DISSOCIATION CONSTANTS OF INORGANIC ACIDS AND BASES IN AQUEOUS SOLUTION

CONSTANTES DE DISSOCIATION DES ACIDES ET DES BASES INORGANIQUES EN SOLUTION AQUEUSE

DIVISION DE CHIMIE ANALYTIQUE

COMMISSION DE CHIMIE ÉLECTROANALYTIQUE*

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D. D. PERRIN
Department of Medical Chemistry
Institute of Advanced Studies
Australian National University, Canberra

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*I. M. Kolthoff, *Président* (U.S.A.), P. Zuman, *Secrétaire* (G.B.), G. Charlot (France), W. Kemula (Pologne), L. Meites (U.S.A.), D. D. Perrin (Australie), N. Tanaka (Japon); *Membres associés*: E. Bishop (G.B.), S. Bruckenstein (U.S.A.), J. Coetzee (U.S.A.), Z. Galus (Pologne), H. Nurnberg (Allemagne), R. Robinson (U.S.A.), B. Tremillon (France).

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CONTENTS

INTRODUCTION

Most of the existing tables of dissociation constants of inorganic acids and bases in aqueous solution are fragmentary in character, include little or no experimental details, and give few references. Easily the most comprehensive of the previous collections is *Stability Constants of Metal-Ion Complexes*, compiled by L. G. Sillén and A. E. Martell, and published as Special Publication No. 17 of the Chemical Society, London, in 1964. However, because of the nature of this compilation, the pK values in it tend to be overlain by the much greater bulk of the stability constant data. In many cases, also, it is difficult to decide by inspection which of the pK values should be taken from the wide range sometimes given for a particular substance.

The present Table follows the pattern of the similar Tables for organic acids and organic bases, which were also prepared at the request of the International Union of Pure and Applied Chemistry as part of the work of the Commission on Electrochemical Data. The Table of organic acids, compiled by Kortum, Vogel, and Andrussow was published in *Pure and Applied Chemistry*, **1**, 187–536 (1960), and also separately as a book*. The Table of organic bases, by the present author, was published in 1965 as a supplement to *Pure and Applied Chemistry*.†

For convenience, the dissociation constants of inorganic acids and bases have been given, in most cases, in the form of pK_a values, and the classes of compounds include not only conventional acids and bases such as boric acid and magnesium hydroxide, but also hydrated metal ions (which behave as acids when they undergo hydrolysis) and free radicals, such as the hydroxyl radical, .OH. All of these reactions have in common the gain or loss of a proton or a hydroxyl ion. On the other hand, the hydrolyses of metal-complex ions such as the cobaltammines have been excluded, as being more appropriate to the stability constant compilation mentioned above.

In general, and largely because of the difficulties attending pK measurements on inorganic species, it is not possible to offer a critical assessment of most of the published values. In particular cases, such as water, highly precise constants are available over a range of temperatures, and the uncertainty is only of the order of 0·001 pH unit. More commonly, only a few, often widely discordant, values have been reported.

This is partly because of the chemical reactivity of the materials themselves. For example, nitrous acid readily decomposes to dinitrogen trioxide. At concentrations above 0·01 M, boric acid is appreciably polymerised to polyboric acids; molybdic acid solutions contain $Mo_7O_{24}^{6-}$ and higher species; bisulphite ion is in equilibrium with pyrosulphite ion, $S_2O_5^{2-}$; and many transition and higher-valent metal ions from polynuclear species on hydrolysis.

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* G. Kortum, W. Vogel and K. Andrussow. *Dissociation Constants of Organic Acids in Aqueous Solution*. Butterworth & Co. Ltd., London, 1961.

† D. D. Perrin. *Dissociation Constants of Organic Bases in Aqueous Solution*. Butterworth & Co. Ltd., London, 1965.

Often, too, unsatisfactory methods of determination have been used. Thus, pH titration measurements are seldom satisfactory if pK values lie below 2 or above 12, and in such circumstances can give quite misleading results. Again, pK values for the hydrolysis of metal ions have often been obtained from measurements of the pH values of solutions of their purified salts in water. As Sillén has pointed out (*Quart. Rev.*, **13**. 146 (1959), inorganic salts often adsorb tenaciously onto their surfaces traces of acidic or basic impurities, which persist even on repeated recrystallization, so that the measured pH values of their solutions may be much higher or lower than expected.

Even with experimentally accurate results, extrapolation to thermodynamic pK values at $I = 0$ is not always possible. The usual basis of such extrapolation is the Debye-Hückel equation,

$$-\log f\pm = \frac{Z_i^2 A I^{\frac{1}{2}}}{1 + \kappa a I^{\frac{1}{2}}} - bI$$

which is used to calculate the activity coefficient term. For precise work, values of a (the "mean distance of nearest approach" of the ions) and b are chosen to fit the data over a range of ionic strengths, so that the value of the pK, extrapolated to $I = 0$, can be obtained. At low ionic strengths and where moderate accuracy (say ±0·05 pH unit) is sufficient some simplifying assumptions can often be made. Thus, Davies' equation (*J. Chem. Soc.* **1938**, 2093) is obtained by taking $Ka = 1$, $b = 0{\cdot}2$; Güntelberg's equation (*Z. physik. Chem. Leipzig*, **123**, 199 (1926)) sets $Ka = 1$, $b = 0$; and the approximation $Ka = 0$, $b = 0$ (*i.e.*—$\log f = Z_i^2 AI^{\frac{1}{2}}$) is also used. However, with moderately strong acids and bases (pK values less than 2 or greater than 12), the numerical values of the thermodynamic pK constants depend in part on the assumptions made in deriving them, including the ion-size parameter a used in the extended Debye-Hückel equation (see, for example, R. G. Bates, V. E. Bower, R. G. Canham and J. E. Prue, *Trans. Faraday Soc.*, **55**, 2062 (1959); A. K. Covington, J. V. Dobson and W. F. K. Wynne-Jones, *Trans. Faraday Soc.*, **61**, 2057 (1965), E. A. Guggenheim, *Trans. Faraday Soc.* 62, 2750 (1966). Thus, the pK of bisulphite ion at 25° varies from 1·927 to 1·967 as K_a is varied from 1·0 to 1·7. In the same way, pK_b for $Ca(OH)_2$ varies from 1·14 to 1·27 at 25°, depending on the choice of parameters.

