

### B.3 Tables of ion interaction coefficients

Table B-4, Table B-5, Table B-6 and Table B-7 contain the selected specific ion interaction coefficients used in this review, according to the specific ion interaction treatment described. Table B-4 contains cation interaction coefficients with  $\text{Cl}^-$ ,  $\text{ClO}_4^-$  and  $\text{NO}_3^-$ , Table B-5 anion interaction coefficients with  $\text{Li}^+$ ,  $\text{Na}^+$  (or  $\text{NH}_4^+$ ) and  $\text{K}^+$ , and Table B-7 neutral species – electroneutral combination of ions. The coefficients have the units of  $\text{kg}\cdot\text{mol}^{-1}$  and are valid for 298.15 K and 1 bar. The species are ordered by charge and appear, within each charge class, in the standard order of arrangement, *cf.* Section II.1.8.

It should be noted that ion interaction coefficients tabulated in Table B-4, Table B-5 and Table B-6 may also involve ion pairing effects, as described in Section B.2. In direct comparisons of ion interaction coefficients, or when estimates are made by analogy, this aspect must be taken into account.

Table B-4: Ion interaction coefficients  $\varepsilon(j,k)$  ( $\text{kg}\cdot\text{mol}^{-1}$ ) for cations  $j$  with  $k = \text{Cl}^-$ ,  $\text{ClO}_4^-$  and  $\text{NO}_3^-$  at 298.15 K. The uncertainties represent the 95% confidence level. The ion interaction coefficients marked with † can be described more accurately with an ionic strength dependent function, listed in Table B-6. The coefficients  $\varepsilon(\text{M}^{n+}, \text{Cl}^-)$  and  $\varepsilon(\text{M}^{n+}, \text{NO}_3^-)$  reported by Ciavatta [1980CIA] were evaluated without taking chloride and nitrate complexation into account, as discussed in Section B.2.

$j$	$k$	$\varepsilon(j,k)$	Comments
$\text{H}^+$	$\text{Cl}^-$	$0.12 \pm 0.01$	Reported by Ciavatta [1980CIA].
	$\text{ClO}_4^-$	$0.14 \pm 0.02$	
	$\text{NO}_3^-$	$0.07 \pm 0.01$	
$\text{NH}_4^+$	$\text{Cl}^-$	$-0.01 \pm 0.01$	Reported by Ciavatta [1980CIA].
	$\text{ClO}_4^-$	$-0.08 \pm 0.04^\dagger$	
	$\text{NO}_3^-$	$-0.06 \pm 0.03^\dagger$	
$\text{H}_2\text{gly}^+$	$\text{Cl}^-$	$-0.06 \pm 0.02$	Reported by Ciavatta [1988CIA].
	$\text{ClO}_4^-$	—	
	$\text{NO}_3^-$	—	
$\text{H}_5\text{edta}^+$	$\text{Cl}^-$	$-0.23 \pm 0.15$	See Section VIII.3.7 of [2005HUM/AND].
	$\text{ClO}_4^-$	$-0.23 \pm 0.15$	
	$\text{NO}_3^-$	$-0.23 \pm 0.15$	
$\text{SnOH}^+$	$\text{Cl}^-$	—	See Section VII.1.1 of [2012GAM/GAJ].
	$\text{ClO}_4^-$	$-0.07 \pm 0.13$	
	$\text{NO}_3^-$	—	
$\text{SnF}^+$	$\text{Cl}^-$	—	See Section VIII.3.1.1 of [2012GAM/GAJ].
	$\text{ClO}_4^-$	$0.14 \pm 0.10$	
	$\text{NO}_3^-$	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
SnCl <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.08 ± 0.07	See Section VIII.3.2.1 of [2012GAM/GAJ].
	NO <sub>3</sub> <sup>-</sup>	—	
SnBr <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.15 ± 0.07	See Section VIII.3.3.1 of [2012GAM/GAJ].
	NO <sub>3</sub> <sup>-</sup>	—	
SnNO <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.17 ± 0.09	See Section X.1.1 of [2012GAM/GAJ].
	NO <sub>3</sub> <sup>-</sup>	—	
SnSCN <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.17 ± 0.29	See Section XI.1.1 of [2012GAM/GAJ].
	NO <sub>3</sub> <sup>-</sup>	—	
Tl <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	-0.21 ± 0.06 <sup>†</sup>	
	NO <sub>3</sub> <sup>-</sup>	—	
ZnHCO <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	0.2	Taken from Ferri <i>et al.</i> [1985FER/GRE].
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	—	
CdCl <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.25 ± 0.02	Reported by Ciavatta [1980CIA].
	NO <sub>3</sub> <sup>-</sup>	—	
CdI <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.27 ± 0.02	Reported by Ciavatta [1980CIA].
	NO <sub>3</sub> <sup>-</sup>	—	
CdSCN <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.31 ± 0.02	Reported by Ciavatta [1980CIA].
	NO <sub>3</sub> <sup>-</sup>	—	
HgCl <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.19 ± 0.02	Reported by Ciavatta [1988CIA].
	NO <sub>3</sub> <sup>-</sup>	—	
Cu <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.11 ± 0.01	Reported by Ciavatta [1980CIA].
	NO <sub>3</sub> <sup>-</sup>	—	
Ag <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.00 ± 0.01	Reported by Ciavatta [1980CIA].
	NO <sub>3</sub> <sup>-</sup>	-0.12 ± 0.05 <sup>†</sup>	

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Table B-4 (continued)

$j$	$k$	$\varepsilon(j,k)$	Comments
NiOH <sup>+</sup>	Cl <sup>-</sup>	-0.01 ± 0.07	Evaluated in [2005GAM/BUG] (Section V.3.1.1) for the reaction Ni <sup>2+</sup> + H <sub>2</sub> O ⇌ NiOH <sup>+</sup> + H <sup>+</sup> from Δε in chloride media / perchlorate media.
	ClO <sub>4</sub> <sup>-</sup>	0.14 ± 0.07	
	NO <sub>3</sub> <sup>-</sup>	—	
NiF <sup>+</sup>	Cl <sup>-</sup>	—	Derived from Δε = ε(NiF <sup>+</sup> , ClO <sub>4</sub> <sup>-</sup> ) - ε(Ni <sup>2+</sup> , ClO <sub>4</sub> <sup>-</sup> ) - ε(Na <sup>+</sup> , F <sup>-</sup> ) = - (0.049 ± 0.060) kg·mol <sup>-1</sup> (see Section V.4.2.3 of [2005GAM/BUG]).
	ClO <sub>4</sub> <sup>-</sup>	0.34 ± 0.08	
	NO <sub>3</sub> <sup>-</sup>	—	
NiCl <sup>+</sup>	Cl <sup>-</sup>	—	See details in Section V.4.2.4 of [2005GAM/BUG].
	ClO <sub>4</sub> <sup>-</sup>	0.47 ± 0.06	
	NO <sub>3</sub> <sup>-</sup>	—	
NiNO <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	—	See details in Section V.6.1.2 of [2005GAM/BUG], specially sub-section V.6.1.2.1 for an alternative treatment of this system.
	ClO <sub>4</sub> <sup>-</sup>	0.44 ± 0.14	
	NO <sub>3</sub> <sup>-</sup>	—	
Ni(H <sub>2</sub> cit) <sup>+</sup>	Cl <sup>-</sup>	—	See Section VII.7 in [2005HUM/AND].
	ClO <sub>4</sub> <sup>-</sup>	0.12 ± 0.50	
	NO <sub>3</sub> <sup>-</sup>	—	
NiBr <sup>+</sup>	Cl <sup>-</sup>	—	See details in [2005GAM/BUG], cf. Section V.4.2.5, specially sub-section V.4.2.5.1 for an alternative treatment of this system.
	ClO <sub>4</sub> <sup>-</sup>	0.59 ± 0.10	
	NO <sub>3</sub> <sup>-</sup>	—	
NiHS <sup>+</sup>	Cl <sup>-</sup>	—	See details in [2005GAM/BUG], Section V.5.1.1.2.
	ClO <sub>4</sub> <sup>-</sup>	-0.85 ± 0.39	
	NO <sub>3</sub> <sup>-</sup>	—	
NiSCN <sup>+</sup>	Cl <sup>-</sup>	—	Derived from Δε = ε(NiSCN <sup>+</sup> , ClO <sub>4</sub> <sup>-</sup> ) - ε(Na <sup>+</sup> , SCN <sup>-</sup> ) - ε(Ni <sup>2+</sup> , ClO <sub>4</sub> <sup>-</sup> ) = - (0.109 ± 0.025) kg·mol <sup>-1</sup> (see [2005GAM/BUG], Section V.7.1.3.1).
	ClO <sub>4</sub> <sup>-</sup>	0.31 ± 0.04	
	NO <sub>3</sub> <sup>-</sup>	—	
Fe(OH) <sub>2</sub> <sup>+</sup>	Cl <sup>-</sup>	—	Determined in Section VII.1.3.2 of TDB-Iron Part 1.
	ClO <sub>4</sub> <sup>-</sup>	0.37 ± 0.18	
	NO <sub>3</sub> <sup>-</sup>	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
FeF <sup>+</sup>	Cl <sup>-</sup>		
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.34 ± 0.07	Determined in Section VIII.2.1.3 of TDB-Iron Part 1.
FeCl <sub>2</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.52 ± 0.05	Determined in Section VIII.2.3.2.2.1 of TDB-Iron Part 1.
FeSO <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.4	Determined in Section IX.2.2.3 of this review.
FeSO <sub>4</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.4 ± 0.1	Determined in Section IX.1.2.1.4.1 of TDB-Iron Part 1.
Zr <sub>4</sub> (OH) <sub>15</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.09 ± 0.92 -0.02 ± 1.46	Determined in [2005BRO/CUR] from the overall fit of the hydrolysis data as described in Appendix D.
ZrF <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.20 ± 0.06	Determined from SIT plot in [2005BRO/CUR].
YCO <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.17 ± 0.04	Taken from Spahiu [1983SPA].
Am(OH) <sub>2</sub> <sup>+</sup>	Cl <sup>-</sup>	-0.27 ± 0.20	Evaluated in [2003GUI/FAN] ( <i>cf.</i> Section 12.3.1.1) from $\Delta\epsilon$ (in NaCl solution) for the reactions $An^{3+} + nH_2O(l) \rightleftharpoons An(OH)_n^{(3-n)} + nH^+$ (An = Am, Cm).
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.17 ± 0.04	Estimated in [1995SIL/BID].
AmF <sub>2</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.17 ± 0.04	Estimated in [1995SIL/BID].
AmSO <sub>4</sub> <sup>+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup> NO <sub>3</sub> <sup>-</sup>	0.22 ± 0.08	Evaluated in [1995SIL/BID].
AmCO <sub>3</sub> <sup>+</sup>	Cl <sup>-</sup>	0.01 ± 0.05	Evaluated in [2003GUI/FAN] (Section 12.6.1.1.1) from $\Delta\epsilon$ (in NaCl solution) for the reactions $An^{3+} + nCO_3^{2-} \rightleftharpoons An(CO_3)_n^{(3-2n)}$ (based on $\epsilon(An^{3+}, Cl^-) = (0.23 \pm 0.02)$ kg·mol <sup>-1</sup> and $\epsilon(Na^+, CO_3^{2-}) = -(0.08 \pm 0.03)$ kg·mol <sup>-1</sup> ).

