq) + H_2O(l)$	**12.928 ± 3.865**	**present**	
$Na_2ZrSi_2O_7(cr) + H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 2\ H_4SiO_4(aq)$	**3.214 ± 2.421**	**present**	
$Na_2ZrSi_3O_9 \cdot 2H_2O(cr) + H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 3\ H_4SiO_4(aq)$	**14.800 ± 3.906**	**present**	
$Na_2ZrSi_4O_{11}(cr) + 5\ H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 4\ H_4SiO_4(aq)$	**-14.601 ± 3.943**	**present**	
$Na_2ZrSi_6O_{15} \cdot 3H_2O(cr) + 6\ H_2O(l) + 6\ H^+ \Leftrightarrow 2\ Na^+ + Zr^{4+} + 6\ H_4SiO_4(aq)$	**14.889 ± 5.632**	**present**	
$Na_4Zr_2Si_3O_{12}(cr) + 2\ H^+ \Leftrightarrow 4\ Na^+ + 2\ Zr^{4+} + 3\ H_4SiO_4(aq)$	**14.721 ± 4.814**	**present**	
$NaZr_2P_3O_{12}(cr) \Leftrightarrow Na^+ + 2\ Zr^{4+} + 3\ PO_4^{3-}$	**-28.298 ± 4.867**	**present**	
$Nb_2O_5(s) + 7\ H_2O \Leftrightarrow 2\ Nb(OH)_6^- + 2\ H^+$	-28.913 ± 0.507	1	
$Mo(metal) + 4\ H_2O(l) \Leftrightarrow MoO_4^{2-} + 8\ H^+ + 6\ e^-$	-19.280	34	
$MoO_2(cr) + 2\ H_2O(l) \Leftrightarrow MoO_4^{2-} + 4\ H^+ + 2\ e^-$	-29.570	34	
$PbMoO_4(cr) \Leftrightarrow MoO_4^{2-} + Pb^{2+}$	-12.980 ± 0.050	54	
$CaMoO_4(cr) \Leftrightarrow MoO_4^{2-} + Ca^{2+}$	-7.950 ± 0.050	34	
$Sm_2(MoO_4)_3 \cdot xH_2O(cr) \Leftrightarrow 3\ MoO_4^{2-} + 2\ Sm^{3+}$	-26.100 ± 0.300	36	
$NH_4TcO_4(cr) \Leftrightarrow TcO_4^- + NH_4^+$	-0.910 ± 0.070	14	
$TlTcO_4(cr) \Leftrightarrow TcO_4^- + Tl^+$	-5.320 ± 0.120	14	
$AgTcO_4(cr) \Leftrightarrow TcO_4^- + Ag^+$	-3.270 ± 0.130	14	
$NaTcO_4 \cdot 4H_2O(s) \Leftrightarrow TcO_4^- + 4\ H_2O(l) + Na^+$	0.790 ± 0.040	14	
$KTcO_4(cr) \Leftrightarrow TcO_4^- + K^+$	-2.288 ± 0.026	14	
$TcO_2 \cdot 1.6H_2O(s) \Leftrightarrow TcO(OH)_2(aq) + 0.6\ H_2O(l)$	**-8.415 ± 0.180**	1	
$TcO_2 \cdot 1.6H_2O(s) + 0.4\ H_2O(l) \Leftrightarrow TcO_4^- + 4\ H^+ + 3\ e^-$	-37.829 ± 0.609	14	
$Tc(cr) + 4\ H_2O(l) \Leftrightarrow TcO_4^- + 8\ H^+ + 7\ e^-$	**-54.512 ± 1.335**	**present**	
$Tc(g) + 4\ H_2O(l) \Leftrightarrow TcO_4^- + 8\ H^+ + 7\ e^-$	**55.984 ± 4.579**	**present**	
$TcO(g) + 3\ H_2O(l) \Leftrightarrow TcO_4^- + 6\ H^+ + 5\ e^-$	**49.663 ± 10.075**	**present**	
$TcO_2(cr) + 2\ H_2O(l) \Leftrightarrow TcO_4^- + 4\ H^+ + 3\ e^-$	**-41.822 ± 2.455**	**present**	
$Tc_2O_7(cr) + H_2O(l) \Leftrightarrow 2\ TcO_4^- + 2\ H^+$	**15.310 ± 3.815**	**present**	
$Tc_2O_7(g) + H_2O(l) \Leftrightarrow 2\ TcO_4^- + 2\ H^+$	**23.275 ± 3.929**	**present**	
$Tc_2O_7 \cdot H_2O(s) \Leftrightarrow 2\ TcO_4^- + 2\ H^+$	**14.105 ± 3.807**	**present**	
$TcS(g) + 4\ H_2O(l) \Leftrightarrow TcO_4^- + HS^- + 7\ H^+ + 5\ e^-$	**29.525 ± 11.472**	**present**	
$TcC(g) + 7\ H_2O(l) \Leftrightarrow TcO_4^- + CO_3^{2-} + 14\ H^+ + 11\ e^-$	**47.464 ± 7.177**	**present**	
$CsTcO_4(cr) \Leftrightarrow TcO_4^- + Cs^+$	**-3.617 ± 0.047**	**present**	
$Pd(cr) \Leftrightarrow Pd^{2+} + 2\ e^-$	-32.860	9	
$Pd(s) \Leftrightarrow Pd^{2+} + 2\ e^-$	-29.570 ± 1.120	37	
$Pd(OH)_2(s) + 2\ H^+ \Leftrightarrow Pd^{2+} + 2\ H_2O(l)$	-4.120 ± 0.630	37	
$Ag(cr) \Leftrightarrow Ag^+ + e^-$	**-13.507 ± 0.027**	**present**	
$Ag(g) \Leftrightarrow Ag^+ + e^-$	**29.592 ± 0.143**	**present**	
$AgCl(cr) \Leftrightarrow Ag^+ + Cl^-$	**-9.748 ± 0.038**	**present**	
$Cd(cr) \Leftrightarrow Cd^{2+} + 2\ e^-$	**13.618 ± 0.131**	**present**	
$Cd(g) \Leftrightarrow Cd^{2+} + 2\ e^-$	**27.148 ± 0.136**	**present**	
$CdO(cr) + 2\ H^+ \Leftrightarrow Cd^{2+} + H_2O(l)$	**15.104 ± 0.169**	**present**	
$CdSO_4 \cdot 2.667H_2O(cr) \Leftrightarrow Cd^{2+} + SO_4^{2-} + 2.667\ H_2O(l)$	**-1.887 ± 0.208**	**present**	
$Sn(cr) + 4\ H_2O(l) \Leftrightarrow Sn(OH)_4(aq) + 4\ H^+ + 4\ e^-$	-0.770	9	
$Sn(OH)_2(s) + 2\ H_2O(l) \Leftrightarrow Sn(OH)_4(aq) + 2\ H^+ + 2\ e^-$	-2.580	9	
$SnO(cr) + 3\ H_2O(l) \Leftrightarrow Sn(OH)_4(aq) + 2\ H^+ + 2\ e^-$	-2.990	9	
$SnClOH(s) + 3\ H_2O(l) \Leftrightarrow Sn(OH)_4(aq) + 3\ H^+ + Cl^- + 2\ e^-$	-7.820	9	
$SnO_2(am) + 2\ H_2O(l) \Leftrightarrow Sn(OH)_4(aq)$	-7.460	9	
$SnO_2(cassiterite) + 2\ H_2O(l) \Leftrightarrow Sn(OH)_4(aq)$	-8.000	9	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$I(g) + e^- \Leftrightarrow I^-$	21.355 ± 0.022	3	
$I_2(cr) + 2\ e^- \Leftrightarrow 2\ I^-$	18.123 ± 0.028	3	
$I_2(g) + 2\ e^- \Leftrightarrow 2\ I^-$	21.508 ± 0.035	present	
$HI(g) \Leftrightarrow I^- + H^+$	9.359 ± 0.028	present	
$IO(g) + 2\ H^+ + 3\ e^- \Leftrightarrow I^- + H_2O(l)$	**68.564**	**present**	*
$IF(g) + 2\ e^- \Leftrightarrow I^- + F^-$	**37.620**	**present**	*
$IF_7(g) + 8\ e^- \Leftrightarrow I^- + 7\ F^-$	**210.945**	**present**	*
$ICl(g) + 2\ e^- \Leftrightarrow I^- + Cl^-$	**31.093**	**present**	*
$ICl_3(cr) + 4\ e^- \Leftrightarrow I^- + 3\ Cl^-$	**74.121**	**present**	*
$IBr(g) + 2\ e^- \Leftrightarrow I^- + Br^-$	**27.902**	**present**	*
$AgI(cr) \Leftrightarrow I^- + Ag^+$	**-16.043**	**present**	*
$AgIO_3(cr) \Leftrightarrow IO_3^- + Ag^+$	**-7.789**	**present**	*
$KI(cr) \Leftrightarrow I^- + K^+$	**1.635**	**present**	*
$KIO_3(cr) \Leftrightarrow IO_3^- + K^+$	**-1.673**	**present**	*
$KIO_4(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow IO_3^- + K^+ + H_2O(l)$	**49.857**	**present**	*
$NaI(cr) \Leftrightarrow I^- + Na^+$	**4.831**	**present**	*
$NaIO_4(cr) + 2\ H^+ + 2\ e^- \Leftrightarrow IO_3^- + Na^+ + H_2O(l)$	**52.983**	**present**	*
$CsI(cr) \Leftrightarrow I^- + Cs^+$	**0.452**	**present**	*
$BI_3(g) + 3\ H_2O(l) \Leftrightarrow 3\ I^- + B(OH)_3(aq) + 3\ H^+$	**75.993**	**present**	*
$BaI_2(cr) \Leftrightarrow 2\ I^- + Ba^{2+}$	**11.110**	**present**	*
$CaI_2(cr) \Leftrightarrow 2\ I^- + Ca^{2+}$	**22.311**	**present**	*
$CdI_2(cr) \Leftrightarrow 2\ I^- + Cd^{2+}$	**-3.539**	**present**	*
$CoI_2(cr) \Leftrightarrow 2\ I^- + Co^{2+}$	**11.751**	**present**	*
$CuI(cr) \Leftrightarrow I^- + Cu^{2+} + e^-$	**-14.509**	**present**	*
$HgI_2(cr) \Leftrightarrow 2\ I^- + Hg^{2+}$	**-28.542**	**present**	*
$Hg_2I_2(cr) \Leftrightarrow 2\ I^- + Hg_2^{2+}$	**-28.227**	**present**	*
$LiI(cr) \Leftrightarrow I^- + Li^+$	**13.024**	**present**	*
$MgI_2(cr) \Leftrightarrow 2\ I^- + Mg^{2+}$	**35.147**	**present**	*
$NH_4I(cr) \Leftrightarrow I^- + NH_4^+$	**3.262**	**present**	*