A distinction must also be made between true and apparent pK values. The first pK of carbon dioxide in water as measured is about 6·4 at 20°, whereas the true pK of carbonic acid (H_2CO_3) is 3·8. The difference between the apparent and the true pK values is due to the slight extent to which carbon dioxide is covalently hydrated in water. Similarly, periodic acid exists as H_5IO_6 and HIO_4 (mainly as the latter), so that its measured second pK (8·3) is very much higher than its first one (about 2).

In the absence of experimental values, especially for some of the oxyacids, attempts have been made to predict pK values, usually from similarities of structure. The more commonly used methods are those of J. E. Ricci (*J. Am. Chem. Soc.*, **70**, 109 (1948)), L. Pauling (*General Chemistry*, Freeman, San Francisco, 1947, p. 394), and A. Kossiakoff and D. Harker (*J. Am. Chem. Soc.*, **60**, 2047, (1938)). Even in apparently simple cases, there may be considerable uncertainty. For example different values would be predicted for germanic acid depending on whether it existed mainly as $GeO(OH)_2$ or $Ge(OH)_4$.

Because of the many different kinds of uncertainties inherent in the present pK compilation, no attempt has been made to assess the accuracy of each entry. Nevertheless, where possible, I have attempted to select what appear to be the best available values. The results for hydrogen sulphide illustrate this. Thus, several methods have indicated that the second pK of hydrogen sulphide is about 14, which is too high for potentiometric titration methods to be applicable. Hence the pK_2 values that have been obtained by potentiometric titration are not set out in the Table. Instead, references to the papers where they are given are included under "other measurements". This heading also covers results where insufficient experimental details are given.

I. HOW TO USE THE TABLE

GENERAL ARRANGEMENT

The Table summarizes data recorded in the literature up to the end of 1967 for the dissociation constants of inorganic acids and bases in aqueous solution. It also includes references to acidity functions for strong acids and bases, and details about the formation of polynuclear species where this is relevant. The substances are listed alphabetically, with chemical formulae, so that the entries are self-indexing.

Column 1 gives the name of the substance and the negative logarithm of the dissociation constant (pK_a). Wherever possible, these values are thermodynamic ones obtained by extrapolation to ionic strength $I = 0$, generally by using some form of the Debye-Hückel equation such as that due to Davies. In all cases, pK values are listed in decreasing extent of protonation.

Column 2 gives the temperature of measurements in °C.

Column 3 lists details such as:

$I = \frac{1}{2}\Sigma C_i Z_i^2$ = ionic strength
c = concentration in mole/l, or
m = concentration in mole/1000 g. of water.

It also records any other details relating to the pK value quoted. Designation of a constant as "practical" implies that it includes both the activity of the hydrogen ion (usually as measured by pH meter) and the concentrations of the other species.

Column 4 summarises the method of measurement, the procedure used in evaluating the constants, and any corrections that were taken into consideration; the symbols have the meanings set out under "Methods of Measurement", page 7. Because different investigators rarely use identical procedures, these symbols can only serve as guides: for fullest details the original papers should be consulted.

Column 5 gives the literature references which are listed alphabetically at the end of the Table.

II. METHODS OF MEASUREMENT AND CALCULATION

The abbreviations in *Column 4* of the Table are, with only minor differences, the same as those used in "Dissociation Constants of Organic Bases in Aqueous Solution".

CONDUCTOMETRIC METHODS

C1	Measurements in solutions of salt and acid
C2	Measurements in solution of base only

ELECTROMETRIC METHODS

[i] Cells without diffusion potentials

E1a	Method of Harned and Ehlers (*J. Am. Chem. Soc.* **54**, 1350 (1932)) (Cell of type Pt $(H_2)|B, BCl, NaCl||B, BCl, NaCl|AgCl|Ag$, for which $E - E_0 + (RT/F) \ln [BH^+] [Cl^-]/[B] = -(RT/F) \ln K'$, and extrapolate to $I = 0$)
E1b	Method of Harned and Owen (*J. Am. Chem. Soc.* **52**, 5079 (1930)) ,$Pt(H_2)|B, NaCl|AgCl|Ag$, where molality of B is M, $E = E_0 - (RT/F) \ln ([m_{H^+}] [m_{Cl^-}]f_{\pm}^2)$. Extrapolate to $I = 0$ at constant M, then to $M = 0$)
E1cg	Determination of $[H^+]$ from cells of the type, Glass|solution, $Cl^-|AgCl|Ag$
E1ch	Determination of $[H^+]$ from the cell, $Pt(H_2)$ solution, $Cl^-|AgCl|Ag$
E1d	Method of Bates (*J. Am. Chem. Soc.* **70**, 1579 (1948)). Determination of K_1 and K_2 for dibasic acids
E1e	Method of Bates and Pinching (*J. Res. Natl. Bur. Std.* **43**, 519 (1949)). A particular case of method E1cg in which the solution is a buffer comprising a weak base and a weak acid