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
Am(ox) <sup>+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.17 ± 0.04	Estimated in [1995SIL/BID].
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.08 ± 0.10	See Section VI.13 of [2005HUM/AND].
PuO <sub>2</sub> <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.24 ± 0.05	Derived from $\Delta\epsilon = \epsilon(\text{PuO}_2^{2+}, \text{ClO}_4^-) - \epsilon(\text{PuO}_2^+, \text{ClO}_4^-) = (0.22 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ [1995CAP/VIT]. In [1992GRE/FUG], $\epsilon(\text{PuO}_2^+, \text{ClO}_4^-) = (0.17 \pm 0.05) \text{ kg}\cdot\text{mol}^{-1}$ was tabulated based on [1989ROB], [1989RIG/ROB] and [1990RIG]. Capdevila and Vitorge's data [1992CAP], [1994CAP/VIT] and [1995CAP/VIT] were unavailable at that time.
PuO <sub>2</sub> F <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.29 ± 0.11	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding Np(IV) reaction.
PuO <sub>2</sub> Cl <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.50 ± 0.09	From $\Delta\epsilon$ evaluated by Giffaut [1994GIF].
NpO <sub>2</sub> <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	0.09 ± 0.05	See Section 12.1 of [2001LEM/FUG].
	ClO <sub>4</sub> <sup>-</sup>	0.25 ± 0.05	Derived from $\Delta\epsilon = \epsilon(\text{NpO}_2^{2+}, \text{ClO}_4^-) - \epsilon(\text{NpO}_2^+, \text{ClO}_4^-) = (0.21 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ [1987RIG/VIT], [1989RIG/ROB] and [1990RIG].
NpO <sub>2</sub> OH <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	-0.06 ± 0.40	Estimated in [2001LEM/FUG].
(NpO <sub>2</sub> ) <sub>3</sub> (OH) <sub>5</sub> <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.45 ± 0.20	See Section 8.1.2 of [2001LEM/FUG].
NpO <sub>2</sub> F <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.29 ± 0.12	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding U(IV) reaction.
	NO <sub>3</sub> <sup>-</sup>	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{NpO}_2\text{Cl}^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.50 \pm 0.14$	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding Pu(VI) reaction.
	$\text{NO}_3^-$	—	
$\text{NpO}_2\text{IO}_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.33 \pm 0.04$	Estimated in [2001LEM/FUG] by assuming $\epsilon(\text{NpO}_2\text{IO}_3^+, \text{ClO}_4^-) \approx \epsilon(\text{UO}_2\text{IO}_3^+, \text{ClO}_4^-)$ .
	$\text{NO}_3^-$	—	
$\text{Np}(\text{SCN})_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.17 \pm 0.04$	Estimated in [2001LEM/FUG] by assuming $\epsilon(\text{Np}(\text{SCN})_3^+, \text{ClO}_4^-) \approx \epsilon(\text{AmF}_2^+, \text{ClO}_4^-)$ .
	$\text{NO}_3^-$	—	
$\text{UO}_2^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.26 \pm 0.03$	Evaluated in [1992GRE/FUG], using $\epsilon(\text{UO}_2^{2+}, \text{ClO}_4^-) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ .
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{OH}^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$-0.06 \pm 0.40$	Evaluated in [1992GRE/FUG], using $\epsilon(\text{UO}_2^{2+}, \text{X}) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ , where $\text{X} = \text{Cl}^-$ , $\text{ClO}_4^-$ and $\text{NO}_3^-$ .
	$\text{NO}_3^-$	$0.51 \pm 1.4$	
$(\text{UO}_2)_3(\text{OH})_5^+$	$\text{Cl}^-$	$0.81 \pm 0.17$	Evaluated in [1992GRE/FUG], using $\epsilon(\text{UO}_2^{2+}, \text{X}) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ , where $\text{X} = \text{Cl}^-$ , $\text{ClO}_4^-$ and $\text{NO}_3^-$ .
	$\text{ClO}_4^-$	$0.45 \pm 0.15$	
	$\text{NO}_3^-$	$0.41 \pm 0.22$	
$\text{UF}_3^+$	$\text{Cl}^-$	$0.1 \pm 0.1$	Estimated in [1992GRE/FUG].
	$\text{ClO}_4^-$	$0.1 \pm 0.1$	
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{F}^+$	$\text{Cl}^-$	$0.04 \pm 0.07$	Taken from Riglet <i>et al.</i> [1989RIG/ROB], where the following assumptions were made: $\epsilon(\text{Np}^{3+}, \text{ClO}_4^-) \approx \epsilon(\text{Pu}^{3+}, \text{ClO}_4^-) = 0.49 \text{ kg}\cdot\text{mol}^{-1}$ as for other $(\text{M}^{3+}, \text{ClO}_4^-)$ interactions, and $\epsilon(\text{NpO}_2^{2+}, \text{ClO}_4^-) \approx \epsilon(\text{PuO}_2^{2+}, \text{ClO}_4^-) \approx \epsilon(\text{UO}_2^{2+}, \text{ClO}_4^-) = 0.46 \text{ kg}\cdot\text{mol}^{-1}$ .
	$\text{ClO}_4^-$	$0.28 \pm 0.04$	See Section 9.4.2.2.1 of [2003GUI/FAN].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{Cl}^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.33 \pm 0.04$	Evaluated in [1992GRE/FUG], using $\epsilon(\text{UO}_2^{2+}, \text{X}) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ , where $\text{X} = \text{Cl}^-$ , $\text{ClO}_4^-$ and $\text{NO}_3^-$ .
	$\text{NO}_3^-$	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{UO}_2\text{ClO}_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.33 \pm 0.04$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{Br}^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.24 \pm 0.04$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{BrO}_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.33 \pm 0.04$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{IO}_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.33 \pm 0.04$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{N}_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.3 \pm 0.1$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{NO}_3^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.33 \pm 0.04$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UO}_2\text{SCN}^+$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.22 \pm 0.04$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{Th}(\text{OH})_3^+$	$\text{Cl}^-$	$0.06 \pm 0.05$	See Table VII-16 in Section VII.3.6.1 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$0.15 \pm 0.10$	
	$\text{NO}_3^-$	$0.05 \pm 0.15$	
$\text{ThF}_3^+$	$\text{Cl}^-$	—	See Table VIII-8 in Section VIII.1.2.1 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$0.1 \pm 0.1$	
	$\text{NO}_3^-$	$0.0 \pm 0.2$	
$\text{Th}(\text{NO}_3)_3^+$	$\text{Cl}^-$	—	Evaluated in Section X.1.3.3 of [2008RAN/FUG], using $\epsilon(\text{Th}^{4+}, \text{X}) = (0.70 \pm 0.10) \text{ kg} \cdot \text{mol}^{-1}$ where $\text{X} = \text{ClO}_4^-$ and $\text{NO}_3^-$ .
	$\text{ClO}_4^-$	$0.25 \pm 0.15$	
	$\text{NO}_3^-$	$0.25 \pm 0.15$	
$\text{H}_6\text{edta}^{2+}$	$\text{Cl}^-$	$-0.20 \pm 0.16$	Evaluated in [2005HUM/AND] (Section VIII.3.7).
	$\text{ClO}_4^-$	$-0.20 \pm 0.16$	
	$\text{NO}_3^-$	$-0.20 \pm 0.16$	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
Sn <sup>2+</sup>	Cl <sup>-</sup>	0.19 ± 0.04	See Section VI.2.1 of [2012GAM/GAJ].
	ClO <sub>4</sub> <sup>-</sup>	0.19 ± 0.04	
	NO <sub>3</sub> <sup>-</sup>	—	
Sn <sub>3</sub> (OH) <sub>4</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	See Section VII.1.1 of [2012GAM/GAJ].
	ClO <sub>4</sub> <sup>-</sup>	-0.02 ± 0.16	
	NO <sub>3</sub> <sup>-</sup>	—	
Pb <sup>2+</sup>	Cl <sup>-</sup>	—	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.15 ± 0.02	
	NO <sub>3</sub> <sup>-</sup>	-0.20 ± 0.12 <sup>†</sup>	
AlOH <sup>2+</sup>	Cl <sup>-</sup>	0.09	Taken from Hedlund [1988HED].
	ClO <sub>4</sub> <sup>-</sup>	0.31	
	NO <sub>3</sub> <sup>-</sup>	—	
Al <sub>2</sub> CO <sub>3</sub> (OH) <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	0.26	Taken from Hedlund [1988HED].
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	—	
Zn <sup>2+</sup>	Cl <sup>-</sup>	—	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.33 ± 0.03	
	NO <sub>3</sub> <sup>-</sup>	0.16 ± 0.02	
ZnCO <sub>3</sub> <sup>2+</sup>	Cl <sup>-</sup>	0.35 ± 0.05	Taken from Ferri <i>et al.</i> [1985FER/GRE].
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	—	
Cd <sup>2+</sup>	Cl <sup>-</sup>	—	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	0.09 ± 0.02	
Hg <sup>2+</sup>	Cl <sup>-</sup>	—	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.34 ± 0.03	
	NO <sub>3</sub> <sup>-</sup>	-0.1 ± 0.1 <sup>†</sup>	
Hg <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.09 ± 0.02	
	NO <sub>3</sub> <sup>-</sup>	-0.2 ± 0.1 <sup>†</sup>	
Cu <sup>2+</sup>	Cl <sup>-</sup>	0.08 ± 0.01	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.32 ± 0.02	
	NO <sub>3</sub> <sup>-</sup>	0.11 ± 0.01	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
Ni <sup>2+</sup>	Cl <sup>-</sup>	0.17 ± 0.02	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.370 ± 0.032	Derived from the ionic strength dependence of the osmotic and mean activity coefficient of Ni(ClO <sub>4</sub> ) <sub>2</sub> solution ([2005GAM/BUG], Section V.4.3).
	NO <sub>3</sub> <sup>-</sup>	0.182 ± 0.010	Derived from the ionic strength dependence of the osmotic and mean activity coefficient of Ni(NO <sub>3</sub> ) <sub>2</sub> solution ([2005GAM/BUG], Section V.6.1.2.1).
Co <sup>2+</sup>	Cl <sup>-</sup>	0.16 ± 0.02	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	0.34 ± 0.03	
	NO <sub>3</sub> <sup>-</sup>	0.14 ± 0.01 <sup>1</sup>	
	NO <sub>3</sub> <sup>-</sup>	0.14 ± 0.02 <sup>2</sup>	
Fe <sup>2+</sup>	Cl <sup>-</sup>	0.17 ± 0.01	Determined in Section VI.4.3 of TDB-Iron Part 1.
	ClO <sub>4</sub> <sup>-</sup>	0.37 ± 0.04	Determined in Section VI.4.4 of TDB-Iron Part 1.
	NO <sub>3</sub> <sup>-</sup>	—	
FeOH <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.46 ± 0.05 <sup>3</sup>	Section VII.1.3.1 of TDB-Iron Part 1
	NO <sub>3</sub> <sup>-</sup>	—	
FeCl <sup>2+</sup>	Cl <sup>-</sup>	0.64 ± 0.06	Determined in Section VIII.2.3.1.3 of [2013LEM/BER].
	ClO <sub>4</sub> <sup>-</sup>	0.63 ± 0.05	Determined in Section VIII.2.3.2.2.1 of [2013LEM/BER].
	NO <sub>3</sub> <sup>-</sup>	—	
FeBr <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	0.19 ± 0.09	A tentative value determined in Section VIII.1.4.2.1 of this review.
FeSCN <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.49 ± 0.05 <sup>4</sup>	Determined in Section X.1.2.1 of this review (replacement).
	NO <sub>3</sub> <sup>-</sup>	0.13 ± 0.04	Determined in Section X.1.2.1 of this review (estimate).
Mn <sup>2+</sup>	Cl <sup>-</sup>	0.13 ± 0.01	Reported by Ciavatta [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	—	
Zr(OH) <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	

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<sup>1</sup> Use of this value would be consistent with calculations done using  $\epsilon$  values tabulated in earlier TDB volumes.<sup>2</sup> Use of this newer  $\epsilon$  value could lead to inconsistencies if the older value was used in earlier data assessments.<sup>3</sup> In earlier TDB volumes (prior to publication of [2013LEM/BER]) a value of 0.38 kg·mol<sup>-1</sup> [1983SPA] was listed, but with no estimated uncertainty.<sup>4</sup> In earlier TDB volumes a value of 0.45 kg·mol<sup>-1</sup> [1983SPA] was listed, but with no estimated uncertainty.

Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$ZrF_2^{2+}$	$ClO_4^-$	$0.62 \pm 0.39$	Determined in [2005BRO/CUR] from the overall fit of the hydrolysis data as described in Appendix D.
	$NO_3^-$	—	
	$Cl^-$	—	
$ZrCl_2^{2+}$	$ClO_4^-$	$0.47 \pm 0.08$	Determined from SIT plot in [2005BRO/CUR].
	$NO_3^-$	—	
	$Cl^-$	—	
$Zr(NO_3)_2^{2+}$	$ClO_4^-$	$0.84 \pm 0.11$	Determined from SIT plot in [2005BRO/CUR].
	$NO_3^-$	—	
	$Cl^-$	—	
$YHCO_3^{2+}$	$ClO_4^-$	$0.84 \pm 0.11$	Determined from SIT plot in [2005BRO/CUR].
	$NO_3^-$	—	
	$Cl^-$	—	
$AmOH^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Taken from Spahiu [1983SPA].
	$NO_3^-$	—	
	$Cl^-$	$-0.04 \pm 0.07$	Evaluated in [2003GUI/FAN] ( <i>cf.</i> Section 12.3.1.1) from $\Delta\epsilon$ (in NaCl solution) for the reactions $An^{3+} + nH_2O(l) \rightleftharpoons An(OH)_n^{(3-n)} + nH^+$ .
$AmF^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Estimated in [1995SIL/BID].
	$NO_3^-$	—	
	$Cl^-$	—	
$AmCl^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Estimated in [1995SIL/BID].
	$NO_3^-$	—	
	$Cl^-$	—	
$AmN_3^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Estimated in [1995SIL/BID].
	$NO_3^-$	—	
	$Cl^-$	—	
$AmNO_2^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Estimated in [1995SIL/BID].
	$NO_3^-$	—	
	$Cl^-$	—	
$AmNO_3^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Estimated in [1995SIL/BID].
	$NO_3^-$	—	
	$Cl^-$	—	
$AmH_2PO_4^{2+}$	$ClO_4^-$	$0.39 \pm 0.04$	Estimated in [1995SIL/BID].
	$Cl^-$	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
AmSCN <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.39 ± 0.04	Estimated in [1995SIL/BID].
PuO <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
PuO <sub>2</sub> <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.46 ± 0.05	By analogy with $\epsilon(\text{UO}_2^{2+}, \text{ClO}_4^-)$ as derived from isopiestic measurements in [1992GRE/FUG]. The uncertainty is increased because the value is estimated by analogy.
	NO <sub>3</sub> <sup>-</sup>	—	
PuF <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.36 ± 0.17	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding U(IV) reaction.
	NO <sub>3</sub> <sup>-</sup>	—	
PuCl <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.39 ± 0.16	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding Am(III) reaction.
	NO <sub>3</sub> <sup>-</sup>	—	
PuI <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.39 ± 0.04	Estimated in [2001LEM/FUG] by assuming $\epsilon(\text{PuI}^{2+}, \text{ClO}_4^-) \approx \epsilon(\text{AmSCN}^{2+}, \text{ClO}_4^-)$ and $\epsilon(\text{NH}_4^+, \text{I}^-) \approx \epsilon(\text{Na}^+, \text{SCN}^-)$ .
	NO <sub>3</sub> <sup>-</sup>	—	
PuSCN <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.39 ± 0.04	Estimated in [2001LEM/FUG] by assuming $\epsilon(\text{PuSCN}^{2+}, \text{ClO}_4^-) \approx \epsilon(\text{AmSCN}^{2+}, \text{ClO}_4^-)$ .
	NO <sub>3</sub> <sup>-</sup>	—	
NpO <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.46 ± 0.05	By analogy with $\epsilon(\text{UO}_2^{2+}, \text{ClO}_4^-)$ as derived from isopiestic measurements noted in [1992GRE/FUG]. The uncertainty is increased because the value is estimated by analogy.
	NO <sub>3</sub> <sup>-</sup>	—	
(NpO <sub>2</sub> ) <sub>2</sub> (OH) <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.57 ± 0.10	See Section 8.1.2 in [2001LEM/FUG].
	NO <sub>3</sub> <sup>-</sup>	—	
NpF <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
NpSO <sub>4</sub> <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.38 ± 0.17	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding U(IV) reaction.
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
Np(SCN) <sub>2</sub> <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.48 ± 0.11	Estimated on Section 10.1.2.1 of [2001LEM/FUG].
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
UO <sub>2</sub> <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.38 ± 0.20	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding U(IV) reaction.
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	0.21 ± 0.02	
	ClO <sub>4</sub> <sup>-</sup>	0.46 ± 0.03	
(UO <sub>2</sub> ) <sub>2</sub> (OH) <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	0.24 ± 0.03	Reported by Ciavatta [1980CIA]. These coefficients were not used in [1992GRE/FUG] because they were evaluated by Ciavatta [1980CIA] without taking chloride and nitrate complexation into account. Instead, Grenthe <i>et al.</i> used $\epsilon(\text{UO}_2^{2+}, \text{X}) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ , for X = Cl <sup>-</sup> , ClO <sub>4</sub> <sup>-</sup> and NO <sub>3</sub> <sup>-</sup> .
	Cl <sup>-</sup>	0.69 ± 0.07	
	ClO <sub>4</sub> <sup>-</sup>	0.57 ± 0.07	
	NO <sub>3</sub> <sup>-</sup>	0.49 ± 0.09	
(UO <sub>2</sub> ) <sub>3</sub> (OH) <sub>4</sub> <sup>2+</sup>	Cl <sup>-</sup>	0.50 ± 0.18	Evaluated in [1992GRE/FUG], using $\epsilon(\text{UO}_2^{2+}, \text{X}) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ , where X = Cl <sup>-</sup> , ClO <sub>4</sub> <sup>-</sup> and NO <sub>3</sub> <sup>-</sup> .
	ClO <sub>4</sub> <sup>-</sup>	0.89 ± 0.23	
	NO <sub>3</sub> <sup>-</sup>	0.72 ± 1.0	
UF <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	Evaluated in [1992GRE/FUG], using $\epsilon(\text{UO}_2^{2+}, \text{X}) = (0.46 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ , where X = Cl <sup>-</sup> , ClO <sub>4</sub> <sup>-</sup> and NO <sub>3</sub> <sup>-</sup> .
	ClO <sub>4</sub> <sup>-</sup>	0.3 ± 0.1	
	NO <sub>3</sub> <sup>-</sup>	—	
USO <sub>4</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	Estimated in [1992GRE/FUG].
	ClO <sub>4</sub> <sup>-</sup>	0.3 ± 0.1	
	NO <sub>3</sub> <sup>-</sup>	—	
U(NO <sub>3</sub> ) <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	—	Evaluated in [1992GRE/FUG] using $\epsilon(\text{U}^{4+}, \text{ClO}_4^-) = (0.76 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ .
	ClO <sub>4</sub> <sup>-</sup>	0.49 ± 0.14	
	NO <sub>3</sub> <sup>-</sup>	—	
Th(OH) <sub>2</sub> <sup>2+</sup>	Cl <sup>-</sup>	0.13 ± 0.05	Calculated in Section VII.3.6.1 of [2008RAN/FUG].
	ClO <sub>4</sub> <sup>-</sup>	0.33 ± 0.10	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
ThF <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	0.10 ± 0.15	See Table VIII-8 in Section VIII.1.2.1 of [2008RAN/FUG].
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.3 ± 0.1	
ThSO <sub>4</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	0.15 ± 0.20	See Section IX.1.3.2 of [2008RAN/FUG].
	Cl <sup>-</sup>	0.14 ± 0.15	
	ClO <sub>4</sub> <sup>-</sup>	0.3 ± 0.1	
Th(N <sub>3</sub> ) <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	—	Estimated in Section X.1.2 of [2008RAN/FUG].
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.40 ± 0.15	
Th(NO <sub>3</sub> ) <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	—	Estimated in Section X.1.3.3 of [2008RAN/FUG], using $\epsilon(\text{Th}^{4+}, \text{X}) = (0.70 \pm 0.10) \text{ kg}\cdot\text{mol}^{-1}$ for $\text{X} = \text{ClO}_4^-$ and $\text{NO}_3^-$ .
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.43 ± 0.18	
Th(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	0.43 ± 0.18	Estimated in Section X.2.3.2 of [2008RAN/FUG].
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.4 ± 0.1	
Th(SCN) <sub>2</sub> <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	—	See Section XI.1.3.6.1 of [2008RAN/FUG].
	Cl <sup>-</sup>	—	
	ClO <sub>4</sub> <sup>-</sup>	0.38 ± 0.20	
Be <sup>2+</sup>	NO <sub>3</sub> <sup>-</sup>	—	Taken from [1986BRU], where it appears to have been based on the average of the values for $\epsilon(\text{Mg}^{2+}, \text{ClO}_4^-)$ and $\epsilon(\text{Ca}^{2+}, \text{ClO}_4^-)$ [1980CIA].
	Cl <sup>-</sup>	—	
Mg <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.30 ± 0.04	Reported by Ciavatta [1980CIA].
	Cl <sup>-</sup>	0.19 ± 0.02	
	NO <sub>3</sub> <sup>-</sup>	0.33 ± 0.03	
Ca <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.17 ± 0.01	Reported by Ciavatta [1980CIA].
	Cl <sup>-</sup>	0.14 ± 0.01	
	NO <sub>3</sub> <sup>-</sup>	0.27 ± 0.03	
Ba <sup>2+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.02 ± 0.01	Reported by Ciavatta [1980CIA].
	Cl <sup>-</sup>	0.07 ± 0.01	
	NO <sub>3</sub> <sup>-</sup>	0.15 ± 0.02	
Al <sup>3+</sup>	ClO <sub>4</sub> <sup>-</sup>	-0.28 ± 0.03	Reported by Ciavatta [1980CIA].
	Cl <sup>-</sup>	0.33 ± 0.02	
	NO <sub>3</sub> <sup>-</sup>	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Ni}_2\text{OH}^{3+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.59 \pm 0.15$	By assuming $\epsilon(\text{Ni}_2\text{OH}^{3+}, \text{ClO}_4^-) \approx \epsilon(\text{Be}_2\text{OH}^{3+}, \text{ClO}_4^-)$ , see Section V.3.1.1 in [2005GAM/BUG].
$\text{Fe}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	$0.76 \pm 0.03$	Determined in Section VI.4.2.2 of TDB-Iron Part 1.
	$\text{ClO}_4^-$	$0.73 \pm 0.04^1$	Determined in Sections VI.1.2.1.1.1 and VI.4.1 of TDB-Iron Part 1.
	$\text{ClO}_4^-$	$0.56 \pm 0.03^2$	Reported by Ciavatta [1980CIA].
$\text{Cr}^{3+}$	$\text{NO}_3^-$	$0.26 \pm 0.08^3$	Determined in Section IX.4.1.3 of this review (analogy).
	$\text{NO}_3^-$	$0.42 \pm 0.08^4$	Reported by Ciavatta [1980CIA].
	$\text{Cl}^-$	$0.30 \pm 0.03$	Reported by Ciavatta [1980CIA].
	$\text{ClO}_4^-$	—	
$\text{ZrOH}^{3+}$	$\text{NO}_3^-$	$0.27 \pm 0.02$	Reported by Ciavatta [1980CIA].
	$\text{Cl}^-$	—	
$\text{Zr}_3(\text{OH})_9^{3+}$	$\text{ClO}_4^-$	$0.57 \pm 0.13$	Determined in [2005BRO/CUR] from the overall fit of the hydrolysis data as described in Appendix D.
	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
$\text{ZrF}^{3+}$	$\text{ClO}_4^-$	$0.93 \pm 0.35$	Determined in [2005BRO/CUR] from the overall fit of the hydrolysis data as described in Appendix D.
	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
$\text{ZrCl}^{3+}$	$\text{ClO}_4^-$	$0.63 \pm 0.10$	Determined from SIT plot in [2005BRO/CUR].
	$\text{NO}_3^-$	—	
$\text{Zr}(\text{NO}_3)^{3+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.87 \pm 0.10$	Determined from SIT plot in [2005BRO/CUR].
	$\text{NO}_3^-$	—	
$\text{Zr}(\text{NO}_3)_3^{3+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.88 \pm 0.11$	Determined from SIT plot in [2005BRO/CUR].
	$\text{NO}_3^-$	—	

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<sup>1</sup> Use of this newer value could lead to inconsistencies if the older  $\epsilon$  value was used in an earlier data assessment.