$PbI_2(cr) \Leftrightarrow 2\ I^- + Pb^{2+}$	**-8.044**	**present**	*
$RbI(cr) \Leftrightarrow I^- + Rb^+$	**1.197**	**present**	*
$SiI_4(cr) + 4\ H_2O(l) \Leftrightarrow 4\ I^- + H_4SiO_4(aq) + 4\ H^+$	**65.604**	**present**	*
$SrI_2(cr) \Leftrightarrow 2\ I^- + Sr^{2+}$	**18.678**	**present**	*
$TlI(cr) \Leftrightarrow I^- + Tl^+$	**-7.231**	**present**	*
$ZnI_2(cr) \Leftrightarrow 2\ I^- + Zn^{2+}$	**7.297**	**present**	*
$AlI_3(cr) \Leftrightarrow 3\ I^- + Al^{3+}$	**60.595**	**present**	*
$AsI_3(cr) + 4\ H_2O(l) \Leftrightarrow 3\ I^- + AsO_4^{3-} + 8\ H^+ + 2\ e^-$	**-35.814**	**present**	*
$Sb(cr) + 3\ H_2O(l) \Leftrightarrow Sb(OH)_3(aq) + 3\ H^+ + 3\ e^-$	-11.990	9	
$Sb_2O_3(valentinite) + 3\ H_2O(l) \Leftrightarrow 2\ Sb(OH)_3(aq)$	-8.720	9	
$Sb_2S_3(stibnite) + 18\ H_2O(l) \Leftrightarrow 2\ Sb(OH)_3(aq) + 3\ SO_4^{2-} + 30\ H^+ + 24\ e^-$	-156.219	9	
$Sb_2O_5(am) + 5\ H_2O(l) \Leftrightarrow 2\ Sb(OH)_5(aq)$	-7.400	9	
$Cs(cr) \Leftrightarrow Cs^+ + e^-$	51.061 ± 0.094	3	
$Cs(g) \Leftrightarrow Cs^+ + e^-$	59.742 ± 0.200	3	
$CsNO_3(s) \Leftrightarrow Cs^+ + NO_3^-$	-0.410	4	
$Cs_2O(s) + 2\ H^+ \Leftrightarrow 2\ Cs^+ + H_2O(l)$	89.890	4	
$CsOH(s) + H^+ \Leftrightarrow Cs^+ + H_2O(l)$	27.420	4	
$Cs_2SO_4(s) \Leftrightarrow 2\ Cs^+ + SO_4^{2-}$	0.870	4	
$Cs_2CO_3(s) \Leftrightarrow 2\ Cs^+ + CO_3^{2-}$	10.070	4	
$CsBr(cr) \Leftrightarrow Cs^+ + Br^-$	**0.724 ± 0.112**	**present**	
$CsCl(cr) \Leftrightarrow Cs^+ + Cl^-$	**1.553 ± 0.103**	**present**	
$Ba(cr) \Leftrightarrow Ba^{2+} + 2\ e^-$	97.697 ± 0.452	3	
$BaO(cr) + 2\ H^+ \Leftrightarrow Ba^{2+} + H_2O(l)$	48.073 ± 0.632	3	
$BaCO_3(witherite) \Leftrightarrow Ba^{2+} + CO_3^{2-}$	-8.540 ± 0.030	30	
$BaSO_4(barite) \Leftrightarrow Ba^{2+} + SO_4^{2-}$	-10.050 ± 0.050	30	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Ba(g) \Leftrightarrow Ba^{2+} + 2\ e^-$	**124.475 ± 0.987**	**present**	
$BaCl_2(cr) \Leftrightarrow Ba^{2+} + 2\ Cl^-$	**2.301 ± 0.633**	**present**	
$BaF(g) \Leftrightarrow Ba^{2+} + F^- + e^-$	**85.775 ± 1.265**	**present**	
$Sm(OH)_3(am) + 3\ H^+ \Leftrightarrow Sm^{3+} + 3\ H_2O(l)$	16.900 ± 0.800	28	
$Sm(OH)_3(cr) + 3\ H^+ \Leftrightarrow Sm^{3+} + 3\ H_2O(l)$	15.600 ± 0.600	28	
$Sm_2(CO_3)_3(am) \Leftrightarrow 2\ Sm^{3+} + 3\ CO_3^{2-}$	-33.400 ± 2.200	28	
$SmCO_3OH(am) + H^+ \Leftrightarrow Sm^{3+} + CO_3^{2-} + H_2O(l)$	-6.199 ± 1.000	28	
$SmCO_3OH•0.5H_2O(cr) + H^+ \Leftrightarrow Sm^{3+} + CO_3^{2-} + 1.5\ H_2O(l)$	-8.399 ± 0.500	28	
$NaSm(CO_3)_2•5H_2O(cr) \Leftrightarrow Sm^{3+} + 2\ CO_3^{2-} + 5\ H_2O(l) + Na^+$	-21.000 ± 0.500	28	
$SmPO_4(am,hydr) \Leftrightarrow Sm^{3+} + PO_4^{3-}$	-24.790 ± 0.600	28	
$Hg(g) \Leftrightarrow Hg^{2+} + 2\ e^-$	**-23.270 ± 0.056**	**present**	
$Hg(l) \Leftrightarrow Hg^{2+} + 2\ e^-$	**-28.848 ± 0.055**	**present**	
$Hg_2Cl_2(cr) \Leftrightarrow 2\ Hg^{2+} + 2\ e^- + 2\ Cl^-$	**-48.638 ± 0.143**	**present**	
$Hg_2SO_4(cr) \Leftrightarrow 2\ Hg^{2+} + SO_4^{2-} + 2\ e^-$	**-36.985 ± 0.150**	**present**	
$HgO(montroydite,red) + 2\ H^+ \Leftrightarrow Hg^{2+} + H_2O(l)$	**2.444 ± 0.062**	**present**	
$Pb(cr) \Leftrightarrow Pb^{2+} + 2\ e^-$	4.250	9	
$Pb(g) \Leftrightarrow Pb^{2+} + 2\ e^-$	**32.668 ± 0.157**	**present**	
$PbO(red,litharge) + 2\ H^+ \Leftrightarrow Pb^{2+} + H_2O(l)$	12.680	9	
$PbO(yellow,massicot) + 2\ H^+ \Leftrightarrow Pb^{2+} + H_2O(l)$	12.960	9	
$Pb(OH)_2(am) + 2\ H^+ \Leftrightarrow Pb^{2+} + 2\ H_2O(l)$	13.050	9	
$PbSO_4(anglesite) \Leftrightarrow Pb^{2+} + SO_4^{2-}$	-7.810	9	
$PbCl_2(s) \Leftrightarrow Pb^{2+} + 2\ Cl^-$	-4.810	9	
$PbClOH(cr) + H^+ \Leftrightarrow Pb^{2+} + Cl^- + H_2O(l)$	0.620	9	
$PbF_2(s) \Leftrightarrow Pb^{2+} + 2\ F^-$	-7.520	9	
$PbFCl(matlockite) \Leftrightarrow Pb^{2+} + F^- + Cl^-$	-8.820	9	
$PbCO_3(cerrusite) \Leftrightarrow Pb^{2+} + CO_3^{2-}$	-13.230	9	
$Pb_3(CO_3)_2(OH)_2(hydrocerrusite) + 2\ H^+ \Leftrightarrow 3\ Pb^{2+} + 2\ CO_3^{2-} + 2\ H_2O(l)$	-17.640	9	
$Pb_{10}(CO_3)_6(OH)_6(plumbonacrite) + 8\ H^+ \Leftrightarrow 10\ Pb^{2+} + 6\ CO_3^{2-} + 7\ H_2O(l)$	-41.210	9	
$PbOHNO_3(cr) + H^+ \Leftrightarrow Pb^{2+} + NO_3^- + H_2O(l)$	2.940	9	
$PbHPO_4(s) \Leftrightarrow Pb^{2+} + PO_4^{3-} + H^+$	-23.780	9	
$Pb(H_2PO_4)_2(s) \Leftrightarrow Pb^{2+} + 2\ PO_4^{3-} + 4\ H^+$	-48.940	9	
$Pb_3(PO)_4(s) \Leftrightarrow 3\ Pb^{2+} + 2\ PO_4^{3-}$	-44.400	9	
$Pb_4(PO_4)_2O(s) + 2\ H^+ \Leftrightarrow 4\ Pb^{2+} + 2\ PO_4^{3-} + H_2O(l)$	-37.090	9	
$Pb_5(PO_4)_3OH(hydroxyl\ pyromorphite) + H^+ \Leftrightarrow 5\ Pb^{2+} + 3\ PO_4^{3-} + H_2O(l)$	-62.800	9	
$Pb_5(PO_4)_3Cl(chloro\ pyromorphite) \Leftrightarrow 5\ Pb^{2+} + 3\ PO_4^{3-} + Cl^-$	-84.400	9	
$Pb_5(PO_4)_3F(fluoro\ pyromorphite) \Leftrightarrow 5\ Pb^{2+} + 3\ PO_4^{3-} + F^-$	-71.600	9	
$PbS(galena) + 4\ H_2O(l) \Leftrightarrow Pb^{2+} + SO_4^{2-} + 8\ H^+ + 8\ e^-$	-45.863	9	
$PbO_2(s) + 4\ H^+ + 2\ e^- \Leftrightarrow Pb^{2+} + 2\ H_2O(l)$	48.980	9	
$Pb_3O_4(s) + 8\ H^+ + 2\ e^- \Leftrightarrow 3\ Pb^{2+} + 4\ H_2O(l)$	70.980	9	
$Bi(OH)_3(am) + 3\ H^+ \Leftrightarrow Bi^{3+} + 3\ H_2O(l)$	31.501 ± 0.927	39	
$0.5\ \alpha\text{-}Bi_2O_3(c) + 3\ H^+ \Leftrightarrow Bi^{3+} + 1.5\ H_2O(l)$	31.501 ± 0.927	39	
$BiPO_4(c) \Leftrightarrow Bi^{3+} + PO_4^{3-}$	-30.350 ± 0.540	39	
$Bi(cr) \Leftrightarrow Bi^{3+} + 3\ e^-$	-16.740	9	
$BiOCl(s) + 2\ H^+ \Leftrightarrow Bi^{3+} + H_2O + Cl^-$	-8.470	9	
$(BiO)_2CO_3(cr) + 4\ H^+ \Leftrightarrow 2\ Bi^{3+} + 2\ H_2O + CO_3^{2-}$	-14.270	9	
$(BiO)_4(OH)_2CO_3(cr) + 10\ H^+ \Leftrightarrow 4\ Bi^{3+} + 6\ H_2O + CO_3^{2-}$	-8.680	9	
$BiONO_3(s) + 2\ H^+ \Leftrightarrow Bi^{3+} + H_2O + NO_3^-$	-2.750	9	
$Po(OH)_4(s) + 4\ H^+ \Leftrightarrow Po^{4+} + 4\ H_2O(l)$	19.520	4	
$RaSO_4(cr) \Leftrightarrow Ra^{2+} + SO_4^{2-}$	-10.050 ± 0.390	30	
$RaCO_3(cr) \Leftrightarrow Ra^{2+} + CO_3^{2-}$	-8.540 ± 0.200	30	
$Ac(OH)_3(am) + 3\ H^+ \Leftrightarrow Ac^{3+} + 3\ H_2O(l)$	16.900 ± 4.800	28	*
$Ac_2(CO_3)_3(am) \Leftrightarrow 2\ Ac^{3+} + 3\ CO_3^{2-}$	-33.400 ± 5.100	28	*
$AcCO_3OH(am) + H^+ \Leftrightarrow Ac^{3+} + CO_3^{2-} + H_2O(l)$	-6.199 ± 5.000	28	*
$AcPO_4(am,hydr) \Leftrightarrow Ac^{3+} + PO_4^{3-}$	-24.790 ± 4.600	28	*