[ii] Approximately symmetrical cells with diffusion potentials

E2a	Method of Owen (*J. Am. Chem. Soc.* **60**, 2229 (1938))
E2b	Method of Larsson and Adell (*Z. Physik. Chem.* **156**, 352, 381 (1931)) (Uses cell $Pt(H_2)|B, NaCl|$sat. $KCl|NaOH, NaCl|(H_2)Pt$ and an approx. K to adjust to equal ionic strengths in the half-cells. From E obtain $[H^+]$ and hence K': extrapolation to $I = 0$ gives K)
E2c	Method of Everett and Landsman (*Proc. Roy. Soc. London*, **A215**, 403, (1952)) (This is like E2b but uses a second weak base of known pK instead of a strong base. The method gives the ratio of the two constants)

[iii] Unsymmetrical cells with diffusion potentials

E3ag	pH measurements in buffer solutions of weak electrolytes using glass electrodes
E3ah	Similar measurements using hydrogen electrodes
E3bg	Measurements of pH changes during titrations using glass electrodes
E3bh	Similar measurements using hydrogen electrodes
E3b, quin	Similar measurements using quinhydrone electrodes
E3c	Differential potentiometric methods
E3d	pH measurements at equal concentrations of salt and base

OPTICAL METHODS

01	Direct determination of the degree of dissociation by extinction coefficient measurements in solutions of weak bases and salts
02	Colorimetric determination with an indicator of known p*K*
03	Colorimetric determination with an indicator calibrated with a buffer solution of known pH
04	Method of von Halban and Brüll (*Helv. Chim. Acta* **27**, 1719 (1944)) (Solutions of the base being studied, plus indicator, are compared with similar solutions containing alkali and indicator)
05	Light absorption measurements combined with electrometric measurements
06	Light absorption measurements using solutions of mineral acids of known concentrations and (usually) Hammett's acidity function, H_0
07	Similar to 06 but using solutions of alkalis

OTHER METHODS

ANALYT	Constants derived from chemical analysis
CALORIM	Calorimetric measurements
CAT	Constants estimated from catalytic coefficients
CRYOSC	Cryoscopic measurements
DISTRIB	Distribution between solvents
FP	Constants derived from freezing-point data
ION	Ion-exchange studies
KIN	Constants estimated from kinetic measurements
NMR	Nuclear magnetic resonance measurements
POLAROG	Polarographic measurements
RAMAN	Measurements of Raman spectra
REDOX	Oxidation-reduction potentials
SOLY	Solubility measurements
VAP	Vapour pressure measurements

CALCULATIONS

[i] Conductance measurements

R1a	Method of Davies (*The Conductivity of Solutions*, Chapman Hall, London 1930) (By successive approximations, f_Λ is calculated from the Debye-Hückel-Onsager equation in the form $f_\Lambda = 1 - A(\alpha c_0)^{\frac{1}{2}}/\Lambda_0$ which assumes that Λ_0 can be obtained from Kohlrausch's law of independent ionic mobilities)
R1b	Method of MacInnes (*J. Am. Chem. Soc.* **48**, 2068 (1926)) (The quantity $\Lambda_e = f_\Lambda \Lambda_0$ is determined directly, where Λ_e is the conductance of the weak electrolyte if it were completely dissociated at the ionic strength studied: it is necessary to know Λ for strong electrolytes as a function of I)
R1c	Method of Fuoss and Krauss (*J. Am. Chem. Soc.* **55**, 476 (1933)) (The Debye-Hückel-Onsager equation is used in the form, $\Lambda_c = \alpha(\Lambda_0 - A(\alpha c_0)^{\frac{1}{2}})$ to derive an equation relating Λ_0, c and K, which is solved by successive approximation until Λ_0 is constant at all values)
R1d	Method of Shedlovsky (*J. Franklin Inst.* **225**, 739 (1938)) (This is like R1c but a different equation is used)
R1e	Method of Fuoss (*J. Am. Chem. Soc.* **79**, 3301 (1957))

[ii] Differential potentiometric measurements

R2a	Method of Kilpi (*Z. Physik. Chem.* **173**, 223, 427 (1935); **175**, 239 (1936) (at point of inflection).