<sup>2</sup> Use of this value would be consistent with calculations done using  $\epsilon$  values tabulated in earlier TDB volumes (prior to publication of [2013LEM//BER])

<sup>3</sup> Use of this newer value could lead to inconsistencies if the older  $\epsilon$  value was used in an earlier data assessment.

<sup>4</sup> Use of this value would be consistent with calculations done using  $\epsilon$  values tabulated in earlier TDB volumes.

Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments	
La <sup>3+</sup>	Cl <sup>-</sup>	0.22 ± 0.02	Reported by Ciavatta [1980CIA].	
	ClO <sub>4</sub> <sup>-</sup>	0.47 ± 0.03		
	NO <sub>3</sub> <sup>-</sup>	—		
La <sup>3+</sup> → Lu <sup>3+</sup>	Cl <sup>-</sup>	—	Taken from Spahiu [1983SPA].	
	ClO <sub>4</sub> <sup>-</sup>	0.47 → 0.52		
	NO <sub>3</sub> <sup>-</sup>	—		
Am <sup>3+</sup>	Cl <sup>-</sup>	0.23 ± 0.02	The $\epsilon(\text{An}^{3+}, \text{Cl}^-)$ for An = Am and Cm is assumed to be equal to $\epsilon(\text{Nd}^{3+}, \text{Cl}^-)$ which is calculated from trace activity coefficients of Nd <sup>3+</sup> ion in 0–4 m NaCl. These trace activity coefficients are based on the Pitzer ion interaction parameters evaluated in [1997KON/FAN] from osmotic coefficients in aqueous NdCl <sub>3</sub> –NaCl and NdCl <sub>3</sub> –CaCl <sub>2</sub> .	
	ClO <sub>4</sub> <sup>-</sup>	0.49 ± 0.03		Estimated in [1995SIL/BID].
	NO <sub>3</sub> <sup>-</sup>	—		
Pu <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated by analogy with $\epsilon(\text{Ho}^{3+}, \text{ClO}_4^-)$ [1983SPA] as in [1992GRE/FUG], [1995SIL/BID]. The uncertainty is increased because the value is estimated by analogy.	
	ClO <sub>4</sub> <sup>-</sup>	0.49 ± 0.05		
	NO <sub>3</sub> <sup>-</sup>	—		
PuOH <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated in [2001LEM/FUG].	
	ClO <sub>4</sub> <sup>-</sup>	0.50 ± 0.05		
	NO <sub>3</sub> <sup>-</sup>	—		
PuF <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated in [2001LEM/FUG].	
	ClO <sub>4</sub> <sup>-</sup>	0.56 ± 0.11		
	NO <sub>3</sub> <sup>-</sup>	—		
PuCl <sup>3+</sup>	Cl <sup>-</sup>	—	Derived from the $\Delta\epsilon$ evaluated in [2001LEM/FUG].	
	ClO <sub>4</sub> <sup>-</sup>	0.85 ± 0.09		
	NO <sub>3</sub> <sup>-</sup>	—		
PuBr <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding U(IV) reaction, and by assuming $\epsilon(\text{H}^+, \text{Br}^-) \approx \epsilon(\text{Na}^+, \text{Br}^-)$ .	
	ClO <sub>4</sub> <sup>-</sup>	0.58 ± 0.16		
	NO <sub>3</sub> <sup>-</sup>	—		
Np <sup>3+</sup>	Cl <sup>-</sup>	—		
	NO <sub>3</sub> <sup>-</sup>	—		

(Continued on next page)

Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
	$\text{ClO}_4^-$	$0.49 \pm 0.05$	Estimated by analogy with $\epsilon(\text{Ho}^{3+}, \text{ClO}_4^-)$ [1983SPA] as in previous books in this series [1992GRE/FUG], [1995SIL/BID]. The uncertainty is increased because the value is estimated by analogy.
$\text{NpOH}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.50 \pm 0.05$	Estimated in [2001LEM/FUG].
$\text{NpF}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.58 \pm 0.07$	Evaluated in [2001LEM/FUG].
$\text{NpCl}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.81 \pm 0.09$	Derived from the $\Delta\epsilon$ selected in [2001LEM/FUG].
$\text{NpI}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.77 \pm 0.26$	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding Np(IV) chloride reaction, and by assuming $\epsilon(\text{H}^+, \text{I}^-) \approx \epsilon(\text{Na}^+, \text{I}^-)$ .
$\text{NpSCN}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	$0.76 \pm 0.12$	Estimated in [2001LEM/FUG] by analogy with $\Delta\epsilon$ of the corresponding U(IV) reaction.
	$\text{ClO}_4^-$	—	
$\text{U}^{3+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.49 \pm 0.05$	Evaluated in [2001LEM/FUG] by analogy with $\epsilon(\text{Am}^{3+}, \text{ClO}_4^-)$ .
	$\text{NO}_3^-$	—	
$\text{UOH}^{3+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.48 \pm 0.08$	Evaluated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UF}^{3+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.48 \pm 0.08$	Estimated in [1992GRE/FUG].
	$\text{NO}_3^-$	—	
$\text{UCI}^{3+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.50 \pm 0.10$	Estimated in [2003GUI/FAN].
	$\text{NO}_3^-$	—	
$\text{UBr}^{3+}$	$\text{Cl}^-$	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
U <sup>3+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.52 ± 0.10	Estimated in [1992GRE/FUG] using $\epsilon(U^{4+}, X) = (0.76 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ , for X = Br <sup>-</sup> and ClO <sub>4</sub> <sup>-</sup> .
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
UNO <sub>3</sub> <sup>3+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.55 ± 0.10	Estimated in [1992GRE/FUG] using $\epsilon(U^{4+}, X) = (0.76 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ , for X = F <sup>-</sup> and ClO <sub>4</sub> <sup>-</sup> .
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
ThOH <sup>3+</sup>	ClO <sub>4</sub> <sup>-</sup>	0.62 ± 0.08	Evaluated in [1992GRE/FUG] using $\epsilon(U^{4+}, X) = (0.76 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ for X = NO <sub>3</sub> <sup>-</sup> and ClO <sub>4</sub> <sup>-</sup> .
	NO <sub>3</sub> <sup>-</sup>	—	
	Cl <sup>-</sup>	—	
ThF <sup>3+</sup>	Cl <sup>-</sup>	0.19 ± 0.05	See Table VII-18 in Section VII.3.6.1 of [2008RAN/FUG].
	ClO <sub>4</sub> <sup>-</sup>	0.48 ± 0.08	
	NO <sub>3</sub> <sup>-</sup>	0.20 ± 0.15	
ThCl <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated in Section VIII.1.2.1 of [2008RAN/FUG] (Table VIII-8).
	ClO <sub>4</sub> <sup>-</sup>	0.48 ± 0.08	
	NO <sub>3</sub> <sup>-</sup>	0.25 ± 0.20	
ThClO <sub>3</sub> <sup>3+</sup>	Cl <sup>-</sup>	0.62 ± 0.11	Calculated in Section VIII.2.2.1.2 of [2008RAN/FUG] using $\epsilon(\text{Th}^{4+}, X) = (0.70 \pm 0.10) \text{ kg}\cdot\text{mol}^{-1}$ , for X = Cl <sup>-</sup> and ClO <sub>4</sub> <sup>-</sup> .
	ClO <sub>4</sub> <sup>-</sup>	0.62 ± 0.11	
	NO <sub>3</sub> <sup>-</sup>	—	
ThBr <sup>3+</sup>	Cl <sup>-</sup>	—	Calculated in Section VIII.2.2.2 of [2008RAN/FUG] using $\epsilon(\text{Th}^{4+}, X) = (0.70 \pm 0.10) \text{ kg}\cdot\text{mol}^{-1}$ , for X = ClO <sub>3</sub> <sup>-</sup> and ClO <sub>4</sub> <sup>-</sup> .
	ClO <sub>4</sub> <sup>-</sup>	0.62 ± 0.11	
	NO <sub>3</sub> <sup>-</sup>	—	
ThBrO <sub>3</sub> <sup>3+</sup>	Cl <sup>-</sup>	—	Calculated in Section VIII.3.2.1 of [2008RAN/FUG] using $\epsilon(\text{Th}^{4+}, X) = (0.70 \pm 0.10) \text{ kg}\cdot\text{mol}^{-1}$ , for X = Br <sup>-</sup> and ClO <sub>4</sub> <sup>-</sup> .
	ClO <sub>4</sub> <sup>-</sup>	0.62 ± 0.08	
	NO <sub>3</sub> <sup>-</sup>	—	
ThN <sub>3</sub> <sup>3+</sup>	Cl <sup>-</sup>	—	See Section X.1.2 of [2008RAN/FUG].
	ClO <sub>4</sub> <sup>-</sup>	0.55 ± 0.15	
	NO <sub>3</sub> <sup>-</sup>	—	

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Table B-4 (continued)