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$ThO_2(am,fresh) + 4\ H^+ \Leftrightarrow Th^{4+} + 2\ H_2O(l)$	9.304 ± 0.900	3	
$ThO_2(am,aged) + 4\ H^+ \Leftrightarrow Th^{4+} + 2\ H_2O(l)$	8.504 ± 0.900	3	
$ThO_2(cr) + 4\ H^+ \Leftrightarrow Th^{4+} + 2\ H_2O(l)$	1.765 ± 1.113	3	
$ThF_4(cr, hyd) + 4\ H^+ \Leftrightarrow Th^{4+} + 4\ HF(aq)$	-19.110 ± 0.400	3	
$Th(SO_4)_2 \cdot 9H_2O(cr) \Leftrightarrow Th^{4+} + 9\ H_2O(l) + 2\ SO_4^{2-}$	-11.250 ± 0.096	3	
$Na_6Th(CO_3)_5 \cdot 12H_2O(cr) \Leftrightarrow Th^{4+} + 5\ CO_3^{2-} + 12\ H_2O(l) + 6\ Na^+$	-42.200 ± 0.800	3	
$Th(cr) \Leftrightarrow Th^{4+} + 4\ e^-$	**123.472 ± 0.928**	**present**	
$Th(g) \Leftrightarrow Th^{4+} + 4\ e^-$	**221.753 ± 1.403**	**present**	
$ThO(g) + 2\ H^+ \Leftrightarrow Th^{4+} + H_2O(l) + 2\ e^-$	**156.030 ± 1.403**	**present**	
$ThO_2(g) + 4\ H^+ \Leftrightarrow Th^{4+} + 2\ H_2O(l)$	**125.601 ± 2.858**	**present**	
$ThH_2(cr) \Leftrightarrow Th^{4+} + 2\ H^+ + 6\ e^-$	**104.995 ± 0.992**	**present**	
$ThH_{3.75}(cr) \Leftrightarrow Th^{4+} + 3.75\ H^+ + 7.75\ e^-$	**98.441 ± 1.681**	**present**	
$ThF(g) \Leftrightarrow Th^{4+} + F^- + 3\ e^-$	**172.654 ± 2.859**	**present**	
$ThF_2(g) \Leftrightarrow Th^{4+} + 2\ F^- + 2\ e^-$	**116.673 ± 3.670**	**present**	
$ThF_3(g) \Leftrightarrow Th^{4+} + 3\ F^- + e^-$	**68.251 ± 2.859**	**present**	
$ThF_4(g) \Leftrightarrow Th^{4+} + 4\ F^-$	**19.542 ± 2.074**	**present**	
$ThOF(g) + 2\ H^+ \Leftrightarrow Th^{4+} + F^- + H_2O(l) + e^-$	**115.146 ± 2.360**	**present**	
$ThOF_2(cr) + 2\ H^+ \Leftrightarrow Th^{4+} + 2\ F^- + H_2O(l)$	**-14.751 ± 1.691**	**present**	
$ThCl(g) \Leftrightarrow Th^{4+} + Cl^- + 3\ e^-$	**184.247 ± 3.679**	**present**	
$ThCl_2(g) \Leftrightarrow Th^{4+} + 2\ Cl^- + 2\ e^-$	**135.928 ± 3.999**	**present**	
$ThCl_3(g) \Leftrightarrow Th^{4+} + 3\ Cl^- + e^-$	**93.670 ± 4.508**	**present**	
$\beta\text{-}ThCl_4 \Leftrightarrow Th^{4+} + 4\ Cl^-$	**24.064 ± 0.994**	**present**	
$ThCl_4(g) \Leftrightarrow Th^{4+} + 4\ Cl^-$	**53.730 ± 1.316**	**present**	
$ThOCl_2(cr) + 2\ H^+ \Leftrightarrow Th^{4+} + 2\ F^- + H_2O(l)$	**61.563 ± 1.039**	**present**	
$ThBr(g) \Leftrightarrow Th^{4+} + Br^- + 3\ e^-$	**197.652 ± 3.679**	**present**	
$ThBr_2(g) \Leftrightarrow Th^{4+} + 2\ Br^- + 2\ e^-$	**159.854 ± 3.663**	**present**	
$ThBr_3(g) \Leftrightarrow Th^{4+} + 3\ Br^- + e^-$	**113.044 ± 2.837**	**present**	
$\beta\text{-}ThBr_4 \Leftrightarrow Th^{4+} + 4\ Br^-$	**34.190 ± 1.033**	**present**	
$ThBr_4(g) \Leftrightarrow Th^{4+} + 4\ Br^-$	**61.519 ± 1.355**	**present**	
$ThI_4(g) \Leftrightarrow Th^{4+} + 4\ I^-$	**68.914 ± 1.372**	**present**	
$ThI_4(cr) \Leftrightarrow Th^{4+} + 4\ I^-$	**44.182 ± 1.042**	**present**	
$Th^{4+} + IO_3^- \Leftrightarrow ThIO_3^{3+}$	**4.140 ± 0.100**	3	
$Th^{4+} + 2\ IO_3^- \Leftrightarrow Th(IO_3)_2^{2+}$	**6.970 ± 0.120**	3	
$Th^{4+} + 3\ IO_3^- \Leftrightarrow Th(IO_3)_3^+$	**9.870 ± 0.110**	3	
$ThS(cr) + H^+ \Leftrightarrow Th^{4+} + HS^- + 2\ e^-$	**52.676 ± 1.477**	**present**	
$ThN(cr) + 3\ H_2O(l) \Leftrightarrow Th^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	**-43.707 ± 1.986**	**present**	
$Th_3N_4(cr) + 12\ H_2O(l) \Leftrightarrow 3\ Th^{4+} + 4\ NO_3^- + 24\ H^+ + 32\ e^-$	**-260.721 ± 3.921**	**present**	
$Th(NO_3)_4 \cdot 5H_2O(cr) \Leftrightarrow Th^{4+} + 4\ NO_3^- + 5\ H_2O(l)$	**1.929 ± 1.091**	**present**	
$ThC_{0.97}(cr) + 2.91\ H_2O(l) \Leftrightarrow Th^{4+} + 0.97\ CO_3^{2-} + 5.82\ H^+ + 7.88\ e^-$	**70.480 ± 1.445**	**present**	
$ThC_{1.94}(s) + 5.82\ H_2O(l) \Leftrightarrow Th^{4+} + 1.94\ CO_3^{2-} + 11.64\ H^+ + 11.76\ e^-$	**38.901 ± 1.615**	**present**	
$PaO_2(cr) + 4\ H^+ \Leftrightarrow Pa^{4+} + 2\ H_2O(l)$	0.600	55	
$PaCl_4(s) \Leftrightarrow Pa^{4+} + 4\ Cl^-$	24.010	41	
$Pa_2O_5(cr) + 2\ e^- + 10\ H^+ \Leftrightarrow 2\ Pa^{4+} + 5\ H_2O(l)$	-8.720	41	
$PaCl_5(cr) - e^- \Leftrightarrow Pa^{4+} + 5\ Cl^-$	32.850	41	
$UO_2(am) + 4\ H^+ \Leftrightarrow U^{4+} + 2\ H_2O(l)$	2.304 ± 1.000	45	
$UO_2(cr) + 4\ H^+ \Leftrightarrow U^{4+} + 2\ H_2O(l)$	-4.852 ± 0.365	14	
$\alpha\text{-}UO_3 + 2\ H^+ \Leftrightarrow UO_2^{2+} + H_2O(l)$	9.524 ± 0.401	14	
$\beta\text{-}UO_3 + 2\ H^+ \Leftrightarrow UO_2^{2+} + H_2O(l)$	8.302 ± 0.382	14	
$\gamma\text{-}UO_3 + 2\ H^+ \Leftrightarrow UO_2^{2+} + H_2O(l)$	7.700 ± 0.372	14	
$\alpha\text{-}UO_3 \cdot 0.9H_2O(cr) + 2\ H^+ \Leftrightarrow UO_2^{2+} + 1.9\ H_2O(l)$	5.003 ± 0.529	14	
$UO_3 \cdot 2H_2O(cr) + 2\ H^+ \Leftrightarrow UO_2^{2+} + 3\ H_2O(l)$	4.812 ± 0.428	14	
$\beta\text{-}UO_2(OH)_2 + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ H_2O(l)$	4.931 ± 0.435	14	
$U(OH)_2SO_4(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ H_2O(l) + SO_4^{2-}$	-3.168 ± 0.500	14	
$U(HPO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow U^{4+} + 2\ PO_4^{3-} + 2\ H^+ + 4\ H_2O(l)$	-55.194 ± 0.383	14	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$UF_6(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ F^- + 4\ H^+$	17.204 ± 0.853	14	
$UO_2(IO_3)_2(cr) + 12\ H^+ + 12\ e^- \Leftrightarrow UO_2^{2+} + 2\ I^- + 6\ H_2O(l)$	215.246 ± 0.294	14	
$UO_2SO_4(cr) \Leftrightarrow UO_2^{2+} + SO_4^{2-}$	1.889 ± 0.560	14	
$UO_2SO_4 \cdot 2.5H_2O(cr) \Leftrightarrow UO_2^{2+} + SO_4^{2-} + 2.5\ H_2O(l)$	-1.589 ± 0.019	14	
$UO_2SO_4 \cdot 3.5H_2O(cr) \Leftrightarrow UO_2^{2+} + SO_4^{2-} + 3.5\ H_2O(l)$	-1.585 ± 0.019	14	
$UO_2HPO_4 \cdot 4H_2O(cr) + 2\ H^+ \Leftrightarrow UO_2^{2+} + PO_4^{3-} + H^+ + 4\ H_2O(l)$	-24.202 ± 0.198	14	
$(UO_2)_3(PO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ PO_4^{3-} + 4\ H_2O(l)$	-48.364 ± 0.462	14	
$UO_2CO_3(cr) \Leftrightarrow UO_2^{2+} + CO_3^{2-}$	-14.760 ± 0.020	14	
$CaU_6O_{19} \cdot 11H_2O(cr) + 14\ H^+ \Leftrightarrow 6\ UO_2^{2+} + Ca^{2+} + 18\ H_2O(l)$	-40.500 ± 1.600	14	
$Na_4UO_2(CO_3)_3(cr) \Leftrightarrow UO_2^{2+} + 3\ CO_3^{2-} + 4\ Na^+$	-27.180 ± 0.165	14	
$K_2U_6O_{19} \cdot 11H_2O(cr) + 14\ H^+ \Leftrightarrow 6\ UO_2^{2+} + 2\ K^+ + 18\ H_2O(l)$	-37.100 ± 0.540	14	
$UO(g) + 2\ H^+ \Leftrightarrow U^{4+} + H_2O(l) + 2\ e^-$	**135.305 ± 1.782**	**present**	
$UO_2(g) + 4\ H^+ \Leftrightarrow U^{4+} + 2\ H_2O(l)$	**91.638 ± 3.524**	**present**	
$\beta\text{-}UO_{2.25} + 4.5\ H^+ + 0.5\ e^- \Leftrightarrow U^{4+} + 2.25\ H_2O(l)$	**-0.991 ± 0.430**	**present**	
$UO_{2.25}(cr) + 4.5\ H^+ + 0.5\ e^- \Leftrightarrow U^{4+} + 2.25\ H_2O(l)$	**-0.999 ± 0.430**	**present**	
$\beta\text{-}UO_{2.3333} + 4.6666\ H^+ + 0.6666\ e^- \Leftrightarrow U^{4+} + 2.3333\ H_2O(l)$	**0.632 ± 0.468**	**present**	
$UO_{2.6667}(cr) + 5.3334\ H^+ + 1.3334\ e^- \Leftrightarrow U^{4+} + 2.6667\ H_2O(l)$	**6.847 ± 0.340**	**present**	
$UO_3(g) + 2\ H^+ \Leftrightarrow UO_2^{2+} + H_2O(l)$	**70.940 ± 2.648**	**present**	
$\beta\text{-}UH_3 \Leftrightarrow U^{3+} + 3\ H^+ + 6\ e^-$	**70.763 ± 0.318**	**present**	
$UF(g) \Leftrightarrow U^{4+} + F^- + 3\ e^-$	**128.679 ± 3.523**	**present**	
$UF_2(g) \Leftrightarrow U^{4+} + 2\ F^- + 2\ e^-$	**93.589 ± 4.428**	**present**	
$UF_3(cr) \Leftrightarrow U^{3+} + 3\ F^-$	**-19.532 ± 0.955**	**present**	
$UF_3(g) \Leftrightarrow U^{3+} + 3\ F^-$	**45.216 ± 3.575**	**present**	
$UF_4(cr) \Leftrightarrow U^{4+} + 4\ F^-$	**-29.360 ± 0.934**	**present**	
$UF_4(g) \Leftrightarrow U^{4+} + 4\ F^-$	**13.858 ± 1.307**	**present**	
$UF_4 \cdot 2.5H_2O(cr) \Leftrightarrow U^{4+} + 4\ F^- + 2.5\ H_2O(l)$	**-33.546 ± 1.227**	**present**	
$\alpha\text{-}UF_5 + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ F^- + 4\ H^+$	**-13.022 ± 1.401**	**present**	
$\beta\text{-}UF_5 + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ F^- + 4\ H^+$	**-13.356 ± 1.199**	**present**	
$UF_5(g) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ F^- + 4\ H^+$	**5.654 ± 2.764**	**present**	
$UF_6(g) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ F^- + 4\ H^+$	**18.039 ± 0.856**	**present**	