Name, Formula and p*K value*		*T*(°C)	*Remarks*	*Methods*	*Reference*
1. (Aquo) **Aluminium ion,** Al^{3+}					
5·28		15	p*K* for hydrolysis of Al^{3+}, $c = 0{\cdot}0005 - 0{\cdot}01$ M in $AlCl_3$, extrapolated against $I^{\frac{1}{2}}$	E3ag	S17
5·15		20			
4·98		25			
4·96		25	p*K* for hydrolysis of Al^{3+}, *I* varied from 0·0025 to 0·019, extrapolated to $I = 0$	E3ag	H41
5·02		25	p*K* for hydrolysis of Al^{3+}, $c = 10^{-5} - 10^{-2}$ M in $Al(ClO_4)_3$, extrapolated to $I = 0$	E3ag	F33
4·96		25	p*K* for hydrolysis of Al^{3+}; also log $K = 7{\cdot}55$ for $2AlOH^{2+} \rightleftharpoons Al_2(OH)_2{}^{4+}$, and log $K = 6{\cdot}89$ for $2Al_2(OH)_4{}^{2+} + 2H_2O \rightleftharpoons Al_4(OH)_{10}{}^{2+} + 2H^+$	E3,quin	K12
5·03		25	p*K* for hydrolysis of Al^{3+}	E3ag	K67
5·10		25	p*K* for hydrolysis of AL^{3+}	E3AG	I19
4·49		25	p*K* for hydrolysis of Al^{3+}, from dissociation field effect relaxation times	KIN	H64a
2·88		100	p*K* for hydrolysis of Al^{3+}	KIN	K69
11·22		25	p*K* for $Al(OH)_3 + H_2O \rightleftharpoons Al(OH)_4{}^- + H^+$	C1	M9
			Hydrolysis of Al^{3+} in 2 M $NaClO_4$ at 40° gives, mainly. onc or more polynuclear complexes		B97
			Other measurements: B94, D23, F5, I20, L1, T7, W25.		
2. Amidophosphoric acid, $NH_2PO_3H_2$					
3·00	8·15	25	$I = 0{\cdot}2$ (KCl), "practical" constants	E3bg	C13
3·3	8·28	25	$I = 1(NMe_4Br)$, concentration constants, $f\pm$ assumed same as for HBr	E3bg	I12
3·8	10.25		Titration of 0·1 M solution; p*K* of $^+NH_3PO_3H_2$ given as 2·1	E3b	R41
2·92	7.86	20		E,Sb	K29
2·8	8·2			E,h	M26
4·6	7·7	10			H15
	8·2	25			R10
			Other measurements: C19		

Name, Formula and p*K value*	T(°C)	*Remarks*	*Methods*	*Reference*
3. Aminodisulphonic acid, $NH(HSO_3)_2$				
8·50	25	pK_3; I = 1·0 (NaCl)	E3ag	D37a
4. Aminophosphazenes, see Hexaminotriphosphazene, Octaminotetraphosphazene.				
5. Aminophosphoric acid, see Amidophosphoric acid.				
6. Ammonia, NH_3				
10·081	0	Equal concentrations of NH_3 and KH phenol sulphonate, c varied from 0·011 to 0·104 M, activity coefficients calculated from Debye-Hückel equation, pK plotted against I	E1ch	B20
9·903	5			
9·730	10			
9·564	15			
9·401	20			
9·246	25			
9·093	30			
8·947	35			
8·805	40			
8·671	45			
8·540	50			
10·081	0		E1a	B19
9·904	5			
9·731	10			
9·564	15			
9·400	20			
9·245	25			
9·093	30			
8·947	35			
8·805	40			
8·670	45			
8·539	50			
		Thermodynamic quantities are derived from these values.		
9·555	15	I varies from 0·06 to 0·20. Extrapolated to zero concentration of NH_4^+ at each I, then extrapolated against I	E2b	E23
9·240	25			
8·946	35			
8·670	45			
		Thermodynamic quantities are derived from these values.		

9·867	5	$c = 0{\cdot}02$ to $0{\cdot}08$; $I = 0{\cdot}07$ to $0{\cdot}2$, extrapolated to $I = 0$, $c = 0$	E2b	E25
9·529	15			
9·215	25			
8·923	35			
8·645	45			
10·19	0		C1	N24
9·58	18			
9·35	25			
7·45	100			
6·45	156			
5·60	218			
5·74	306			
4·68	49	pK_b values	C1	W29
4·83	93			
5·04	138			
5·36	182			
5.76	227			
6·21	271			
6·62	293			
7·58	100	taking pK_w = 12·38; inversion of sucrose	CAT	K69
		Ref. H49a gives an equation fitting literature values of pK from 0° to 300°.		
4·29	25	pK_b values 1000 atmospheres pressure	C1, R1a	B105
3·91	25	2000		
3·61	25	3000		
4·32	45	1000		
3·95	45	2000		
3·65	45	3000		
4·71	45	pK_b values 1 atmosphere pressure	C1, R1a	H17
4·30		1100		
3·74		2500		
3·32		4000		
2·95		5400		
2·68		6800		
2·42		8200		
2·21		9600		
2·11		11000		
2·00		12000		
32·72	−50	Self-ionization of liquid ammonia, from cell potential data		P30

Name, Formula and p*K value*		*T*(°C)	*Remarks*	*Methods*	*Reference*
32·49	−33·2		Self-ionization of liquid ammonia, from thermodynamic data		C32
27·66	24·8				
29·8	25		Self-ionization of liquid ammonia, from thermodynamic data		J13
40			Approximate p*K* of NH_2^-, theoretical calculation		S29
			A value of 4·20 at 25° has been claimed from high field conductance measurements to be the true pK_b of $NH_4^+ + OH^- \rightleftharpoons NH_4OH$		B35
			A similar value, 4·28 at 20°, has been estimated from published data		M43
			For p*K* values in methanol-water mixtures, see E26, P1. Other measurements: B51, F41, H26, H37, K3, K26, L49, M44, N25, O16, P13, S31, W22.		
7. (Aquo) **Atimony III ion,** Sb^{3+}					
1·4	25		p*K* for $SbOH^{2+} \rightleftharpoons SbO^+ + H^+$	SOLY	K5
11·8	25		p*K* for $SbO^+ + H_2O \rightleftharpoons HSbO_2 + H^+$	SOLY	
0·87	25		p*K* for $SbO^+ + H_2O \rightleftharpoons HSbO_2 + H^+$	SOLY	P29
11·0	25		p*K* for $HSbO_2 + 2H_2O \rightleftharpoons Sb(OH)_4^- + H^+$	SOLY	
8. Antimony pentoxide, Sb_2O_5 See also Dodeca-antimonic acid.					
2·55	25		p*K* for $HSb(OH)_6 \rightleftharpoons Sb(OH)_6^- + H^+$; $I = 0{\cdot}5(NMe_4Cl)$; Sb concentration $\leqslant 10^{-3}$ M; at higher concentrations polynuclear complexes are also formed.	E3b	L17
Aquo metal ion, See entry under appropriate metal iron					
9. Arsenic acid, H_3AsO_4					
2·089	7·054	0	*I* varied from 0·007 to 0·096 (for K_1). and 0·010 to 0·21 (for K_2); extrapolated to $I = 0$	E1a,quin	A10
2·114	7·032	5			
2·138	7·015	10			
2·163	6·999	15			
2·194	6·990	20			
2·223	6·980	25			
2·265	6·974	30			
2·296	6.973	35			
2·332	6·973	40			