$j$	$k$	$\varepsilon(j,k)$	Comments
ThNO <sub>3</sub> <sup>3+</sup>	Cl <sup>-</sup>	—	Calculated in Section X.1.3.3 of [2008RAN/FUG] using $\varepsilon(\text{Th}^{4+}, X) = (0.70 \pm 0.10) \text{ kg}\cdot\text{mol}^{-1}$ , for $X = \text{ClO}_4^-$ and $\text{NO}_3^-$ .
	ClO <sub>4</sub> <sup>-</sup>	$0.56 \pm 0.14$	
	NO <sub>3</sub> <sup>-</sup>	$0.56 \pm 0.14$	
Th(H <sub>2</sub> PO <sub>4</sub> ) <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated in Section X.2.3.2 of [2008RAN/FUG].
	ClO <sub>4</sub> <sup>-</sup>	$0.5 \pm 0.1$	
	NO <sub>3</sub> <sup>-</sup>	—	
Th(H <sub>2</sub> PO <sub>4</sub> )(H <sub>3</sub> PO <sub>4</sub> ) <sup>3+</sup>	Cl <sup>-</sup>	—	Estimated in Section X.2.3.2 of [2008RAN/FUG].
	ClO <sub>4</sub> <sup>-</sup>	$0.5 \pm 0.1$	
	NO <sub>3</sub> <sup>-</sup>	—	
ThSCN <sup>3+</sup>	Cl <sup>-</sup>	—	See Section XI.1.3.6.1 of [2008RAN/FUG].
	ClO <sub>4</sub> <sup>-</sup>	$0.50 \pm 0.10$	
	NO <sub>3</sub> <sup>-</sup>	—	
Be <sub>2</sub> OH <sup>3+</sup>	Cl <sup>-</sup>	—	Taken from [1986BRU], where the assumption was made that $\varepsilon(\text{Be}^{2+}, \text{ClO}_4^-) = 0.30 \text{ kg}\cdot\text{mol}^{-1}$ , apparently based on the average of the values for $\varepsilon(\text{Mg}^{2+}, \text{ClO}_4^-)$ and $\varepsilon(\text{Ca}^{2+}, \text{ClO}_4^-)$ [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	$0.50 \pm 0.05$	
	NO <sub>3</sub> <sup>-</sup>	—	
Be <sub>3</sub> (OH) <sub>3</sub> <sup>3+</sup>	Cl <sup>-</sup>	—	Taken from [1986BRU], where the assumption was made that $\varepsilon(\text{Be}^{2+}, \text{ClO}_4^-) = 0.30 \text{ kg}\cdot\text{mol}^{-1}$ , apparently based on the average of the values for $\varepsilon(\text{Mg}^{2+}, \text{ClO}_4^-)$ and $\varepsilon(\text{Ca}^{2+}, \text{ClO}_4^-)$ [1980CIA].
	ClO <sub>4</sub> <sup>-</sup>	$0.51 \pm 0.05$	
	NO <sub>3</sub> <sup>-</sup>	—	
Sn <sup>4+</sup>	Cl <sup>-</sup>	—	See Section VI.3.1 of [2012GAM/GAJ].
	ClO <sub>4</sub> <sup>-</sup>	$0.7 \pm 0.2$	
	NO <sub>3</sub> <sup>-</sup>	—	
Al <sub>3</sub> HCO <sub>3</sub> (OH) <sub>4</sub> <sup>4+</sup>	Cl <sup>-</sup>	0.41	Taken from Hedlund [1988HED].
	ClO <sub>4</sub> <sup>-</sup>	—	
	NO <sub>3</sub> <sup>-</sup>	—	
Ni <sub>4</sub> (OH) <sub>4</sub> <sup>4+</sup>	Cl <sup>-</sup>	—	Derived from $\Delta\varepsilon = 4\varepsilon(\text{H}^+, \text{ClO}_4^-) - \varepsilon(\text{Ni}_4\text{OH}_4^{4+}, \text{ClO}_4^-)$ $- 4\varepsilon(\text{Ni}^{2+}, \text{ClO}_4^-) = (0.16 \pm 0.05) \text{ kg}\cdot\text{mol}^{-1}$ (see [2005GAM/BUG], Section V.3.1.1.1).
	ClO <sub>4</sub> <sup>-</sup>	$1.08 \pm 0.08$	
	NO <sub>3</sub> <sup>-</sup>	—	

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Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Fe}_2(\text{OH})_2^{4+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$1.04 \pm 0.10^1$	Determined in Section VII.1.3.3 of TDB-Iron Part 1.
	$\text{NO}_3^-$	—	
$\text{Zr}^{4+}$	$\text{Cl}^-$	$0.33 \pm 0.09$	Determined in [2005BRO/CUR]
	$\text{ClO}_4^-$	$0.89 \pm 0.10$	
	$\text{NO}_3^-$	$0.33 \pm 0.35$	
$\text{Y}_2\text{CO}_3^{4+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.80 \pm 0.04$	Taken from Spahiu [1983SPA].
	$\text{NO}_3^-$	—	
$\text{Pu}^{4+}$	$\text{Cl}^-$	$0.37 \pm 0.05$	Calculated in Section VI.3.1 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$0.82 \pm 0.07$	Derived from $\Delta\epsilon = \epsilon(\text{Pu}^{4+}, \text{ClO}_4^-) - \epsilon(\text{Pu}^{3+}, \text{ClO}_4^-) = (0.33 \pm 0.035) \text{ kg}\cdot\text{mol}^{-1}$ [1995CAP/VIT]. Uncertainty estimated in [2001LEM/FUG]. In the [1992GRE/FUG], $\epsilon(\text{Pu}^{3+}, \text{ClO}_4^-) = (1.03 \pm 0.05) \text{ kg}\cdot\text{mol}^{-1}$ was tabulated based on references [1989ROB], [1989RIG/ROB], [1990RIG]. Capdevila and Vitorge's data [1992CAP], [1994CAP/VIT] and [1995CAP/VIT] were unavailable at that time.
$\text{Np}^{4+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.84 \pm 0.06$	Derived from $\Delta\epsilon = \epsilon(\text{Np}^{4+}, \text{ClO}_4^-) - \epsilon(\text{Np}^{3+}, \text{ClO}_4^-) = (0.35 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ [1989ROB], [1989RIG/ROB], [1990RIG].
$\text{U}^{4+}$	$\text{NO}_3^-$	—	
	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.76 \pm 0.06$	Estimated in [1992GRE/FUG]. Using the measured value of $\Delta\epsilon = \epsilon(\text{U}^{4+}, \text{ClO}_4^-) - \epsilon(\text{U}^{3+}, \text{ClO}_4^-) = (0.35 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ p.89 [1990RIG], where the uncertainty is recalculated in [2001LEM/FUG] from the data given in this thesis, and $\epsilon(\text{U}^{3+}, \text{ClO}_4^-) = (0.49 \pm 0.05) \text{ kg}\cdot\text{mol}^{-1}$ , a value for $\epsilon(\text{U}^{4+}, \text{ClO}_4^-)$ can be calculated in the same way as is done for $\epsilon(\text{Np}^{4+}, \text{ClO}_4^-)$ and $\epsilon(\text{Pu}^{4+}, \text{ClO}_4^-)$ . This value, $\epsilon(\text{U}^{4+}, \text{ClO}_4^-) = (0.84 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ is consistent with that tabulated $\epsilon(\text{U}^{4+}, \text{ClO}_4^-) = (0.76 \pm 0.06) \text{ kg}\cdot\text{mol}^{-1}$ , since the uncertainties overlap. The authors of [2001LEM/FUG] do not believe that a change in the previously selected value for $\epsilon(\text{U}^{4+}, \text{ClO}_4^-)$ is justified at present.

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<sup>1</sup> In earlier TDB volumes (prior to publication of [2013LEM//BER]) a value of  $0.82 \text{ kg}\cdot\text{mol}^{-1}$  [1983SPA] was listed, but with no estimated uncertainty.

Table B-4 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
	$\text{NO}_3^-$	—	
$\text{Th}^{4+}$	$\text{Cl}^-$	$0.25 \pm 0.03$	Reported by Ciavatta [1980CIA].
	$\text{ClO}_4^-$	$0.70 \pm 0.10$	Evaluated in Section VI.3.1 of [2008RAN/FUG].
	$\text{NO}_3^-$	$0.31 \pm 0.12$	Evaluated in Section VI.3.1 of [2008RAN/FUG].
$\text{Th}_4(\text{OH})_{12}^{4+}$	$\text{Cl}^-$	$0.25 \pm 0.20$	See Section VII.3.4.1.3 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$0.56 \pm 0.42$	
	$\text{NO}_3^-$	$0.42 \pm 0.50$	
$\text{Th}(\text{H}_3\text{PO}_4)^{4+}$	$\text{Cl}^-$	—	
	$\text{ClO}_4^-$	$0.7 \pm 0.1$	Estimated in Section X.2.3.2 of [2008RAN/FUG].
	$\text{NO}_3^-$	—	
$\text{Al}_3(\text{OH})_4^{5+}$	$\text{Cl}^-$	0.66	Taken from Hedlund [1988HED]
	$\text{ClO}_4^-$	1.30	Taken from Hedlund [1988HED]
	$\text{NO}_3^-$	—	
$\text{Th}_2(\text{OH})_3^{5+}$	$\text{Cl}^-$	$0.29 \pm 0.09$	Calculated in Section VII.3.4.1.1 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$0.91 \pm 0.21$	
	$\text{NO}_3^-$	$0.69 \pm 0.25$	
$\text{Th}_2(\text{OH})_2^{6+}$	$\text{Cl}^-$	$0.40 \pm 0.16$	Evaluated in Section VII.3.4.1.1 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$1.22 \pm 0.24$	
	$\text{NO}_3^-$	$0.69 \pm 0.26$	
$\text{Zr}_3(\text{OH})_4^{8+}$	$\text{Cl}^-$	$0.33 \pm 0.28$	Determined in [2005BRO/CUR] from the overall fit of the hydrolysis data as described in Appendix D.
	$\text{ClO}_4^-$	$1.89 \pm 0.31$	
	$\text{NO}_3^-$	$2.28 \pm 0.35$	
$\text{Zr}_4(\text{OH})_8^{8+}$	$\text{Cl}^-$	—	Determined in [2005BRO/CUR] from the overall fit of the hydrolysis data as described in Appendix D.
	$\text{ClO}_4^-$	$3.61 \pm 1.02$	
	$\text{NO}_3^-$	—	
$\text{Th}_4(\text{OH})_8^{8+}$	$\text{Cl}^-$	$0.70 \pm 0.20$	Evaluated in Section VII.3.4.1.3 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$1.69 \pm 0.42$	
	$\text{NO}_3^-$	$1.59 \pm 0.51$	
$\text{Th}_6(\text{OH})_{15}^{9+}$	$\text{Cl}^-$	$0.72 \pm 0.30$	See details in Section VII.3.4.1.4 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$1.85 \pm 0.74$	
	$\text{NO}_3^-$	$2.20 \pm 0.77$	
$\text{Th}_6(\text{OH})_{14}^{10+}$	$\text{Cl}^-$	$0.83 \pm 0.30$	Estimated in Section VII.3.4.1.4 of [2008RAN/FUG].
	$\text{ClO}_4^-$	$2.2 \pm 0.3$	
	$\text{NO}_3^-$	$2.9 \pm 0.5$	

Table B-5: Ion interaction coefficients,  $\epsilon(j,k)$  ( $\text{kg}\cdot\text{mol}^{-1}$ ), for anions  $j$  with  $k = \text{Li}^+, \text{Na}^+$  and  $\text{K}^+$  at 298.15 K. The uncertainties represent the 95% confidence level. The ion interaction coefficients marked with † can be described more accurately with an ionic strength dependent function, listed in Table B-6.