$U_2F_9(cr) + e^- \Leftrightarrow 2\ U^{4+} + 9\ F^-$	**-38.292 ± 3.232**	**present**	
$U_4F_{17}(cr) + e^- \Leftrightarrow 4\ U^{4+} + 17\ F^-$	**-97.874 ± 5.779**	**present**	
$UOF_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ F^- + H_2O(l)$	**-18.234 ± 1.192**	**present**	
$UOF_4(cr) + H_2O(l) \Leftrightarrow UO_2^{2+} + 4\ F^- + 2\ H^+$	**4.422 ± 0.942**	**present**	
$UOF_4(g) + H_2O(l) \Leftrightarrow UO_2^{2+} + 4\ F^- + 2\ H^+$	**23.947 ± 3.575**	**present**	
$UO_2F_2(cr) \Leftrightarrow UO_2^{2+} + 2\ F^-$	**-7.310 ± 0.453**	**present**	
$UO_2F_2(g) \Leftrightarrow UO_2^{2+} + 2\ F^-$	**34.603 ± 1.836**	**present**	
$U_2O_3F_6(cr) + H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 6\ F^- + 2\ H^+$	**-2.738 ± 2.762**	**present**	
$U_3O_5F_8(cr) + H_2O(l) \Leftrightarrow 3\ UO_2^{2+} + 8\ F^- + 2\ H^+$	**-3.055 ± 2.171**	**present**	
$UOFOH(cr) \Leftrightarrow UO_2^{2+} + F^- + H^+$	**-18.019 ± 2.292**	**present**	
$UOFOH \cdot 0.5H_2O(cr) \Leftrightarrow UO_2^{2+} + F^- + H^+ + 0.5\ H_2O(l)$	**-18.478 ± 1.265**	**present**	
$UOF_2 \cdot H_2O(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ F^- + 2\ H_2O(l)$	**-18.796 ± 0.825**	**present**	
$UO_2FOH \cdot H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + F^- + 2\ H_2O(l)$	**-2.338 ± 1.355**	**present**	
$UO_2FOH \cdot 2H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + F^- + 3\ H_2O(l)$	**-2.722 ± 1.510**	**present**	
$UO_2F_2 \cdot 3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ F^- + 3\ H_2O(l)$	**-7.470 ± 1.277**	**present**	
$UCl(g) \Leftrightarrow U^{4+} + Cl^- + 3\ e^-$	**143.135 ± 3.521**	**present**	
$UCl_2(g) \Leftrightarrow U^{4+} + 2\ Cl^- + 2\ e^-$	**108.210 ± 3.556**	**present**	
$UCl_3(cr) \Leftrightarrow U^{3+} + 3\ Cl^-$	**12.968 ± 0.477**	**present**	
$UCl_3(g) \Leftrightarrow U^{3+} + 3\ Cl^-$	**61.049 ± 3.557**	**present**	
$UCl_4(cr) \Leftrightarrow U^{4+} + 4\ Cl^-$	**21.920 ± 0.544**	**present**	
$UCl_4(g) \Leftrightarrow U^{4+} + 4\ Cl^-$	**46.476 ± 0.924**	**present**	
$UCl_5(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Cl^- + 4\ H^+$	**37.265 ± 0.757**	**present**	
$UCl_5(g) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Cl^- + 4\ H^+$	**51.379 ± 2.661**	**present**	
$UCl_6(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ Cl^- + 4\ H^+$	**57.542 ± 0.627**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$UCl_6(g) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 6\ Cl^- + 4\ H^+$	**63.767 ± 0.972**	**present**	
$UOCl(cr) + 2\ H^+ \Leftrightarrow U^{3+} + Cl^- + H_2O(l)$	**10.367 ± 0.914**	**present**	
$UOCl_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ Cl^- + H_2O(l)$	**5.423 ± 0.567**	**present**	
$UOCl_3(cr) + H_2O(l) \Leftrightarrow UO_2^+ + 3\ Cl^- + 2\ H^+$	**12.606 ± 1.502**	**present**	
$UO_2Cl(cr) \Leftrightarrow UO_2^+ + Cl^-$	**-0.528 ± 1.501**	**present**	
$UO_2Cl_2(cr) \Leftrightarrow UO_2^{2+} + 2\ Cl^-$	**12.114 ± 0.384**	**present**	
$UO_2Cl_2(g) \Leftrightarrow UO_2^{2+} + 2\ Cl^-$	**48.353 ± 2.664**	**present**	
$U_2O_2Cl_5(cr) + 2\ H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 5\ Cl^- + 4\ H^+ + e^-$	**8.690 ± 1.058**	**present**	
$(UO_2)_2Cl_3(cr) + e^- \Leftrightarrow 2\ UO_2^{2+} + 3\ Cl^-$	**11.212 ± 0.801**	**present**	
$U_5O_{12}Cl(cr) + 4\ H^+ \Leftrightarrow 5\ UO_2^{2+} + Cl^- + 2\ H_2O(l) + 5\ e^-$	**-26.226 ± 2.659**	**present**	
$UO_2Cl_2{\cdot}H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Cl^- + H_2O(l)$	**8.255 ± 0.651**	**present**	
$UO_2ClOH{\cdot}2H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + Cl^- + 3\ H_2O(l)$	**2.272 ± 0.847**	**present**	
$UO_2Cl_2{\cdot}3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Cl^- + 3\ H_2O(l)$	**5.569 ± 0.614**	**present**	
$UCl_3F(cr) \Leftrightarrow U^{4+} + 3\ Cl^- + F^-$	**10.242 ± 0.964**	**present**	
$UCl_2F_2(cr) \Leftrightarrow U^{4+} + 2\ Cl^- + 2\ F^-$	**-3.614 ± 1.056**	**present**	
$UClF_3(cr) \Leftrightarrow U^{4+} + Cl^- + 3\ F^-$	**-17.644 ± 1.022**	**present**	
$UBr(g) \Leftrightarrow U^{4+} + Br^- + 3\ e^-$	**145.993 ± 2.651**	**present**	
$UBr_2(g) \Leftrightarrow U^{4+} + 2\ Br^- + 2\ e^-$	**113.991 ± 2.698**	**present**	
$UBr_3(cr) \Leftrightarrow U^{3+} + 3\ Br^-$	**20.116 ± 0.807**	**present**	
$UBr_3(g) \Leftrightarrow U^{3+} + 3\ Br^-$	**66.557 ± 3.605**	**present**	
$UBr_4(cr) \Leftrightarrow U^{4+} + 4\ Br^-$	**31.146 ± 0.703**	**present**	
$UBr_4(g) \Leftrightarrow U^{4+} + 4\ Br^-$	**54.424 ± 0.928**	**present**	
$UBr_5(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Br^- + 4\ H^+$	**41.465 ± 1.648**	**present**	
$UBr_5(g) + 2\ H_2O(l) \Leftrightarrow UO_2^+ + 5\ Br^- + 4\ H^+$	**59.176 ± 2.701**	**present**	
$UOBr_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ Br^- + H_2O(l)$	**7.893 ± 1.505**	**present**	
$UOBr_3(cr) + H_2O(l) \Leftrightarrow UO_2^+ + 3\ Br^- + 2\ H^+$	**23.464 ± 3.751**	**present**	
$UO_2Br_2(cr) \Leftrightarrow UO_2^{2+} + 2\ Br^-$	**16.438 ± 0.444**	**present**	
$UO_2Br_2{\cdot}H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Br^- + H_2O(l)$	**12.044 ± 0.540**	**present**	
$UO_2BrOH{\cdot}2H_2O(cr) + H^+ \Leftrightarrow UO_2^{2+} + Br^- + 3\ H_2O(l)$	**4.145 ± 0.826**	**present**	
$UO_2Br_2{\cdot}3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ Br^- + 3\ H_2O(l)$	**9.318 ± 1.025**	**present**	
$UBr_2Cl(cr) \Leftrightarrow U^{3+} + 2\ Br^- + Cl^-$	**17.695 ± 1.741**	**present**	
$UBr_3Cl(cr) \Leftrightarrow U^{4+} + 3\ Br^- + Cl^-$	**28.996 ± 1.741**	**present**	
$UBrCl_2(cr) \Leftrightarrow U^{3+} + Br^- + 2\ Cl^-$	**14.443 ± 1.741**	**present**	
$UBr_2Cl_2(cr) \Leftrightarrow U^{4+} + 2\ Br^- + 2\ Cl^-$	**26.121 ± 1.740**	**present**	
$UBrCl_3(cr) \Leftrightarrow U^{4+} + Br^- + 3\ Cl^-$	**23.451 ± 1.643**	**present**	
$UI(g) \Leftrightarrow U^{4+} + I^- + 3\ e^-$	**152.494 ± 4.399**	**present**	
$UI_2(g) \Leftrightarrow U^{4+} + 2\ I^- + 2\ e^-$	**118.018 ± 4.422**	**present**	
$UI_3(cr) \Leftrightarrow U^{3+} + 3\ I^-$	**28.998 ± 0.916**	**present**	
$UI_3(g) \Leftrightarrow U^{3+} + 3\ I^-$	**75.856 ± 4.423**	**present**	
$UI_4(cr) \Leftrightarrow U^{4+} + 4\ I^-$	**39.258 ± 0.732**	**present**	
$UI_4(g) \Leftrightarrow U^{4+} + 4\ I^-$	**64.325 ± 1.134**	**present**	
$UO_2(IO_3)_2(cr) \Leftrightarrow UO_2^{2+} + 2\ IO_3^-$	**-7.880 ± 0.100**	**14**	
$UClI_3(cr) \Leftrightarrow U^{4+} + Cl^- + 3\ I^-$	**35.119 ± 2.013**	**present**	
$UCl_2I_2(cr) \Leftrightarrow U^{4+} + 2\ Cl^- + 2\ I^-$	**30.201 ± 2.013**	**present**	
$UCl_3I(cr) \Leftrightarrow U^{4+} + 3\ Cl^- + I^-$	**25.465 ± 1.568**	**present**	
$US(cr) + H^+ \Leftrightarrow U^{4+} + HS^- + 2\ e^-$	**34.458 ± 2.260**	**present**	
$US_{1.90}(cr) + 1.9\ H^+ \Leftrightarrow U^{4+} + 1.9\ HS^- + 0.2\ e^-$	**-0.503 ± 3.741**	**present**	
$US_2(cr) + 2\ H^+ \Leftrightarrow U^{4+} + 2\ HS^-$	**-2.429 ± 1.615**	**present**	
$US_3(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 3\ HS^- + H^+$	**-16.768 ± 2.490**	**present**	
$U_2S_3(cr) + 3\ H^+ \Leftrightarrow 2\ U^{3+} + 3\ HS^-$	**6.382 ± 11.808**	**present**	
$U_3S_5(cr) + 5\ H^+ \Leftrightarrow 3\ U^{4+} + 5\ HS^- + 2\ e^-$	**18.095 ± 17.690**	**present**	
$UO_2SO_3(cr) \Leftrightarrow UO_2^{2+} + SO_3^{2-}$	**-15.828 ± 2.358**	**present**	
$U(SO_3)_2(cr) \Leftrightarrow U^{4+} + 2\ SO_3^{2-}$	**-36.444 ± 3.979**	**present**	
$U(SO_4)_2(cr) \Leftrightarrow U^{4+} + 2\ SO_4^{2-}$	**-11.677 ± 2.489**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$U(OH)_2SO_4(cr) + 2\ H^+ \Leftrightarrow U^{4+} + SO_4^{2-} + 2\ H_2O(l)$	**-3.167 ± 0.673**	**present**	
$UO_2SO_4 \cdot 3H_2O(cr) \Leftrightarrow UO_2^{2+} + SO_4^{2-} + 3\ H_2O(l)$	**-1.504 ± 0.447**	**present**	
$U(SO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow U^{4+} + 2\ SO_4^{2-} + 4\ H_2O(l)$	**-11.717 ± 2.032**	**present**	