2·383	6·973		45			
2·420	6·980		50			
$pK_1 = 2{\cdot}014 + 5 \times 10^{-5} (t - 40{\cdot}0)^2$ $pK_2 = 6{\cdot}971 + 5 \times 10^{-2} (t - 39{\cdot}4)^2$, t in °C.						
				Thermodynamic quantities are derived from the results.		
2·49	7·05	11·33	10		E,g	F19
2·19	6·94	11·50	25			
1·95	6·87	11·64	35			
2·15	6·80	11·92	50			
	7·08		25	Taking pK_2 of H_3PO_4 as 7·16	E3ag	H78
2·301			25		E3ag	S3
				For values of pK_1 in D_2O/H_2O mixtures, see S3		
				Other measurements: B58, B86, C23, K48, L50, M8, S54, W4, W5		
10. Arsenious acid, H_3AsO_3 ($HAsO_2$)						
9·295			15	Molal scale; $c = 0{\cdot}008$, $I = 0{\cdot}1$ (KCl)	E3dg	A29
9·265			20			
9·18			25			
9·09			30			
8·97			35			
8·885			40			
8·81			45			
9·294			25	In KCl solutions, extrapolated to $I = 0$	E	A28
9·22			25	Taking pK of boric acid as 9·19	E3ag	H78
9·26			18	"Practical" constant, titration of 0·017 M H_3AsO_3	E3bg	B86
9·08			25		E3ag	I15
9·4	13·5		Room	pK_2 obtained from ultraviolet spectra	O	G33
	13·8		32		CRYOSC	S61
				Other measurements: B58, C11, G5, K36, K48, T15, W5, W25, Z2		
11. Azido-dithiocarbonic acid, $HSCSN_3$						
1·67			25	Free acid readily decomposes	C1	S55
12. (Aquo) **Barium ion**, Ba^{2+}						
0·62			5	pK_h of $BaOH^+$; $I = 0{\cdot}1$; f± calculated by Davies' equation, for extrapolation to $I = 0$; from e.m.f. data of H.S. Harned and		
0·60			15			

Name, Formula and pK value	T(°C)	Remarks	Methods	Reference
0·64	25	C. G. Geary, *J.Am. Chem. Soc.* **59** 2032 (1937)		
0·69	25			
0.72	45	Thermodynamic quantities are derived from the results.		
0·64	25	pK_b of $BaOH^+$; $I = 0{\cdot}04$ to 0·17; using Davies' equation and activity measurements of H. S. Harned and C. M. Mason, *J. Am. Chem. Soc.* **54**, 1441 (1932)		D7
0·85	25	$c = 0{\cdot}02 - 0{\cdot}05$ ($Ba(OH)_2$), $I = 0{\cdot}23$ to 0·6 ($Ba(OH)_2 + BaCl_2$), extrapolation to $I = 0$, using Davies' equation	KIN	B30
0·62	25	$I = 0{\cdot}1$ to 0·45	CAT,KIN	B31
0·72		Concentration constant; 0·2 — 1 N $BaCl_2$; salt effect on indicator	O3	K39
0·00	25	$I = 3$ ($NaClO_4$)	E2ah	C7
		Other measurements: B32, K64		
13. (Aquo) **Beryllium ion,** Be^{2+}				
		Beryllium ions readily hydrolyze in solution and form condensed species containing more than one beryllium atom. See, for example, C8 and K1.		
5·7 ~7	20	Successive pK values for hydrolysis of Be^{2+}; $I = 0{\cdot}1$ ($NaClO_4$); rapid-reaction measurements; $BeOH^+$ quickly forms trimer $Be_3(OH)_3^{3+}$	E3ag	S30
6·5	25	pK for $Be^{2+} \rightleftharpoons BeOH^+ + H^+$; $I = 1(NaClO_4)$; Be_2OH^{3+} also formed	E3bg	M21
>6·1	25	pK for $Be^{2+} \rightleftharpoons BeOH^+ + H^+$; $I = 3(NaClO_4)$; recalculation of data from refs. C8 and K1 using a computer; also $-\log K = 10{\cdot}87$ for $Be^{2+} + 2H_2O \rightleftharpoons Be(OH)^2 + 2H^+$; constants given for $Be_3(OH)_3^{3+}$ and Be_2OH^{3+}		H56
10·82		pK_b for $Be(OH)_2 \rightleftharpoons BeOH^+ + OH^-$; $c = 0{\cdot}01$; between pH 6·2 — 5·4; at lower pH values di- and tri-nuclear complexes are formed; constants are given	E3b	A9
10·46		pK for $Be(OH)_2 + H_2O \rightleftharpoons Be(OH)_3^- + H^+$; tracer concentrations; also $-\log K = 13{\cdot}65$ for $Be^{2+} + 2H_2O \rightleftharpoons Be(OH)_2 + 2H^+$	DISTRIB	G39