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{OH}^-$	$\text{Li}^+$	$-0.02 \pm 0.03^\dagger$	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$0.04 \pm 0.01$	
	$\text{K}^+$	$0.09 \pm 0.01$	
$\text{F}^-$	$\text{Li}^+$	—	Evaluated in [1992GRE/FUG]. [1988CIA]
	$\text{Na}^+$	$0.02 \pm 0.02$	
	$\text{K}^+$	$0.03 \pm 0.02$	
$\text{HF}_2^-$	$\text{Li}^+$	—	Evaluated in [1992GRE/FUG].
	$\text{Na}^+$	$-0.11 \pm 0.06$	
	$\text{K}^+$	—	
$\text{Cl}^-$	$\text{Li}^+$	$0.10 \pm 0.01$	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$0.03 \pm 0.01$	
	$\text{K}^+$	$0.00 \pm 0.01$	
$\text{ClO}_3^-$	$\text{Li}^+$	—	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$-0.01 \pm 0.02$	
	$\text{K}^+$	—	
$\text{ClO}_4^-$	$\text{Li}^+$	$0.15 \pm 0.01$	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$0.01 \pm 0.01$	
	$\text{K}^+$	—	
$\text{Br}^-$	$\text{Li}^+$	$0.13 \pm 0.02$	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$0.05 \pm 0.01$	
	$\text{K}^+$	$0.01 \pm 0.02$	
$\text{BrO}_3^-$	$\text{Li}^+$	—	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$-0.06 \pm 0.02$	
	$\text{K}^+$	—	
$\text{I}^-$	$\text{Li}^+$	$0.16 \pm 0.01$	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$0.08 \pm 0.02$	
	$\text{K}^+$	$0.02 \pm 0.01$	
$\text{IO}_3^-$	$\text{Li}^+$	—	Estimated in [1992GRE/FUG].
	$\text{Na}^+$	$-0.06 \pm 0.02$	
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{HSO}_4^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.01 \pm 0.02$	Reported by Ciavatta [1980CIA].
	$\text{K}^+$	—	
$\text{N}_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.015 \pm 0.020$	See Section X.1.2 of [2008RAN/FUG].
	$\text{K}^+$	—	
$\text{NO}_2^-$	$\text{Li}^+$	$0.06 \pm 0.04^\dagger$	
	$\text{Na}^+$	$0.00 \pm 0.02$	Reported by Ciavatta [1980CIA].
	$\text{K}^+$	$-0.04 \pm 0.02$	Reported by Ciavatta [1988CIA].
$\text{NO}_3^-$	$\text{Li}^+$	$0.08 \pm 0.01$	Reported by Ciavatta [1980CIA].
	$\text{Na}^+$	$-0.04 \pm 0.03^\dagger$	
	$\text{K}^+$	$-0.11 \pm 0.04^\dagger$	
$\text{H}_2\text{PO}_4^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.08 \pm 0.04^\dagger$	
	$\text{K}^+$	$-0.14 \pm 0.04^\dagger$	
$\text{H}_2\text{AsO}_4^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.01 \pm 0.01$	Evaluated in Appendix A of this review in the entry for [2002RAP/SAN]
	$\text{K}^+$	—	
$\text{HCO}_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.00 \pm 0.02$	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	$-0.06 \pm 0.05$	Calculated in [2001LEM/FUG] from Pitzer coefficients [1998RAI/FEL].
$\text{Hox}^-$	$\text{Li}^+$	$-0.28 \pm 0.09$	Evaluated in Section VI.3.5 of [2005HUM/AND].
	$\text{Na}^+$	$-0.07 \pm 0.01$	
	$\text{K}^+$	$-0.01 \pm 0.08$	
$\text{H}_2\text{cit}^-$	$\text{Li}^+$	$-0.11 \pm 0.03$	Evaluated in Section VII.3.6 of [2005HUM/AND].
	$\text{Na}^+$	$-0.05 \pm 0.01$	
	$\text{K}^+$	$-0.04 \pm 0.01$	
$\text{CN}^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.07 \pm 0.03$	As reported in [1992BAN/BLI].
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
SCN <sup>-</sup>	Li <sup>+</sup>	—	Reported by Ciavatta [1980CIA].
	Na <sup>+</sup>	0.05 ± 0.01	
	K <sup>+</sup>	-0.01 ± 0.01	
HCOO <sup>-</sup>	Li <sup>+</sup>	—	Reported by Ciavatta [1980CIA].
	Na <sup>+</sup>	0.03 ± 0.01	
	K <sup>+</sup>	—	
CH <sub>3</sub> COO <sup>-</sup>	Li <sup>+</sup>	0.05 ± 0.01	Reported by Ciavatta [1980CIA].
	Na <sup>+</sup>	0.08 ± 0.01	
	K <sup>+</sup>	0.09 ± 0.01	
H <sub>3</sub> edta <sup>-</sup>	Li <sup>+</sup>	—	Evaluated in Section VIII.3.7 of [2005HUM/AND].
	Na <sup>+</sup>	-0.33 ± 0.14	
	K <sup>+</sup>	-0.14 ± 0.17	
SiO(OH) <sub>3</sub> <sup>-</sup>	Li <sup>+</sup>	—	Evaluated in [1992GRE/FUG].
	Na <sup>+</sup>	-0.08 ± 0.03	
	K <sup>+</sup>	—	
Si <sub>2</sub> O <sub>2</sub> (OH) <sub>5</sub> <sup>-</sup>	Li <sup>+</sup>	—	Estimated in [1992GRE/FUG].
	Na <sup>+</sup>	-0.08 ± 0.04	
	K <sup>+</sup>	—	
Sn(OH) <sub>3</sub> <sup>-</sup>	Li <sup>+</sup>	—	See Section VII.1.1 of [2012GAM/GAJ].
	Na <sup>+</sup>	0.22 ± 0.03	
	K <sup>+</sup>	—	
SnCl <sub>3</sub> <sup>-</sup>	Li <sup>+</sup>	—	See Section VIII.3.2.1 of [2012GAM/GAJ].
	Na <sup>+</sup>	0.04 ± 0.07	
	K <sup>+</sup>	—	
SnBr <sub>3</sub> <sup>-</sup>	Li <sup>+</sup>	—	See Section VIII.3.3.1 of [2012GAM/GAJ].
	Na <sup>+</sup>	0.16 ± 0.08	
	K <sup>+</sup>	—	
B(OH) <sub>4</sub> <sup>-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.07 ± 0.05†	
	K <sup>+</sup>	—	
Ni(SCN) <sub>3</sub> <sup>-</sup>	Li <sup>+</sup>	—	Evaluated in [2005GAM/BUG] (see Section V.7.1.3.1).
	Na <sup>+</sup>	0.66 ± 0.13	
	K <sup>+</sup>	—	
Ni(cit) <sup>-</sup>	Li <sup>+</sup>	—	Evaluated in Section VII.7 of [2005HUM/AND].
	Na <sup>+</sup>	0.22 ± 0.50	
	K <sup>+</sup>	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Fe}(\text{SO}_4)_2^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.24 \pm 0.14$	Estimated in Section IX.1.2.1.4.3 of TDB-Iron Part 1.
	$\text{K}^+$	—	
$\text{ZrF}_5^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.14 \pm 0.03$	Determined from SIT plots in [2005BRO/CUR].
	$\text{K}^+$	—	
$\text{Am}(\text{SO}_4)_2^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.05 \pm 0.05$	Estimated in [1995SIL/BID].
	$\text{K}^+$	—	
$\text{Am}(\text{CO}_3)_2^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.14 \pm 0.06$	Evaluated Section 12.6.1.1.1 [2003GUI/FAN], from $\Delta\epsilon_n$ in NaCl solution for the reactions $\text{An}^{3+} + n \text{CO}_3^{2-} \rightleftharpoons \text{An}(\text{CO}_3)_n^{(3-2n)}$ (An = Am, Cm) based on $\epsilon(\text{Am}^{3+}, \text{Cl}^-) = (0.23 \pm 0.02) \text{ kg}\cdot\text{mol}^{-1}$ and $\epsilon(\text{Na}^+, \text{CO}_3^{2-}) = -(0.08 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ .
	$\text{K}^+$	—	
$\text{Am}(\text{ox})_2^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.21 \pm 0.08$	Evaluated in Section VI.13 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{Am}(\text{edta})^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.01 \pm 0.16$	Evaluated in Section VIII.13.2.1 of [2005HUM/AND].
	$\text{K}^+$	$0.01 \pm 0.16$	Estimated in [2005HUM/AND] Section VIII.13.2.1 by assuming $\epsilon(\text{K}^+, \text{Am}(\text{edta})^-) \approx \epsilon(\text{Na}^+, \text{Am}(\text{edta})^-)$ .
$\text{PuO}_2\text{CO}_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.18 \pm 0.18$	Estimated in [2001LEM/FUG] by analogy with $\epsilon(\text{Na}^+, \text{NpO}_2\text{CO}_3^-)$ .
	$\text{K}^+$	—	
$\text{Pu}(\text{edta})^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	—	
	$\text{K}^+$	$0.01 \pm 0.16$	Estimated in [2005HUM/AND], Section VIII.12.2.1 by assuming $\epsilon(\text{K}^+, \text{Pu}(\text{edta})^-) \approx \epsilon(\text{Na}^+, \text{Am}(\text{edta})^-)$ .
$\text{NpO}_2(\text{OH})_2^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.01 \pm 0.07$	Estimated in [2001LEM/FUG] (Section 8.1.3).
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{NpO}_2\text{CO}_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.18 \pm 0.15$	Calculated in [2001LEM/FUG] (Section 12.1.2.1.3).
	$\text{K}^+$	—	
$\text{NpO}_2(\text{ox})^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.4 \pm 0.1$	Evaluated in Section VI.11.2.3 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{NpO}_2(\text{H}_2\text{edta})^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.18 \pm 0.16$	Evaluated in Section VIII.11.2.3 of [2005HUM/AND].
	$\text{K}^+$	—	
$(\text{NpO}_2)_2\text{CO}_3(\text{OH})_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.00 \pm 0.05$	Estimated by analogy in [2001LEM/FUG] (Section 12.1.2.1.2).
	$\text{K}^+$	—	
$\text{UO}_2(\text{OH})_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.09 \pm 0.05$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{UO}_2\text{F}_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.14 \pm 0.05$	Evaluated in [2003GUI/FAN], Section 9.4.2.2.1.1.
	$\text{K}^+$	—	
$\text{UO}_2(\text{N}_3)_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.0 \pm 0.1$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$(\text{UO}_2)_2\text{CO}_3(\text{OH})_3^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.00 \pm 0.05$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{UO}_2\text{cit}^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.11 \pm 0.09$	Evaluated in [2005HUM/AND].
	$\text{K}^+$	—	
$\text{Th}(\text{OH})_3(\text{CO}_3)^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.05 \pm 0.20$	See Section XI.1.3.2 of [2008RAN/FUG].
	$\text{K}^+$	—	
$\text{Mg}(\text{cit})^-$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.03 \pm 0.03$	Evaluated in [2005HUM/AND].
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
UO <sub>2</sub> (Hedta) <sup>-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.18 ± 0.16	Evaluated in Section VIII.10.2.4 of [2005HUM/AND].
	K <sup>+</sup>	—	
Mg(Hedta) <sup>-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	0.11 ± 0.20	Estimated in Section VIII.5.1 of [2005HUM/AND]
	K <sup>+</sup>	—	
SO <sub>3</sub> <sup>2-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.08 ± 0.05†	Reported by Ciavatta [1988CIA].
	K <sup>+</sup>	—	
SO <sub>4</sub> <sup>2-</sup>	Li <sup>+</sup>	-0.03 ± 0.04†	
	Na <sup>+</sup>	-0.12 ± 0.06†	Reported by Ciavatta [1988CIA].
	K <sup>+</sup>	-0.06 ± 0.02	
S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.08 ± 0.05†	Reported by Ciavatta [1988CIA].
	K <sup>+</sup>	—	
HPO <sub>4</sub> <sup>2-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.15 ± 0.06†	Reported by Ciavatta [1988CIA].
	K <sup>+</sup>	-0.10 ± 0.06†	
CO <sub>3</sub> <sup>2-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.08 ± 0.03	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for CO <sub>3</sub> <sup>2-</sup> and HCO <sub>3</sub> <sup>-</sup> are based on [1980CIA].
	K <sup>+</sup>	0.02 ± 0.01	
ox <sup>2-</sup>	Li <sup>+</sup>	-0.51 ± 0.09	
	Na <sup>+</sup>	-0.08 ± 0.01	
	K <sup>+</sup>	0.07 ± 0.08	
Hcit <sup>2-</sup>	Li <sup>+</sup>	-0.17 ± 0.04	Evaluated in Section VII.3.6 of [2005HUM/AND].
	Na <sup>+</sup>	-0.04 ± 0.02	
	K <sup>+</sup>	-0.01 ± 0.02	
H <sub>2</sub> edta <sup>2-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.37 ± 0.14	Evaluated in Section VII.3.7 of [2005HUM/AND].
	K <sup>+</sup>	-0.17 ± 0.18	
SiO <sub>2</sub> (OH) <sub>2</sub> <sup>2-</sup>	Li <sup>+</sup>	—	
	Na <sup>+</sup>	-0.10 ± 0.07	Evaluated in [1992GRE/FUG].
	K <sup>+</sup>	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Si}_2\text{O}_3(\text{OH})_4^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.15 \pm 0.06$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{Ni}(\text{ox})_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.26 \pm 0.03$	Evaluated in Section VI.7.2 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{Ni}(\text{CN})_4^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.185 \pm 0.081$	Evaluated in [2005GAM/BUG] (see Section V.7.1.2.1.1).
	$\text{K}^+$	—	
$\text{Fe}(\text{CO}_3)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.05 \pm 0.05$	By analogy. See Appendix A entry for [1992BRU/WER].
	$\text{K}^+$	—	
$\text{CrO}_4^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.06 \pm 0.04^\dagger$	
	$\text{K}^+$	$-0.08 \pm 0.04^\dagger$	
$\text{Zr}(\text{OH})_6^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.10 \pm 0.10$	Determined in [2005BRO/CUR] by analogy to known interaction coefficients of doubly charged anionic species with alkali ions (source: [2001LEM/FUG]).
	$\text{K}^+$	—	
$\text{ZrF}_6^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.15 \pm 0.06$	Determined from SIT plots in [2005BRO/CUR].
	$\text{K}^+$	—	
$\text{NpO}_2(\text{HPO}_4)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.1 \pm 0.10$	Estimated in [2001LEM/FUG].
	$\text{K}^+$	—	
$\text{NpO}_2(\text{CO}_3)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.02 \pm 0.14$	Estimated by analogy in [2001LEM/FUG] (Section 12.1.2.1.2).
	$\text{K}^+$	—	
$\text{NpO}_2\text{cit}^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.06 \pm 0.03$	Evaluated in Section VII.11 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{NpO}_2(\text{Hedta})^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.07 \pm 0.16$	Estimated in Section VIII.11.2.3 of [2005HUM/AND].
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{UO}_2\text{F}_4^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.30 \pm 0.06$	Evaluated in [2003GUI/FAN], Section 9.4.2.2.1.1.
	$\text{K}^+$	—	
$\text{UO}_2(\text{SO}_4)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.12 \pm 0.06$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{UO}_2(\text{N}_3)_4^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.1 \pm 0.1$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{UO}_2(\text{ox})_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.18 \pm 0.07$	Estimated in Section VI.1.2.4.1 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{UO}_2\text{edta}^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.22 \pm 0.18$	Estimated in Section VIII.10.2.4 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{UO}_2(\text{CO}_3)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.02 \pm 0.09$	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUJ]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	—	
$(\text{UO}_2)_2(\text{OH})_2(\text{SO}_4)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.14 \pm 0.22$	Evaluated in Section 9.5.1.1.2 of [2003GUI/FAN].
	$\text{K}^+$	—	
$\text{ThF}_6^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.30 \pm 0.06$	See Table VIII-8 in Section VIII.1.2.1 of [2008RAN/FUG].
	$\text{K}^+$	—	
$\text{Th}(\text{SO}_4)_3^{2-}$	$\text{Li}^+$	$-0.068 \pm 0.003$	In combination with $\epsilon_2 = (0.093 \pm 0.007)$ .
	$\text{Na}^+$	$-0.091 \pm 0.038$	See Section IX.1.3.2 of [2008RAN/FUG].
	$\text{K}^+$	$-0.091 \pm 0.038$	
$\text{Th}(\text{OH})_2(\text{CO}_3)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.1 \pm 0.2$	See Section XI.1.3.2 of [2008RAN/FUG].
	$\text{K}^+$	—	
$\text{Th}(\text{OH})_4(\text{CO}_3)_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.1 \pm 0.2$	See Section XI.1.3.2 of [2008RAN/FUG].
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Mg(ox)}_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.15 \pm 0.03$	Estimated in Section VI.5.1 of [2005HUM/AND].
	$\text{K}^+$	$-0.15 \pm 0.10$	Estimated in [2005HUM/AND], Section VI.5.1 by assuming $\epsilon(\text{K}^+, \text{Mg(ox)}_2^{2-}) \approx \epsilon(\text{Na}^+, \text{Mg(ox)}_2^{2-})$ .
$\text{Mg(edta)}^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.01 \pm 0.15$	Evaluated in Section VIII.5.2 of [2005HUM/AND].
	$\text{K}^+$	—	
$\text{Ca(ox)}_2^{2-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.15 \pm 0.10$	Estimated in [2005HUM/AND], Section VI.5.2 by assuming $\epsilon(\text{Na}^+, \text{Ca(ox)}_2^{2-}) \approx \epsilon(\text{Na}^+, \text{Mg(ox)}_2^{2-})$ .
	$\text{K}^+$	$-0.15 \pm 0.10$	Estimated in [2005HUM/AND], Section VI.5.2 by assuming $\epsilon(\text{K}^+, \text{Ca(ox)}_2^{2-}) \approx \epsilon(\text{Na}^+, \text{Mg(ox)}_2^{2-})$ .
$\text{cit}^{3-}$	$\text{Li}^+$	$-0.44 \pm 0.15^\dagger$	
	$\text{Na}^+$	$-0.076 \pm 0.030^\dagger$	
	$\text{K}^+$	$0.02 \pm 0.02$	Evaluated in Section VI.3.6 of [2005HUM/AND].
$\text{Hedta}^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.10 \pm 0.14$	Evaluated in Section VIII.3.7 of [2005HUM/AND].
	$\text{K}^+$	$0.31 \pm 0.18$	
$\text{PO}_4^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.25 \pm 0.03^\dagger$	
	$\text{K}^+$	$-0.09 \pm 0.02$	Reported by Ciavatta [1980CIA].
$\text{Si}_3\text{O}_6(\text{OH})_3^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.25 \pm 0.03$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{Si}_3\text{O}_5(\text{OH})_5^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.25 \pm 0.03$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{Si}_4\text{O}_7(\text{OH})_5^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.25 \pm 0.03$	Estimated in [1992GRE/FUG].
	$\text{K}^+$	—	
$\text{Ni(CN)}_5^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.25 \pm 0.14$	Evaluated in [2005GAM/BUG] (see Section V.7.1.2.1.1).
	$\text{K}^+$	—	
$\text{Fe(CO}_3)_3^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.23 \pm 0.07$	By analogy. See Appendix A entry for [2005GRI] of [2013LEM/BER].
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Am}(\text{CO}_3)_3^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.23 \pm 0.07$	Evaluated Section 12.6.1.1.1 [2003GUI/FAN], from $\Delta\epsilon_0$ in NaCl solution for the reactions $\text{An}^{3+} + n\text{CO}_3^{2-} \rightleftharpoons \text{An}(\text{CO}_3)_n^{(3-2n)}$ (An = Am, Cm) based on $\epsilon(\text{Am}^{3+}, \text{Cl}^-) = (0.23 \pm 0.02) \text{ kg}\cdot\text{mol}^{-1}$ and $\epsilon(\text{Na}^+, \text{CO}_3^{2-}) = -(0.08 \pm 0.03) \text{ kg}\cdot\text{mol}^{-1}$ .
$\text{Am}(\text{ox})_3^{3-}$	$\text{K}^+$	—	
	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.23 \pm 0.10$	Estimated in [2005HUM/AND], Section VI.13.2.1 by assuming $\epsilon(\text{Na}^+, \text{Am}(\text{ox})_3^{3-}) \approx \epsilon(\text{Na}^+, \text{Am}(\text{CO}_3)_3^{3-})$ .
	$\text{K}^+$	—	
$\text{Np}(\text{CO}_3)_3^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	—	
	$\text{K}^+$	$-0.15 \pm 0.07$	Estimated by analogy in [2001LEM/FUG] (Section 12.1.2.1.5).
$\text{NpO}_2(\text{CO}_3)_2^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.33 \pm 0.17$	Calculated in [2001LEM/FUG] (Section 12.1.2.1.3).
	$\text{K}^+$	—	
$\text{NpO}_2(\text{CO}_3)_2\text{OH}^{3-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.40 \pm 0.19$	Estimated in [2001LEM/FUG] by analogy with $\text{NpO}_2(\text{CO}_3)_3^{4-}$ .
	$\text{K}^+$	—	
	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.3 \pm 0.2$	Evaluated in Section VI.11.2.3 of [2005HUM/AND].
$\text{NpO}_2(\text{ox})_2^{3-}$	$\text{K}^+$	—	
	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.20 \pm 0.16$	Estimated in Section VIII.11.2.3 of [2005HUM/AND].
$\text{NpO}_2\text{edta}^{3-}$	$\text{K}^+$	—	
	$\text{Li}^+$	—	
$\text{edta}^{4-}$	$\text{Na}^+$	$0.32 \pm 0.14$	Evaluated in Section VIII.3.7 of [2005HUM/AND].
	$\text{K}^+$	$1.07 \pm 0.19$	
	$\text{Li}^+$	—	
$\text{P}_2\text{O}_7^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.26 \pm 0.05$	Reported by Ciavatta [1988CIA].
	$\text{K}^+$	$-0.15 \pm 0.05$	Reported by Ciavatta [1988CIA].