$U(SO_4)_2 \cdot 8H_2O(cr) \Leftrightarrow U^{4+} + 2\ SO_4^{2-} + 8\ H_2O(l)$	**-12.773 ± 2.952**	**present**	
$USe(cr) + H^+ \Leftrightarrow U^{4+} + HSe^- + 2\ e^-$	**37.339 ± 3.189**	**present**	
$\alpha\text{-}USe_2 + 2\ H^+ \Leftrightarrow U^{4+} + 2\ HSe^-$	**2.776 ± 7.399**	**present**	
$\beta\text{-}USe_2 + 2\ H^+ \Leftrightarrow U^{4+} + 2\ HSe^-$	**2.618 ± 7.430**	**present**	
$USe_3(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 3\ HSe^- + H^+$	**-18.244 ± 7.494**	**present**	
$U_2Se_3(cr) + 3\ H^+ \Leftrightarrow 2\ U^{3+} + 3\ HSe^-$	**17.754 ± 13.198**	**present**	
$U_3Se_4(cr) + 4\ H^+ \Leftrightarrow 3\ U^{4+} + 4\ HSe^- + 4\ e^-$	**74.796 ± 15.118**	**present**	
$U_3Se_5(cr) + 5\ H^+ \Leftrightarrow 3\ U^{4+} + 5\ HSe^- + 2\ e^-$	**42.329 ± 19.996**	**present**	
$UN(cr) + 3\ H_2O(l) \Leftrightarrow U^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	**-58.838 ± 0.615**	**present**	
$\alpha\text{-}UN_{1.59} + 4.77\ H_2O(l) \Leftrightarrow U^{4+} + 1.59\ NO_3^- + 9.54\ H^+ + 11.95\ e^-$	**-133.730 ± 0.970**	**present**	
$\alpha\text{-}UN_{1.73} + 5.19\ H_2O(l) \Leftrightarrow U^{4+} + 1.73\ NO_3^- + 10.38\ H^+ + 12.65\ e^-$	**-151.186 ± 1.356**	**present**	
$UO_2(NO_3)_2(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^-$	**11.921 ± 1.050**	**present**	
$UO_2(NO_3)_2 \cdot H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + H_2O(l)$	**8.464 ± 1.875**	**present**	
$UO_2(NO_3)_2 \cdot 2H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + 2\ H_2O(l)$	**4.891 ± 0.488**	**present**	
$UO_2(NO_3)_2 \cdot 3H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + 3\ H_2O(l)$	**3.655 ± 0.484**	**present**	
$UO_2(NO_3)_2 \cdot 6H_2O(cr) \Leftrightarrow UO_2^{2+} + 2\ NO_3^- + 6\ H_2O(l)$	**2.236 ± 0.444**	**present**	
$UP(cr) + 4\ H_2O(l) \Leftrightarrow U^{4+} + PO_4^{3-} + 8\ H^+ + 9\ e^-$	**59.718 ± 1.989**	**present**	
$UP_2(cr) + 8\ H_2O(l) \Leftrightarrow U^{4+} + 2\ PO_4^{3-} + 16\ H^+ + 14\ e^-$	**68.179 ± 2.709**	**present**	
$U_3P_4(cr) + 16\ H_2O(l) \Leftrightarrow U^{4+} + 4\ PO_4^{3-} + 32\ H^+ + 32\ e^-$	**187.607 ± 4.782**	**present**	
$UPO_5(cr) + H_2O(l) \Leftrightarrow UO_2^+ + PO_4^{3-} + 2\ H^+$	**-30.718 ± 0.967**	**present**	
$UP_2O_7(cr) + 3\ H_2O(l) \Leftrightarrow UO_2^{2+} + 2\ PO_4^{3-} + 6\ H^+ + 2\ e^-$	**-64.323 ± 1.133**	**present**	
$(UO_2)_2P_2O_7(cr) + H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 2\ PO_4^{3-} + 2\ H^+$	**-36.976 ± 1.458**	**present**	
$(UO_2)_3(PO_4)_2(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ PO_4^{3-}$	**-36.324 ± 1.435**	**present**	
$U(HPO_4)_2 \cdot 4H_2O(cr) \Leftrightarrow U^{4+} + 2\ PO_4^{3-} + 4\ H_2O(l) + 2\ H^+$	**-55.194 ± 0.909**	**present**	
$(UO_2)_3(PO_4)_2 \cdot 6H_2O(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ PO_4^{3-} + 6\ H_2O(l)$	**-49.325 ± 2.580**	**present**	
$UAs(cr) + 4\ H_2O(l) \Leftrightarrow U^{4+} + AsO_4^{3-} + 8\ H^+ + 9\ e^-$	**-1.445 ± 1.602**	**present**	
$UAs_2(cr) + 8\ H_2O(l) \Leftrightarrow U^{4+} + 2\ AsO_4^{3-} + 16\ H^+ + 14\ e^-$	**-56.645 ± 2.695**	**present**	
$U_3As_4(cr) + 16\ H_2O(l) \Leftrightarrow 3\ U^{4+} + 4\ AsO_4^{3-} + 32\ H^+ + 32\ e^-$	**-58.971 ± 4.327**	**present**	
$UO_2(AsO_3)_2(cr) + 2\ H_2O(l) \Leftrightarrow UO_2^{2+} + 2\ AsO_4^{3-} + 4\ H^+$	**-29.769 ± 2.548**	**present**	
$(UO_2)_2As_2O_7(cr) + H_2O(l) \Leftrightarrow 2\ UO_2^{2+} + 2\ AsO_4^{3-} + 2\ H^+$	**-29.007 ± 2.602**	**present**	
$(UO_2)_3(AsO_4)_2(cr) \Leftrightarrow 3\ UO_2^{2+} + 2\ AsO_4^{3-}$	**-27.403 ± 2.691**	**present**	
$UC(cr) + 3\ H_2O(l) \Leftrightarrow U^{4+} + CO_3^{2-} + 6\ H^+ + 8\ e^-$	**43.349 ± 0.614**	**present**	
$\alpha\text{-}UC_{1.94} + 5.82\ H_2O(l) \Leftrightarrow U^{4+} + 1.94\ CO_3^{2-} + 11.64\ H^+ + 11.76\ e^-$	**15.142 ± 0.500**	**present**	
$U_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ U^{4+} + 3\ CO_3^{2-} + 18\ H^+ + 20\ e^-$	**56.034 ± 1.871**	**present**	
$USiO_4(cr) + 4\ H^+ \Leftrightarrow U^{4+} + H_4SiO_4(aq)$	**-8.060 ± 0.792**	**present**	
$MgUO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + Mg^{2+} + 2\ H_2O(l)$	**23.231 ± 0.467**	**present**	
$CaUO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + Ca^{2+} + 2\ H_2O(l)$	**15.930 ± 0.555**	**present**	
$\alpha\text{-}SrUO_4 + 4\ H^+ \Leftrightarrow UO_2^{2+} + Sr^{2+} + 2\ H_2O(l)$	**19.155 ± 0.595**	**present**	
$BaUO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + Ba^{2+} + 2\ H_2O(l)$	**17.639 ± 0.807**	**present**	
$Ba_3UO_6(cr) + 8\ H^+ \Leftrightarrow UO_2^{2+} + 3\ Ba^{2+} + 4\ H_2O(l)$	**92.699 ± 2.129**	**present**	
$BaU_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{2+} + Ba^{2+} + 3\ H_2O(l)$	**21.388 ± 1.401**	**present**	
$Ba_2U_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^+ + 2\ Ba^{2+} + 3\ H_2O(l)$	**35.346 ± 1.742**	**present**	
$Li_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Li^+ + 2\ H_2O(l)$	**27.939 ± 0.496**	**present**	
$NaUO_3(cr) + 2\ H^+ \Leftrightarrow UO_2^+ + Na^+ + H_2O(l)$	**8.342 ± 1.779**	**present**	
$\alpha\text{-}Na_2UO_4 + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Na^+ + 2\ H_2O(l)$	**30.034 ± 0.687**	**present**	
$Na_3UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^+ + 3\ Na^+ + 2\ H_2O(l)$	**56.280 ± 1.436**	**present**	
$Na_2U_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{2+} + 2\ Na^+ + 3\ H_2O(l)$	**22.595 ± 0.933**	**present**	
$K_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ K^+ + 2\ H_2O(l)$	**33.874 ± 0.648**	**present**	
$Rb_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Rb^+ + 2\ H_2O(l)$	**34.111 ± 0.649**	**present**	
$Cs_2UO_4(cr) + 4\ H^+ \Leftrightarrow UO_2^{2+} + 2\ Cs^+ + 2\ H_2O(l)$	**35.804 ± 0.419**	**present**	
$Cs_2U_2O_7(cr) + 6\ H^+ \Leftrightarrow 2\ UO_2^{2+} + 2\ Cs^+ + 3\ H_2O(l)$	**30.931 ± 1.866**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$Cs_2U_4O_{12}(cr) + 8\ H^+ \Leftrightarrow 4\ UO_2^{2+} + 2\ Cs^+ + 4\ H_2O(l) + 2\ e^-$	**15.875 ± 1.392**	**present**	
$Na_4UO_2(CO_3)_3(cr) \Leftrightarrow UO_2^{2+} + 4\ Na^+ + 3\ CO_3^{2-}$	**-27.180 ± 0.555**	**present**	
$NpO_2(am) + 4\ H^+ \Leftrightarrow Np^{4+} + 2\ H_2O(l)$	0.604 ± 1.000	45	
$NpO_2OH(am, aged) + H^+ \Leftrightarrow NpO_2^+ + H_2O(l)$	4.700 ± 0.500	14	
$NpO_2OH(am,\ fresh) + H^+ \Leftrightarrow NpO_2^+ + H_2O(l)$	5.300 ± 0.200	14	
$Na_3NpO_2(CO_3)_2(cr) \Leftrightarrow NpO_2^+ + 2\ CO_3^{2-} + 3\ Na^+$	-14.220 ± 0.500	14	
$NaNpO_2CO_3{\bullet}3.5H_2O(cr) \Leftrightarrow NpO_2^+ + CO_3^{2-} + 3.5\ H_2O + Na^+$	-11.000 ± 0.240	14	
$KNpO_2CO_3(s) \Leftrightarrow NpO_2^+ + CO_3^{2-} + K^+$	-13.150 ± 0.190	14	
$K_3NpO_2(CO_3)_2(s) \Leftrightarrow NpO_2^+ + 2\ CO_3^{2-} + 3\ K^+$	-15.460 ± 0.160	14	
$NpO_3{\bullet}H_2O(cr) + 2\ H^+ \Leftrightarrow NpO_2^{2+} + 2\ H_2O(l)$	5.470 ± 0.400	14	
$NpO_2CO_3(s) \Leftrightarrow NpO_2^{2+} + CO_3^{2-}$	-14.596 ± 0.469	14	
$(NH_4)_4NpO_2(CO_3)_3(s) + e^- \Leftrightarrow NpO_2^+ + 3\ CO_3^{2-} + 4\ NH_4^+$	-7.223 ± 0.346	14	
$K_4NpO_2(CO_3)_3(s) + e^- \Leftrightarrow NpO_2^+ + 3\ CO_3^{2-} + 4\ K^+$	-6.813 ± 0.894	14	
$Np(cr) \Leftrightarrow Np^{4+} + 4\ e^-$	**86.155 ± 0.979**	**present**	
$Np(g) \Leftrightarrow Np^{4+} + 4\ e^-$	**159.944 ± 1.112**	**present**	
$NpO_2(cr) + 4\ H^+ \Leftrightarrow Np^{4+} + 2\ H_2O(l)$	**-9.754 ± 1.073**	**present**	
$Np_2O_5(cr) + 2\ H^+ \Leftrightarrow 2\ NpO_2^+ + H_2O(l)$	**3.696 ± 2.785**	**present**	
$NpO_2(OH)_2(cr) + 2\ H^+ \Leftrightarrow NpO_2^{2+} + 2\ H_2O(l)$	**5.469 ± 1.492**	**present**	
$NpF(g) \Leftrightarrow Np^{4+} + F^- + 3\ e^-$	**116.281 ± 4.497**	**present**	
$NpF_2(g) \Leftrightarrow Np^{4+} + 2\ F^- + 2\ e^-$	**81.410 ± 5.377**	**present**	
$NpF_3(cr) \Leftrightarrow Np^{3+} + 3\ F^-$	**-18.056 ± 1.802**	**present**	
$NpF_3(g) \Leftrightarrow Np^{3+} + 3\ F^-$	**43.734 ± 4.536**	**present**	
$NpF_4(cr) \Leftrightarrow Np^{4+} + 4\ F^-$	**-29.070 ± 3.016**	**present**	