		$-\log K = 8{\cdot}81$ for $3Be^{2+} \rightleftharpoons Be_3(OH)_3^{3+} + 3H^+$; $-\log K = 3{\cdot}24$ for $2Be^{2+} \rightleftharpoons Be_2OH^{3+} + H^+$; $-\log K = 11{\cdot}0$ for $Be^{2+} \rightleftharpoons Be(OH)_2 + 2H^+$; all for $I = 0{\cdot}5(NaClO_4)$, *c* 0·001 to 0·08 M in Be^{2+}		B37
		$-\log K = 10{\cdot}9$ for $Be^{2+} \rightleftharpoons Be(OH)_2 + 2H^+$, at 25° and $I = 3(NaClO_4)$; constants also given for di- and tri-nuclear species.		K1
		Other measurements: L40, W26.		
14. (Aquo) **Bismuth(III) ion,** Bi^{3+}				
1·58	25	p*K* for $Bi^{3+} \rightleftharpoons BiOH^{2+} + H^+$; $I = 3(NaClO_4)$; $[Bi^{3+}]$ determined by Bi-Hg electrode; main equilibrium is $6Bi^{3+} + H_2O \rightleftharpoons Bi_6(OH)_{12}^{6+} + 12H^+$, with $\log K = 0{\cdot}33$	E3bg	O6
		Hydrolysis of Bi^{3+} gives $Bi_6O_6^{6+} + 12H^+$, with $-\log K = 0{\cdot}53$ at 25° and $I = 1(NaClO_4)$, and at higher pH values $Bi_6O_6(OH)_3^{3+}$, with $\log K = -8{\cdot}1$		T9
		Hydrolysis of $Bi_6O_6^{6+}$ ($= Bi_6(OH)_{12}^{6+}$) gives $Bi_9(OH)_{20}^{7+}$, $Bi_9(OH)_{21}^{6+}$ and $Bi_9(OH)_{22}^{5+}$; constants are listed		O7
15. Boric acid, H_3BO_3				
9·5078	0	Molal scale; equimolal concentrations (0·003 to 0·03 M) of NaCl, borax and boric acid; extrapolated to $I = 0$ using extended Debye-Hückel equation	E1ch	M11
9·4374	5			
9·3785	10			
9·3255	15			
9·2780	20			
9·2340	25			
9·1947	30			
9·1605	35			
9·1282	40			
9·1013	45			
9·0766	50			
9·0537	55			
9·0310	60			
		$pK = 2237{\cdot}94/T + 0{\cdot}016883T - 3{\cdot}305$ (T in °K) Thermodynamic quantities are derived from the results.		
9·440	5	Molal scale. I varied from 0·02 to 3 by adding NaCl; extrapolated to zero boric acid concentration at constant I, then to $I = 0$	E1ch	O18
9·380	10			
9·327	15			
9·280	20			

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
9·237	25			
9·198	30			
9·164	35			
9·132	40			
9·080	50			
		Thermodynamic quantities are derived from the results		
9·380	10	I varied from 0·01 to 0·12; constants corrected using Debye-Hückel equation and extrapolated to $I = 0$	E1a	O15
9·327	15			
9·280	20			
9·236	25			
9·197	30			
9·132	40			
9·080	50			
		p$K = 9{\cdot}023 + 8 \times 10^{-5} (76{\cdot}7 - t)^2$ (t in °C)		
9·21	20	$I = 0{\cdot}04$. The second pK of boric acid is greater than 14	E3ah	F31
8·98	25	$I = 0{\cdot}1$ ($NaClO_4$)	E3bh	I4
9·00	25	$I = 3(NaClO_4)$ At boric acid concentrations above 0·4 M, higher than trimeric complexes are also formed		
9·00	25	$I = 3(NaClO_4)$; boric acid concentrations varied from 0·01 to 0·60 M. Other equilibria were: $3H_3BO_3 \rightleftharpoons H_4B_3O_7^- + H^+ + 2H_2O$, $\log K = -6{\cdot}84$, $3H_3BO_3 \rightleftharpoons H_5B_3O_8^{2-} + 2H^+ + H_2O$, $\log K = -15{\cdot}44$ Polymeric species are important at concentrations above about 0·01 M Other measurements: B71, B88, E6, F9, H10, H25, I5, I6, K42, K48, L15, L41, M24, O17, P39.	E3bh	I9
16. (Aquo) **Cadmium ion**, Cd^{2+}				
10·2	25	pK for hydrolysis of Cd^{2+}; $I = 3(NaClO_4 + Cd(ClO_4)_2)$; $c = 0{\cdot}1$ to 1·45 ($Cd(ClO_4)_2$); Cd_2OH^{3+} and $Cd_4(OH)_4^{4-}$ are also formed	E3bg, quin	B44
9·0	25	pK for hydrolysis of Cd^{2+}; $I = 3(NaClO_4 + Cd(ClO_4)_2)$; $c = 0{\cdot}01$ to 0·9 ($Cd(ClO_4)_2$)	E3bg	M12