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{Fe}(\text{CN})_6^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	—	
	$\text{K}^+$	$-0.17 \pm 0.03$	
$\text{Zr}(\text{CO}_3)_4^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.09 \pm 0.20$	This value, referring to $\epsilon(\text{NH}_4^+, \text{Zr}(\text{CO}_3)_4^{4-})$ has been estimated in [2005BRO/CUR] by analogy with the homovalent ion pair ( $\text{Na}^+, \text{U}(\text{CO}_3)_4^{4-}$ ), see [1997GRE/PLY].
	$\text{K}^+$	—	
$\text{NpO}_2(\text{CO}_3)_3^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.40 \pm 0.19$	Calculated in [2001LEM/FUG] (Section 12.1.2.1.2).
	$\text{K}^+$	$-0.62 \pm 0.42$	$\epsilon(\text{NH}_4^+, \text{NpO}_2(\text{CO}_3)_3^{4-}) = -(0.78 \pm 0.25) \text{ kg}\cdot\text{mol}^{-1}$ is calculated in [2001LEM/FUG] (Section 12.1.2.2.1).
$\text{U}(\text{CO}_3)_4^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.09 \pm 0.10$	These values differ from those estimated in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	—	
$\text{UO}_2(\text{CO}_3)_3^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.01 \pm 0.11$	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	—	
$\text{UO}_2(\text{ox})_3^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.01 \pm 0.11$	Estimated in [2005HUM/AND], Section VI.10.2.4.1 by assuming $\epsilon(\text{Na}^+, \text{UO}_2(\text{ox})_3^{4-}) \approx \epsilon(\text{Na}^+, \text{UO}_2(\text{CO}_3)_3^{4-})$ .
	$\text{K}^+$	—	
$(\text{UO}_2)_3(\text{OH})_4(\text{SO}_4)_3^{4-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.6 \pm 0.6$	Estimated in Section 9.5.1.1.2 of [2003GUI/FAN].
	$\text{K}^+$	—	

(Continued on next page)

Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{NpO}_2(\text{CO}_3)_3^{5-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.53 \pm 0.19$	Calculated in [2001LEM/FUG] (Section 12.1.2.1.3).
	$\text{K}^+$	$-0.22 \pm 0.03$	Evaluated in [2003GUI/FAN] (discussion of [1998ALM/NOV] in Appendix A) from $\Delta\epsilon$ for the reactions $\text{KNpO}_2\text{CO}_3(\text{s}) + 2\text{CO}_3^{2-} \rightleftharpoons \text{NpO}_2(\text{CO}_3)_3^{5-} + \text{K}^+$ (in $\text{K}_2\text{CO}_3$ -KCl solution) and $\text{K}_3\text{NpO}_2(\text{CO}_3)_2(\text{s}) + \text{CO}_3^{2-} \rightleftharpoons \text{NpO}_2(\text{CO}_3)_3^{5-} + 3\text{K}^+$ (in $\text{K}_2\text{CO}_3$ solution) (based on $\epsilon(\text{K}^+, \text{CO}_3^{2-}) = (0.02 \pm 0.01) \text{ kg}\cdot\text{mol}^{-1}$ ).
$\text{UO}_2(\text{CO}_3)_3^{5-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.62 \pm 0.15$	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	—	
$\text{Th}(\text{OH})(\text{CO}_3)_4^{5-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.22 \pm 0.13$	Evaluated in Section XI.1.3.2.1 of [2008RAN/FUG].
	$\text{K}^+$	—	
$\text{Np}(\text{CO}_3)_5^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	—	
	$\text{K}^+$	$-0.73 \pm 0.68$	Calculated in [2001LEM/FUG] (Section 12.1.2.1.4).
$(\text{NpO}_2)_3(\text{CO}_3)_6^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.46 \pm 0.73$	Calculated in [2001LEM/FUG] (Section 12.1.2.1.2).
	$\text{K}^+$	—	
$\text{U}(\text{CO}_3)_5^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.30 \pm 0.15$	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	$-0.70 \pm 0.31$	Calculated in [2001LEM/FUG] from Pitzer coefficients [1998RAI/FEL].
$(\text{UO}_2)_3(\text{CO}_3)_6^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.37 \pm 0.11$	These values differ from those reported in [1992GRE/FUG]. See the discussion in [1995GRE/PUI]. Values for $\text{CO}_3^{2-}$ and $\text{HCO}_3^-$ are based on [1980CIA].
	$\text{K}^+$	—	
$(\text{UO}_2)_2\text{NpO}_2(\text{CO}_3)_6^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$0.09 \pm 0.71$	Estimated by analogy in [2001LEM/FUG] (Section 12.1.2.2.1).
	$\text{K}^+$	—	

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Table B-5 (continued)

$j$	$k$	$\epsilon(j,k)$	Comments
$(\text{UO}_2)_5(\text{OH})_8(\text{SO}_4)_4^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$1.10 \pm 0.5$	Estimated in Section 9.5.1.1.2 of [2003GUI/FAN].
	$\text{K}^+$	—	
$\text{Th}(\text{CO}_3)_5^{6-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$-0.30 \pm 0.15$	Estimated in Section XI.1.3.2.1 of [2008RAN/FUG].
	$\text{K}^+$	—	
$(\text{UO}_2)_4(\text{OH})_7(\text{SO}_4)_4^{7-}$	$\text{Li}^+$	—	
	$\text{Na}^+$	$2.80 \pm 0.7$	Estimated in Section 9.5.1.1.2 of [2003GUI/FAN].
	$\text{K}^+$	—	

Table B-6: Ion interaction coefficients,  $\varepsilon_1(j,k)$  and  $\varepsilon_2(j,k)$ , both in  $\text{kg}\cdot\text{mol}^{-1}$ , for cations  $j$  with  $k = \text{Cl}^-$ ,  $\text{ClO}_4^-$  and  $\text{NO}_3^-$  (first part), and for anions  $j$  with  $k = \text{Li}^+$ ,  $\text{Na}^+$  and  $\text{K}^+$  (second part), according to the relationship  $\varepsilon = \varepsilon_1 + \varepsilon_2 \log_{10} I_m$  at 298.15 K. The data are taken from Ciavatta [1980CIA], [1988CIA] unless indicated otherwise. The uncertainties represent the 95% confidence level.

$j\ k \rightarrow$ ↓	$\text{Cl}^-$		$\text{ClO}_4^-$		$\text{NO}_3^-$	
	$\varepsilon_1$	$\varepsilon_2$	$\varepsilon_1$	$\varepsilon_2$	$\varepsilon_1$	$\varepsilon_2$
$\text{NH}_4^+$			$-0.088 \pm 0.002$	$0.095 \pm 0.012$	$-0.075 \pm 0.001$	$0.057 \pm 0.004$
$\text{Tl}^+$			$-0.18 \pm 0.02$	$0.09 \pm 0.02$		
$\text{Ag}^+$					$-0.1432 \pm 0.0002$	$0.0971 \pm 0.0001$
$\text{Pb}^{2+}$					$-0.329 \pm 0.007$	$0.288 \pm 0.018$
$\text{Hg}^{2+}$					$-0.145 \pm 0.001$	$0.194 \pm 0.002$
$\text{Hg}_2^{2+}$					$-0.2300 \pm 0.0004$	$0.194 \pm 0.002$
$j\ k \rightarrow$ ↓	$\text{Li}^+$		$\text{Na}^+$		$\text{K}^+$	
	$\varepsilon_1$	$\varepsilon_2$	$\varepsilon_1$	$\varepsilon_2$	$\varepsilon_1$	$\varepsilon_2$
$\text{OH}^-$	$-0.039 \pm 0.002$	$0.072 \pm 0.006$				
$\text{NO}_2^-$	$0.02 \pm 0.01$	$0.11 \pm 0.01$				
$\text{NO}_3^-$			$-0.049 \pm 0.001$	$0.044 \pm 0.002$	$-0.131 \pm 0.002$	$0.082 \pm 0.006$
$\text{H}_2\text{PO}_4^-$			$-0.109 \pm 0.001$	$0.095 \pm 0.003$	$-0.1473 \pm 0.0008$	$0.121 \pm 0.004$
$\text{B}(\text{OH})_4^-$			$-0.092 \pm 0.002$	$0.103 \pm 0.005$		
$\text{SO}_3^{2-}$			$-0.125 \pm 0.008$	$0.106 \pm 0.009$		
$\text{SO}_4^{2-}$	$-0.068 \pm 0.003$	$0.093 \pm 0.007$	$-0.184 \pm 0.002$	$0.139 \pm 0.006$		
$\text{S}_2\text{O}_3^{2-}$			$-0.125 \pm 0.008$	$0.106 \pm 0.009$		
$\text{HPO}_4^{2-}$			$-0.19 \pm 0.01$	$0.11 \pm 0.03$	$-0.152 \pm 0.007$	$0.123 \pm 0.016$
$\text{CrO}_4^{2-}$			$-0.090 \pm 0.005$	$0.07 \pm 0.01$	$-0.123 \pm 0.003$	$0.106 \pm 0.007$
$\text{cit}^{3-}$	$-0.55 \pm 0.11^a$	$0.3 \pm 0.2^a$	$-0.15 \pm 0.03^a$	$0.13 \pm 0.03^a$		
$\text{PO}_4^{3-}$			$-0.29 \pm 0.02$	$0.10 \pm 0.01$		

a: See Section VII.3.6 of [2005HUM/AND].

Table B-7: SIT interaction coefficients  $\epsilon(j,k)$  ( $\text{kg}\cdot\text{mol}^{-1}$ ) for neutral species,  $j$ , with  $k$ , electroneutral combination of ions at 298.15 K.

$j \quad k \rightarrow$ $\downarrow$	$\text{Na}^+ + \text{ClO}_4^-$	$\text{Na}^+ + \text{Cl}^-$	$\text{K}^+ + \text{NO}_3^-$
$\text{H}_2\text{ox}(\text{aq})$	$0.00 \pm 0.01^{\text{b}}$	$0.00 \pm 0.01^{\text{b}}$	$0.00 \pm 0.01^{\text{b}}$
$\text{H}_3\text{cit}(\text{aq})$	$0.00 \pm 0.01^{\text{b}}$	$0.00 \pm 0.01^{\text{b}}$	$0.00 \pm 0.01^{\text{b}}$
$\text{H}_4\text{edta}(\text{aq})$	$-0.29 \pm 0.14$	$-0.29 \pm 0.14$	$-0.29 \pm 0.14$
$\text{SnBr}_2(\text{aq})$	$0.14 \pm 0.07$		
$\text{SnSO}_4(\text{aq})$	$0.19 \pm 0.35$		
$\text{Sn}(\text{NO}_3)_2(\text{aq})$	$0.130 \pm 0.111$		
$\text{Ni}(\text{ox})(\text{aq})$	$-0.07 \pm 0.03$	$-0.07 \pm 0.03$	
$\text{Ni}(\text{Hcit})(\text{aq})$	$-0.07 \pm 0.5$		
$\text{Ni}(\text{SCN})_2(\text{aq})$	$0.38 \pm 0.06^{\text{a}}$		
$\text{Am}(\text{cit})(\text{aq})$		$0.00 \pm 0.05$	
$\text{Np}(\text{edta})(\text{aq})$	$-0.19 \pm 0.19^{\text{g}}$		
$\text{UO}_2\text{ox}(\text{aq})$	$-0.05 \pm 0.06$	$-0.05 \pm 0.06$	
$\text{Uedta}(\text{aq})$	$-0.19 \pm 0.19$		
$\text{Mg}(\text{ox})(\text{aq})$		$0.00 \pm 0.03$	$0.0 \pm 0.1^{\text{c}}$
$\text{Mg}(\text{Hcit})(\text{aq})$	$0.02 \pm 0.05$	$0.02 \pm 0.05$	
$\text{Ca}(\text{ox})(\text{aq})$	$0.0 \pm 0.1^{\text{d}}$	$0.0 \pm 0.1^{\text{e}}$	$0.0 \pm 0.1^{\text{f}}$

(a): See Section V.7.1.3.1 in [2005GAM/BUG].

(b): Basic assumption made in [2005HUM/AND]. See Sections VI.3.5 and VII.3.6 of that review for discussions.

(c): Estimated in Section VI.5.2 of [2005HUM/AND] by assuming  $\epsilon(\text{Mg}(\text{ox})\text{(aq)}, \text{KNO}_3) \approx \epsilon(\text{Mg}(\text{ox})\text{(aq)}, \text{NaCl})$ .

(d): Estimated in Section VI.5.2 of [2005HUM/AND] by assuming  $\epsilon(\text{Ca}(\text{ox})\text{(aq)}, \text{NaClO}_4) \approx \epsilon(\text{Mg}(\text{ox})\text{(aq)}, \text{NaCl})$ .

(e): Estimated in Section VI.5.1 of [2005HUM/AND] by assuming  $\epsilon(\text{Ca}(\text{ox})\text{(aq)}, \text{NaCl}) \approx \epsilon(\text{Mg}(\text{ox})\text{(aq)}, \text{NaCl})$ .

(f): Estimated in Section VI.5.2 of [2005HUM/AND] by assuming  $\epsilon(\text{Ca}(\text{ox})\text{(aq)}, \text{KNO}_3) \approx \epsilon(\text{Mg}(\text{ox})\text{(aq)}, \text{NaCl})$ .

(g): Estimated in Section VIII.11.2.2 of [2005HUM/AND] by assuming  $\epsilon(\text{Np}(\text{edta})\text{(aq)}, \text{NaClO}_4) \approx \epsilon(\text{Uedta}(\text{aq}), \text{NaClO}_4)$ .

Table B-8: Other ion-ion interaction coefficients  $\epsilon(j,k)$  ( $\text{kg}\cdot\text{mol}^{-1}$ ) used in TDB-Iron Parts 1 and 2 for cations  $j$  and anions  $k$ .

$j$	$k$	$\epsilon(j,k)$	Comments
$\text{H}^+$	$\text{HSO}_4^-$	$0.14 \pm 0.05$	Determined in TDB-Iron Part 1, p. 476, footnote
$\text{NH}_4^+$	$\text{F}^-$	$-0.04 \pm 0.03$	Determined in Section VIII.1.1.1.1. of the present review (and is preferred to a value derived earlier in [2008RAN/FUG])