$NpF_4(g) \Leftrightarrow Np^{4+} + 4\ F^-$	**14.467 ± 4.040**	**present**	
$NpF_5(cr) + 2\ H_2O(l) \Leftrightarrow NpO_2^+ + 5\ F^- + 4\ H^+$	**1.169 ± 4.598**	**present**	
$NpF_6(cr) + 2\ H_2O(l) \Leftrightarrow NpO_2^{2+} + 6\ F^- + 4\ H^+$	**29.594 ± 3.712**	**present**	
$NpF_6(g) + 2\ H_2O(l) \Leftrightarrow NpO_2^{2+} + 6\ F^- + 4\ H^+$	**30.356 ± 3.712**	**present**	
$NpCl_3(cr) \Leftrightarrow Np^{3+} + 3\ Cl^-$	**13.438 ± 1.145**	**present**	
$NpCl_3(g) \Leftrightarrow Np^{3+} + 3\ Cl^-$	**56.790 ± 2.141**	**present**	
$NpCl_4(cr) \Leftrightarrow Np^{4+} + 4\ Cl^-$	**21.212 ± 1.114**	**present**	
$NpCl_4(g) \Leftrightarrow Np^{4+} + 4\ Cl^-$	**44.077 ± 1.374**	**present**	
$NpOCl_2(cr) + 2\ H^+ \Leftrightarrow Np^{4+} + 2\ Cl^- + H_2O(l)$	**5.379 ± 1.730**	**present**	
$NpBr_3(cr) \Leftrightarrow Np^{3+} + 3\ Br^-$	**20.829 ± 1.195**	**present**	
$NpBr_4(cr) \Leftrightarrow Np^{4+} + 4\ Br^-$	**29.665 ± 1.160**	**present**	
$NpOBr_2(cr) + 2\ H^+ \Leftrightarrow Np^{4+} + 2\ Br^- + H_2O(l)$	**5.200 ± 2.173**	**present**	
$NpI_3(cr) \Leftrightarrow Np^{3+} + 3\ I^-$	**27.249 ± 1.189**	**present**	
$NpN(cr) + 3\ H_2O(l) \Leftrightarrow Np^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	**-68.201 ± 2.010**	**present**	
$NpO_2(NO_3)_2{\cdot}6H_2O(cr) \Leftrightarrow NpO_2^{2+} + 2\ NO_3^- + 6\ H_2O(l)$	**2.155 ± 1.393**	**present**	
$NpC_{0.91}(cr) + 2.73\ H_2O(l) \Leftrightarrow Np^{4+} + 0.91\ CO_3^{2-} + 5.46\ H^+ + 7.64\ e^-$	**43.578 ± 2.012**	**present**	
$Np_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ Np^{4+} + 3\ CO_3^{2-} + 18\ H^+ + 20\ e^-$	**42.144 ± 3.933**	**present**	
$Na_3NpF_8(cr) + e^- \Leftrightarrow 3\ Na^+ + Np^{4+} + 8\ F^-$	**1.503 ± 3.979**	**present**	
$K_4NpO_2(CO_3)_3(s) \Leftrightarrow 4\ K^+ + NpO_2^{2+} + 3\ CO_3^{2-}$	**-26.404 ± 1.676**	**present**	
$Cs_2NpCl_6(cr) \Leftrightarrow 2\ Cs^+ + Np^{4+} + 6\ Cl^-$	**5.072 ± 1.318**	**present**	
$Cs_2NpBr_6(cr) \Leftrightarrow 2\ Cs^+ + Np^{4+} + 6\ Br^-$	**13.606 ± 1.194**	**present**	
$Pu(OH)_3(am) + 3\ H^+ \Leftrightarrow Pu^{3+} + 3\ H_2O(l)$	16.900 ± 0.800	28	
$PuCO_3OH(am) + H^+ \Leftrightarrow Pu^{3+} + CO_3^{2-} + H_2O(l)$	-6.199 ± 1.000	28	
$PuCO_3OH{\bullet}0.5H_2O(cr) + H^+ \Leftrightarrow Pu^{3+} + CO_3^{2-} + 1.5\ H_2O(l)$	-8.399 ± 0.500	28	
$Pu(OH)_3(cr) + 3\ H^+ \Leftrightarrow Pu^{3+} + 3\ H_2O(l)$	15.600 ± 0.600	28	
$Pu_2(CO_3)_3(am) \Leftrightarrow 2\ Pu^{3+} + 3\ CO_3^{2-}$	-33.400 ± 2.200	28	
$PuPO_4(am,hydr) \Leftrightarrow Pu^{3+} + PO_4^{3-}$	-24.790 ± 0.600	28	
$PuO_2(am) + 4\ H^+ \Leftrightarrow Pu^{4+} + 2\ H_2O(l)$	-2.326 ± 0.520	14	
$PuO_2OH(am) + H^+ \Leftrightarrow PuO_2^+ + H_2O(l)$	5.000 ± 0.500	14	
$PuO_2(OH)_2{\cdot}H_2O(cr) + 2\ H^+ \Leftrightarrow PuO_2^{2+} + 3\ H_2O(l)$	5.500 ± 1.000	14	
$Pu(HPO_4)_2(am) \Leftrightarrow Pu^{4+} + 2\ H^+ + 2\ PO_4^{3-}$	5.750 ± 0.514	14	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$PuO_2CO_3(s) \Leftrightarrow PuO_2^{2+} + CO_3^{2-}$	-14.650 ± 0.470	14	
$Pu(cr) \Leftrightarrow Pu^{4+} + 4\ e^-$	**83.739 ± 0.474**	**present**	
$Pu(g) \Leftrightarrow Pu^{4+} + 4\ e^-$	**138.472 ± 0.709**	**present**	
$PuO_{1.61}(bcc) + 3.22\ H^+ \Leftrightarrow Pu^{4+} + 1.61\ H_2O(l) + 0.78\ e^-$	**4.382 ± 1.834**	**present**	
$PuO_2(cr) + 4\ H^+ \Leftrightarrow Pu^{4+} + 2\ H_2O(l)$	**-8.032 ± 0.507**	**present**	
$Pu_2O_3(cr) + 6\ H^+ \Leftrightarrow 2\ Pu^{3+} + 3\ H_2O(l)$	**50.633 ± 1.991**	**present**	
$Pu(OH)_3(cr) + 3\ H^+ \Leftrightarrow Pu^{3+} + 3\ H_2O(l)$	**15.800 ± 1.641**	**present**	
$PuF(g) \Leftrightarrow Pu^{4+} + F^- + 3\ e^-$	**108.364 ± 1.838**	**present**	
$PuF_2(g) \Leftrightarrow Pu^{4+} + 2\ F^- + 2\ e^-$	**72.684 ± 1.289**	**present**	
$PuF_3(cr) \Leftrightarrow Pu^{3+} + 3\ F^-$	**-16.436 ± 0.881**	**present**	
$PuF_3(g) \Leftrightarrow Pu^{3+} + 3\ F^-$	**45.983 ± 1.024**	**present**	
$PuF_4(cr) \Leftrightarrow Pu^{4+} + 4\ F^-$	**-26.745 ± 3.569**	**present**	
$PuF_4(g) \Leftrightarrow Pu^{4+} + 4\ F^-$	**15.103 ± 3.948**	**present**	
$PuF_6(cr) + 2\ H_2O(l) \Leftrightarrow PuO_2^{2+} + 6\ F^- + 4\ H^+$	**43.334 ± 3.642**	**present**	
$PuF_6(g) + 2\ H_2O(l) \Leftrightarrow PuO_2^{2+} + 6\ F^- + 4\ H^+$	**44.174 ± 3.630**	**present**	
$PuOF(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + F^- + H_2O(l)$	**1.064 ± 3.576**	**present**	
$PuCl_3(cr) \Leftrightarrow Pu^{3+} + 3\ Cl^-$	**14.161 ± 0.593**	**present**	
$PuCl_3(g) \Leftrightarrow Pu^{3+} + 3\ Cl^-$	**58.047 ± 0.789**	**present**	
$PuCl_4(cr) \Leftrightarrow Pu^{4+} + 4\ Cl^-$	**21.634 ± 1.128**	**present**	
$PuCl_4(g) \Leftrightarrow Pu^{4+} + 4\ Cl^-$	**41.726 ± 1.891**	**present**	
$PuOCl(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + Cl^- + H_2O(l)$	**11.376 ± 0.581**	**present**	
$PuCl_3 \cdot 6H_2O(cr) \Leftrightarrow Pu^{3+} + 3\ Cl^- + 6\ H_2O(l)$	**5.278 ± 0.658**	**present**	
$PuBr_3(cr) \Leftrightarrow Pu^{3+} + 3\ Br^-$	**21.585 ± 0.673**	**present**	
$PuBr_3(g) \Leftrightarrow Pu^{3+} + 3\ Br^-$	**63.196 ± 2.784**	**present**	
$PuOBr(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + Br^- + H_2O(l)$	**14.299 ± 1.569**	**present**	
$PuI_3(cr) \Leftrightarrow Pu^{3+} + 3\ I^-$	**27.182 ± 0.928**	**present**	
$PuI_3(g) \Leftrightarrow Pu^{3+} + 3\ I^-$	**64.407 ± 2.783**	**present**	
$PuOI(cr) + 2\ H^+ \Leftrightarrow Pu^{3+} + I^- + H_2O(l)$	**15.981 ± 3.621**	**present**	
$PuN(cr) + 3\ H_2O(l) \Leftrightarrow Pu^{4+} + NO_3^- + 6\ H^+ + 9\ e^-$	**-69.438 ± 0.656**	**present**	
$PuP(cr) + 4\ H_2O(l) \Leftrightarrow Pu^{4+} + PO_4^{3-} + 8\ H^+ + 9\ e^-$	**42.250 ± 3.733**	**present**	
$PuPO_4(s, hyd) \Leftrightarrow Pu^{3+} + 3\ PO_4^{3-}$	**-24.600 ± 1.112**	**present**	
$PuAs(cr) + 4\ H_2O(l) \Leftrightarrow Pu^{4+} + AsO_4^{3-} + 8\ H^+ + 9\ e^-$	**-11.147 ± 3.624**	**present**	
$PuC_{0.84}(cr) + 2.52\ H_2O(l) \Leftrightarrow Pu^{4+} + 0.84\ CO_3^{2-} + 5.04\ H^+ + 7.36\ e^-$	**48.003 ± 1.485**	**present**	
$Pu_3C_2(cr) + 6\ H_2O(l) \Leftrightarrow 3\ Pu^{4+} + 2\ CO_3^{2-} + 12\ H^+ + 20\ e^-$	**165.284 ± 5.454**	**present**	
$Pu_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ Pu^{4+} + 3\ CO_3^{2-} + 18\ H^+ + 20\ e^-$	**43.605 ± 3.088**	**present**	
$Cs_2PuCl_6(cr) \Leftrightarrow 2\ Cs^+ + Pu^{4+} + 6\ Cl^-$	**1.745 ± 1.288**	**present**	
$Cs_3PuCl_6(cr) \Leftrightarrow 3\ Cs^+ + Pu^{3+} + 6\ Cl^-$	**5.713 ± 1.755**	**present**	
$CsPu_2Cl_7(cr) \Leftrightarrow Cs^+ + 2\ Pu^{3+} + 7\ Cl^-$	**23.270 ± 1.332**	**present**	
$Cs_2PuBr_6(cr) \Leftrightarrow 2\ Cs^+ + Pu^{4+} + 6\ Br^-$	**8.702 ± 1.205**	**present**	
$Cs_2NaPuCl_6(cr) \Leftrightarrow Na^+ + 2\ Cs^+ + Pu^{3+} + 6\ Cl^-$	**11.853 ± 1.047**	**present**	
$Am(OH)_3(am) + 3\ H^+ \Leftrightarrow Am^{3+} + 3\ H_2O(l)$	16.900 ± 0.800	14	
$Am(OH)_3(cr) + 3\ H^+ \Leftrightarrow Am^{3+} + 3\ H_2O(l)$	15.600 ± 0.600	14	
$Am_2(CO_3)_3(am) \Leftrightarrow 2\ Am^{3+} + 3\ CO_3^{2-}$	-33.400 ± 2.200	14	
$AmCO_3OH(am) + H^+ \Leftrightarrow Am^{3+} + CO_3^{2-} + H_2O(l)$	-6.199 ± 1.000	14	
$AmCO_3OH \cdot 0.5H_2O(cr) + H^+ \Leftrightarrow Am^{3+} + CO_3^{2-} + 1.5\ H_2O(l)$	-8.399 ± 0.500	14	
$NaAm(CO_3)_2 \cdot 5H_2O(cr) \Leftrightarrow Am^{3+} + 2\ CO_3^{2-} + 5\ H_2O(l) + Na^+$	-21.000 ± 0.500	14	
$AmPO_4(am,hydr) \Leftrightarrow Am^{3+} + PO_4^{3-}$	-24.790 ± 0.600	14	
$AmO_2OH(am) + H^+ \Leftrightarrow AmO_2^+ + H_2O(l)$	**5.300 ± 0.500**	**14**	
$NaAmO_2CO_3(s) \Leftrightarrow AmO_2^+ + CO_3^{2-} + Na^+$	**-10.900 ± 0.400**	**14**	
$Am(cr) \Leftrightarrow Am^{3+} + 3\ e^-$	**104.887 ± 0.833**	**present**	
$Am(g) \Leftrightarrow Am^{3+} + 3\ e^-$	**147.338 ± 0.880**	**present**	
$AmO_2(cr) + 4\ H^+ \Leftrightarrow Am^{4+} + 2\ H_2O(l)$	**-9.994 ± 1.697**	**present**	
$Am_2O_3(cr) + 6\ H^+ \Leftrightarrow 2\ Am^{3+} + 3\ H_2O(l)$	**53.147 ± 2.210**	**present**	
$AmH_2(cr) \Leftrightarrow Am^{2+} + 2\ H^+$	**42.417 ± 3.752**	**present**	