9·49	100	pK for hydrolysis of Cd^{2+}; $c = 0{\cdot}02$ ($CdCl_2$)	KIN	K69
9·3	25	pK for hydrolysis of Cd^{2+}	SOLY	G14
0·7	25	pK_b for $HCdO_2^+ + H_2O \rightleftharpoons Cd(OH)_2 + OH^-$	DISTRIB	D46
4·30	25	$I = 3(NaClO_4)$, pK_b for $CdOH^+ \rightleftharpoons Cd^{2+} + OH^-$		
3·44		pK_b for $Cd(OH)_2 \rightleftharpoons CdOH^+ + OH^-$		
2·58		pK_b for $Cd(OH)_3^- \rightleftharpoons Cd(OH)_2 + OH^-$		
1·72		pK_b for $Cd(OH)_4^{2-} \rightleftharpoons Cd(OH)_3^- + OH^-$ on assumption that $\log K_n = \frac{1}{4}\log K_1 K_2 K_3 K_4 + ((5 - 2n)/2) \log (K_n/K_{n+1})$		
		$\log K$ for $Cd^{2+} + 4OH^- \rightleftharpoons Cd(OH)_4^{2-}$ is about 9·7 at 25° Other measurements: C12, G38, L39	POLAROG	L3

17. Caesium hydroxide, CsOH

For alkalinity function for CsOH solutions, see L12a, M40.

18. (Aquo) Calcium ion, Ca^{2+}

1·02–1·14	0	pK_b for $CaOH^+$; $m = 0{\cdot}002 - 0{\cdot}02$ $Ca(OH)_2$ in $0{\cdot}003 - 0{\cdot}01$ M $CaCl_2$ or $0{\cdot}006 - 0{\cdot}02$ M KCl; values of pK_b depend on choice of γ_{Cl}/γ_{OH} used to evaluate molality of hydroxyl ion.	E1b	B17
1·12–1·24	10			
1·14–1·27	25			
1·36–1·45	40			
1·34	15	pK_b for $CaOH^+$; $I = 0{\cdot}02$ to $0{\cdot}1$ ($Ca(OH)_2 + CaCl_2$); $f\pm$ calculated assuming Davies' equation	E1ch	G26
1·37	25			
1·40	35			
1·37	0	pK_b for $CaOH^+$; $I = 0{\cdot}007$ to $0{\cdot}08$	SOLY	B29
1·40	25	$I = 0{\cdot}02$ to $0{\cdot}08$		
1·48	40	$I = 0{\cdot}04$ to $0{\cdot}10$ extrapolated to $I = 0$ assuming Davies' equation; $Ca(IO_3)_2$ in KOH solutions.		
1·30	25	pK_b for $CaOH^+$; $Ca(IO_3)_2$ in $Ca(OH)_2$ solutions; extrapolated using Davies' equation.	SOLY	D9
1·25–1·34	0	pK_b for $CaOH^+$; $I = 0{\cdot}18$ to $0{\cdot}30$; value sensitive to choice of activity coefficient	KIN	B32
1·24–1·36	0	$I = 0{\cdot}025$ to $0{\cdot}08$	SOLY	D6
1·51	25	$I = 0{\cdot}03$ to $0{\cdot}15$; extrapolated using Davies' equation; recalculation of data of G. Kilde, *Z. Anorg. Allgem. Chem.*, **218** 113 (1934)		
1·31	25	Recalculation of data of F. M. Lea and G. E. Bessey, *J. Chem. Soc.* **1937** 1612	C2	B30

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
1·46	25	$I = 0{\cdot}13$ to $0{\cdot}24$ ($Ca(OH)_2 + CaCl_2$); $c = 0{\cdot}02 - 0{\cdot}03$ $Ca(OH)_2$; extrapolated using Davies' equation	KIN	B30
1·29	25	$I = 0{\cdot}02$ to $0{\cdot}05$; $f\pm$ calculated from Guggenheim's equation (*Phil. Mag.*, **19**, 588 (1935))	CAT, KIN	B31
1·03		Concentration constant; 0·2 − 1*N* $CaCl_2$; from salt effect on indicator	O3	K39
0·64	25	$I = 3(NaClO_4)$	E2ah	C7
		For the acidity function of $Ca(OH)_2$ solutions from 0–95° and $I = 0{\cdot}01$ to $0{\cdot}20$, see B18		
		Other measurements: G42		
19. Carbonic acid, H_2CO_3				
6·577	0	Apparent p*K* values; double extrapolation procedure to eliminate effect of added NaCl and to obtain values at zero bicarbonate concentration	E1ch	H29
6·517	5			
6·465	10			
6·420	15			
6·382	20			
6·351	25			
6·327	30			
6·309	35			
6·296	40			
6·289	45			
6·287	50			
		$pK_1 = 3404{\cdot}71/T - 14{\cdot}8435 + 0{\cdot}032786T$ (T in °K) Thermodynamic quantities are derived from the results.		
6·579	0	Apparent p*K* values; $I = 0{\cdot}004 - 0{\cdot}2$, extrapolated to $I = 0$	E1ch	H31
6·517	5			
6·464	10			
6·419	15			
6·381	20			
6·352	25			
6·327	30			
6·309	35			
6·298	40			
6·290	45			