Reaction	$\log_{10} K°$	ref.	t.v.[*1]
$AmF_3(cr) \Leftrightarrow Am^{3+} + 3\ F^-$	**-13.402 ± 2.636**	**present**	
$AmF_3(g) \Leftrightarrow Am^{3+} + 3\ F^-$	**51.764 ± 3.076**	**present**	
$AmF_4(cr) \Leftrightarrow Am^{4+} + 4\ F^-$	**-28.040 ± 3.407**	**present**	
$AmCl_3(cr) \Leftrightarrow Am^{3+} + 3\ Cl^-$	**15.284 ± 0.927**	**present**	
$AmBr_3(cr) \Leftrightarrow Am^{3+} + 3\ Br^-$	**23.927 ± 1.446**	**present**	
$AmOCl(cr) + 2\ H^+ \Leftrightarrow Am^{3+} + Cl^- + H_2O(l)$	**12.264 ± 1.443**	**present**	
$AmOBr(cr) + 2\ H^+ \Leftrightarrow Am^{3+} + Br^- + H_2O(l)$	**15.978 ± 1.908**	**present**	
$AmI_3(cr) \Leftrightarrow Am^{3+} + 3\ I^-$	**25.301 ± 1.952**	**present**	
$Am_2C_3(cr) + 9\ H_2O(l) \Leftrightarrow 2\ Am^{3+} + 8\ H^+ + 8\ e^- + 3\ CO_3^{2-}$	**85.979 ± 7.622**	**present**	
$Cs_2NaAmCl_6(cr) \Leftrightarrow Am^{3+} + 2\ Cs^+ + Na^+ + 6\ Cl^-$	**12.564 ± 1.213**	**present**	
$Cm(OH)_3(am) + 3\ H^+ \Leftrightarrow Cm^{3+} + 3\ H_2O(l)$	16.900 ± 0.800	28	
$Cm(OH)_3(cr) + 3\ H^+ \Leftrightarrow Cm^{3+} + 3\ H_2O(l)$	15.600 ± 0.600	28	
$Cm_2(CO_3)_3(am) \Leftrightarrow 2\ Cm^{3+} + 3\ CO_3^{2-}$	-33.400 ± 2.200	28	
$CmCO_3OH(am) + H^+ \Leftrightarrow Cm^{3+} + CO_3^{2-} + H_2O(l)$	-6.199 ± 1.000	28	
$CmCO_3OH•0.5H_2O(cr) + H^+ \Leftrightarrow Cm^{3+} + CO_3^{2-} + 1.5\ H_2O(l)$	-8.399 ± 0.500	28	
$NaCm(CO_3)_2•5H_2O(cr) \Leftrightarrow Cm^{3+} + 2\ CO_3^{2-} + 5\ H_2O(l) + Na^+$	-21.000 ± 0.500	28	
$CmPO_4(am,hydr) \Leftrightarrow Cm^{3+} + PO_4^{3-}$	-24.790 ± 0.600	28	
$UO_2ox·3H_2O(cr) \Leftrightarrow UO_2^{2+} + ox^{2-} + 3\ H_2O(l)$	-8.930 ± 0.314	46	
$Ca(ox)·H_2O(cr) \Leftrightarrow Ca^{2+} + H_2O(l) + ox^{2-}$	-8.730 ± 0.060	46	
$Ca(ox)·2H_2O(cr) \Leftrightarrow Ca^{2+} + 2\ H_2O(l) + ox^{2-}$	-8.300 ± 0.060	46	
$Ca(ox)·3H_2O(cr) \Leftrightarrow Ca^{2+} + 3\ H_2O(l) + ox^{2-}$	-8.190 ± 0.040	46	
$H_3cit(cr) \Leftrightarrow cit^{3-} + 3\ H^+$	-13.041 ± 0.500	46	
$H_3cit·H_2O(cr) \Leftrightarrow cit^{3-} + 3\ H^+ + H_2O(l)$	-12.950 ± 0.024	46	
$Ca_3(cit)_2·4H_2O(cr) \Leftrightarrow 3\ Ca^{2+}\ 4\ H_2O(l) + 2\ cit^{3-}$	-17.900 ± 0.100	46	
$H_4edta(cr) \Leftrightarrow\ edta^{4-} + 4\ H^+$	-27.220 ± 0.201	46	
$Ca(isa)_2(cr) \Leftrightarrow Ca^{2+} + 2\ isa^-$	-6.400 ± 0.200	46	

[*1] Tentative values.

Appendix 2. Text Files of JAEA-TDB for Geochemical Calculation Programs

Enclosed CD-ROM contains three text files of JAEA-TDB for geochemical calculation programs. Correspondence between file name and its corresponding geochemical calculation program is shown in Table A3.

Table A3 Correspondence between file name and its corresponding geochemical calculation program

file name	corresponding geochemical calculation program
100331c2.tdb	PHREEQC [5]
100331e1.tdb	EQ3/6 Ver. 7.2c [6]
100331g1.tdb	Geochemist's Workbench [7]

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国際単位系（SI）

表１．SI 基本単位

基本量	SI 基本単位	
	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光度	カンデラ	cd

表２．基本単位を用いて表されるSI組立単位の例

組立量	SI 基本単位	
	名称	記号
面積	平方メートル	m^2
体積	立法メートル	m^3
速さ，速度	メートル毎秒	m/s
加速度	メートル毎秒毎秒	m/s^2
波数	毎メートル	m^{-1}
密度，質量密度	キログラム毎立方メートル	kg/m^3
面積密度	キログラム毎平方メートル	kg/m^2
比体積	立方メートル毎キログラム	m^3/kg
電流密度	アンペア毎平方メートル	A/m^2
磁界の強さ	アンペア毎メートル	A/m
量濃度(a)，濃度	モル毎立方メートル	mol/m^3
質量濃度	キログラム毎立法メートル	kg/m^3
輝度	カンデラ毎平方メートル	cd/m^2
屈折率(b)	（数字の） 1	1
比透磁率(b)	（数字の） 1	1

(a) 量濃度（amount concentration）は臨床化学の分野では物質濃度（substance concentration）ともよばれる。
(b) これらは無次元量あるいは次元１をもつ量であるが、そのことを表す単位記号である数字の１は通常は表記しない。

表３．固有の名称と記号で表されるSI組立単位

組立量	SI 組立単位			
	名称	記号	他のSI単位による表し方	SI基本単位による表し方
平面角	ラジアン(b)	rad	1 (b)	m/m
立体角	ステラジアン(b)	sr(c)	1 (b)	m^2/m^2
周波数	ヘルツ(d)	Hz		s^{-1}
力	ニュートン	N		m kg s^{-2}
圧力，応力	パスカル	Pa	N/m^2	m^{-1} kg s^{-2}
エネルギー，仕事，熱量	ジュール	J	N m	m^2 kg s^{-2}
仕事率，工率，放射束	ワット	W	J/s	m^2 kg s^{-3}
電荷，電気量	クーロン	C		s A
電位差（電圧），起電力	ボルト	V	W/A	m^2 kg s^{-3} A^{-1}
静電容量	ファラド	F	C/V	m^{-2} kg^{-1} s^4 A^2
電気抵抗	オーム	Ω	V/A	m^2 kg s^{-3} A^{-2}
コンダクタンス	ジーメンス	S	A/V	m^{-2} kg^{-1} s^3 A^2
磁束	ウエーバ	Wb	Vs	m^2 kg s^{-2} A^{-1}
磁束密度	テスラ	T	Wb/m^2	kg s^{-2} A^{-1}
インダクタンス	ヘンリー	H	Wb/A	m^2 kg s^{-2} A^{-2}
セルシウス温度	セルシウス度(e)	℃		K
光束	ルーメン	lm	cd sr(c)	cd
照度	ルクス	lx	lm/m^2	m^{-2} cd
放射性核種の放射能(f)	ベクレル(d)	Bq		s^{-1}
吸収線量，比エネルギー分与，カーマ	グレイ	Gy	J/kg	m^2 s^{-2}
線量当量，周辺線量当量，方向性線量当量，個人線量当量	シーベルト(g)	Sv	J/kg	m^2 s^{-2}
酸素活性	カタール	kat		s^{-1} mol

(a)SI接頭語は固有の名称と記号を持つ組立単位と組み合わせても使用できる。しかし接頭語を付した単位はもはやコヒーレントではない。
(b)ラジアンとステラジアンは数字の１に対する単位の特別な名称で、量についての情報をつたえるために使われる。実際には、使用する時には記号rad及びsrが用いられるが、習慣として組立単位としての記号である数字の１は明示されない。
(c)測光学ではステラジアンという名称と記号srを単位の表し方の中に、そのまま維持している。
(d)ヘルツは周期現象についてのみ、ベクレルは放射性核種の統計的過程についてのみ使用される。
(e)セルシウス度はケルビンの特別な名称で、セルシウス温度を表すために使用される。セルシウス度とケルビンの単位の大きさは同一である。したがって、温度差や温度間隔を表す数値はどちらの単位で表しても同じである。
(f)放射性核種の放射能（activity referred to a radionuclide）は、しばしば誤った用語で"radioactivity"と記される。
(g)単位シーベルト（PV,2002,70,205）についてはCIPM勧告2（CI-2002）を参照。

表４．単位の中に固有の名称と記号を含むSI組立単位の例

組立量	SI 組立単位		
	名称	記号	SI 基本単位による表し方
粘度	パスカル秒	Pa s	m^{-1} kg s^{-1}
力のモーメント	ニュートンメートル	N m	m^2 kg s^{-2}
表面張力	ニュートン毎メートル	N/m	kg s^{-2}
角速度	ラジアン毎秒	rad/s	m m^{-1} s^{-1}=s^{-1}
角加速度	ラジアン毎秒毎秒	rad/s^2	m m^{-1} s^{-2}=s^{-2}
熱流密度，放射照度	ワット毎平方メートル	W/m^2	kg s^{-3}
熱容量，エントロピー	ジュール毎ケルビン	J/K	m^2 kg s^{-2} K^{-1}
比熱容量，比エントロピー	ジュール毎キログラム毎ケルビン	J/(kg K)	m^2 s^{-2} K^{-1}
比エネルギー	ジュール毎キログラム	J/kg	m^2 s^{-2}
熱伝導率	ワット毎メートル毎ケルビン	W/(m K)	m kg s^{-3} K^{-1}
体積エネルギー	ジュール毎立方メートル	J/m^3	m^{-1} kg s^{-2}
電界の強さ	ボルト毎メートル	V/m	m kg s^{-3} A^{-1}
電荷密度	クーロン毎立方メートル	C/m^3	m^{-3} sA
表面電荷	クーロン毎平方メートル	C/m^2	m^{-2} sA
電束密度，電気変位	クーロン毎平方メートル	C/m^2	m^{-2} sA
誘電率	ファラド毎メートル	F/m	m^{-3} kg^{-1} s^4 A^2
透磁率	ヘンリー毎メートル	H/m	m kg s^{-2} A^{-2}
モルエネルギー	ジュール毎モル	J/mol	m^2 kg s^{-2} mol^{-1}
モルエントロピー，モル熱容量	ジュール毎モル毎ケルビン	J/(mol K)	m^2 kg s^{-2} K^{-1} mol^{-1}
照射線量（X線及びγ線）	クーロン毎キログラム	C/kg	kg^{-1} sA
吸収線量率	グレイ毎秒	Gy/s	m^2 s^{-3}
放射強度	ワット毎ステラジアン	W/sr	m^4 m^{-2} kg s^{-3}=m^2 kg s^{-3}
放射輝度	ワット毎平方メートル毎ステラジアン	$W/(m^2 sr)$	m^2 m^{-2} kg s^{-3}=kg s^{-3}
酵素活性濃度	カタール毎立方メートル	kat/m^3	m^{-3} s^{-1} mol

表５．SI 接頭語

乗数	接頭語	記号	乗数	接頭語	記号
10^{24}	ヨタ	Y	10^{-1}	デシ	d
10^{21}	ゼタ	Z	10^{-2}	センチ	c
10^{18}	エクサ	E	10^{-3}	ミリ	m
10^{15}	ペタ	P	10^{-6}	マイクロ	μ
10^{12}	テラ	T	10^{-9}	ナノ	n
10^{9}	ギガ	G	10^{-12}	ピコ	p
10^{6}	メガ	M	10^{-15}	フェムト	f
10^{3}	キロ	k	10^{-18}	アト	a
10^{2}	ヘクト	h	10^{-21}	ゼプト	z
10^{1}	デカ	da	10^{-24}	ヨクト	y

表６．SIに属さないが、SIと併用される単位

名称	記号	SI 単位による値
分	min	1 min=60s
時	h	1h =60 min=3600 s
日	d	1 d=24 h=86 400 s
度	°	1°=(π/180) rad
分	’	1’=(1/60)°=(π/10800) rad
秒	”	1”=(1/60)’=(π/648000) rad
ヘクタール	ha	$1ha=1hm^2=10^4m^2$
リットル	L，l	$1L=11=1dm^3=10^3cm^3=10^{-3}m^3$
トン	t	$1t=10^3$ kg

表７．SIに属さないが、SIと併用される単位で、SI単位で表される数値が実験的に得られるもの

名称	記号	SI 単位で表される数値
電子ボルト	eV	$1eV=1.602\ 176\ 53(14)\times10^{-19}J$
ダルトン	Da	$1Da=1.660\ 538\ 86(28)\times10^{-27}kg$
統一原子質量単位	u	1u=1 Da
天文単位	ua	$1ua=1.495\ 978\ 706\ 91(6)\times10^{11}m$

表８．SIに属さないが、SIと併用されるその他の単位

名称	記号	SI 単位で表される数値
バール	bar	1 bar=0.1MPa=100kPa=10^5Pa
水銀柱ミリメートル	mmHg	1mmHg=133.322Pa
オングストローム	Å	1 Å=0.1nm=100pm=10^{-10}m
海里	M	1 M=1852m
バーン	b	$1\ b=100fm^2=(10^{-12}cm)2=10^{-28}m^2$
ノット	kn	1 kn=(1852/3600)m/s
ネーパ	Np	SI単位との数値的な関係は、対数量の定義に依存。
ベル	B	
デジベル	dB	

表９．固有の名称をもつCGS組立単位

名称	記号	SI 単位で表される数値
エルグ	erg	$1\ erg=10^{-7}$ J
ダイン	dyn	$1\ dyn=10^{-5}$N
ポアズ	P	1 P=1 dyn s cm^{-2}=0.1Pa s
ストークス	St	1 St =$1cm^2$ s^{-1}=$10^{-4}m^2$ s^{-1}
スチルブ	sb	1 sb =1cd cm^{-2}=10^4cd m^{-2}
フォト	ph	1 ph=1cd sr cm^{-2} 10^4lx
ガル	Gal	1 Gal =1cm s^{-2}=$10^{-2}ms^{-2}$
マクスウェル	Mx	1 Mx = 1G cm^2=10^{-8}Wb
ガウス	G	1 G =1Mx cm^{-2} =10^{-4}T
エルステッド(c)	Oe	1 Oe ≙ $(10^3/4\pi)$A m^{-1}

(c) 3元系のCGS単位系とSIでは直接比較できないため、等号「 ≙ 」は対応関係を示すものである。

表10．SIに属さないその他の単位の例

名称	記号	SI 単位で表される数値
キュリー	Ci	$1\ Ci=3.7\times10^{10}Bq$
レントゲン	R	$1\ R = 2.58\times10^{-4}C/kg$
ラド	rad	$1\ rad=1cGy=10^{-2}Gy$
レム	rem	$1\ rem=1\ cSv=10^{-2}Sv$
ガンマ	γ	$1\ \gamma=1\ nT=10\text{-}9T$
フェルミ		1フェルミ=1 fm=10-15m
メートル系カラット		1メートル系カラット = 200 mg = 2×10-4kg
トル	Torr	1 Torr = (101 325/760) Pa
標準大気圧	atm	1 atm = 101 325 Pa
カロリー	cal	1cal=4.1858J（「15℃」カロリー），4.1868J（「IT」カロリー） 4.184J（「熱化学」カロリー）
ミクロン	μ	1 μ =1μm=10^{-6}m

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