6·285		50				
6·514		5	Apparent pK values; $I = 0{\cdot}003 - 3$; extrapolated to $I = 0$		E3bh	N7
6·421		15	by fitting to an extended Debye-Hückel equation			
6·349		25				
6·310		35				
6·294		45				
			$\mathrm{p}K_1 = 6{\cdot}572 - 0{\cdot}012173t + 0{\cdot}00013329t^2$ (t in °C)			
6·583		0	Apparent pK values; 0·001 N in KHCO$_3$, KCl, HCl, and		C1,R1d	S40
6·429		15	saturated CO$_2$ solutions			
6·366		25				
6·317		38				
6·35		25	Apparent pK value		E2b, quin	A45
6·35		25	Apparent pK value		E1c, quin	A44
6·38		25	Apparent pK values, molal scale,	1 atmosphere,	C1	E10
5·90			I varied from 0·0001 to 0·1,	1035 atmosphere		
5·48				2050 atmosphere		
5·15				2930 atmosphere		
6·32		35		1 atmosphere		
5·85				1030 atmosphere		
5·45				2035 atmopshere		
5·12				2930 atmosphere		
6·32		45		1 atmosphere		
5·89				1015 atmopshere		
5·50				2010 atmosphere		
5·16				3000 atmosphere		
6·30		55		1 atmosphere		
5·86				1020 atmosphere		
5·49				2010 atmosphere		
5·17				2950 atmosphere		
6·31		65		1 atmosphere		
5·88				1050 atmosphere		
5·51				2060 atmosphere		
5·26				2800 atmosphere		
	10·625	0	I varied from 0·02 to 0·16; extrapolated to $I = 0$ using extended		E3ah	H39
	10·557	5	Debye-Hückel equation			
	10·490	10				
	10·430	15				
	10·377	20				
	10·329	25				

Name, Formula and p*K value*		*T*(°C)	*Remarks*	*Methods*	*Reference*
	10·290	30			
	10·250	35			
	10·220	40			
	10·195	45			
	10·172	50			
	10·179	60	$pK_2 = 2902{\cdot}39/T - 6{\cdot}4980 + 0{\cdot}02379T$ (T in °K) Thermodynamic quantities are derived from the results. I varied from 0·005 to 0·1; extrapolated against I	E,g	C45
	10·153	70			
	10·142	80			
	10·140	90			
	10·641	0	$pK_2 = 2909{\cdot}10/T - 6{\cdot}119 + 0{\cdot}02272T$ (T in °K) Double extrapolation, first to values in pure aqueous NaCl solutions, then against I to $I = 0$	E3ah	W9
	10·397	18			
	10·32	25	$I = 0$		N6
6·35	10·33	25	$I = 1$(NaCl)	VAP	E9
6·29	10·17	50			
6·24	10·14	100			
6·33	10·25	150			
6·55	10·42	200			
6·42	10·13	100		Cl	R49
6·77	10·37	150			
7·27	10·80	200			
7·89	11·30	250			
8·70	12·0	300			
6·46	10·14	100		Cl	R48
6·81	10·41	156			
7·14		200			
	10·96	218			
6·34	10·25	25	I varied from 0·01 to 0·2; extrapolated against $I^{\frac{1}{2}}$	E3ag	M5
6·31	10·20	38	I varied from 0·01 to 0·2; extrapolated against $I^{\frac{1}{2}}$	E3ag	M6
3·81		5	True pK for $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$; high field conductivity measurements	C	W23
3·75		15			
3·76		25			
3.78		35			

3·80		38			
3·80		45			
3·68		0·5	True p*K* for H_2CO_3, calculated from apparent p*K*, using rates of hydration and dehydration		D31
3·88		25	True pK for H_2CO_3; from high field conductivity measurements, taking $pK_{obs} = 6·352$	C2	B34
3·75		23·5	True p*K* for H_2CO_3; from rapid-reaction measurements	KIN	S13
3·82		30·2			
3·89		35·6			
3·80		4	True p*K* for H_2CO_3; 150 atmospheres; pressure jump method. Other measurements: B79, B101, B111, C40, C41, F6, F34, H42, K6, K7, K8, K9, K10, K28, K43, M22, M28, M45, N12, R37, S1, S69.	C1	L38

20. Caro's acid, see Peroxymonosulphuric acid

21. (Aquo) **Cerium(III) ion,** Ce^{3+}

~9		25	p*K* for hydrolysis of Ce^{3+}; from hydrolysis of "pure" salts; $c = 0·001 - 0·5$ M $Ce_2(SO_4)_3$	E3ag	M38
			$Ce_3(OH)_5^{4+}$ was formed at 25° by hydrolysis of 0·05 M Ce^{3+} in 3 M $LiClO_4$ Other measurements: R8, S72		B49

22. (Aquo) **Cerium(IV) ion,** Ce^{4+}

0·06		5	$I = 1·1 - 4(HClO_4,\ NaClO_4)$; $c = 1 - 14 \times 10^{-3}$ M; dimerization was important	O6	R20a
−0·32		15			
−0·72		25			
−1·18		35			
0·70		25	$I = 0·9$ to $1·7(HClO_4)$ $c = 1 \times 10^{-3}$ M Ce(IV); polymerisation was negligible.	O6	O1a
−0·9	1·1	1·6	p*K* values for hydrolysis to $CeOH^{3+}$ and $Ce(OH)_2^{2+}$;	REDOX	B8
−1·15	0·82	25	$I = 2(HClO_4,\ NaClO_4)$; $c = 3·5 \times 10^{-3}$ M Ce(IV); from pH-dependence of redox potential		
	−0·22	25	p*K* for $CeOH^{3+} \rightleftharpoons Ce(OH)_2^{2+} + H^+$; $HClO_4$ concentration from 0·2 − 0·4 M; from pH-dependence of redox potential Other measurements: D2a	REDOX	S42

23. Chloramine, see Monochloramine

Name, Formula and p*K value*	T(°C)	*Remarks*	*Methods*	*Reference*
24. Chloric acid, $HClO_3$				
∼ − 2·7		Theoretical prediction, based on structure		K52
25. Chlorosulphuric acid, $HClSO_3$ For pK in sulphuric acid, see B11				
26. Chlorous acid, $HClO_2$				
1·94	25	Spectral differences extrapolated to zero time; c = 0·001 to 0·003 M $NaClO_2$, acidified with $HClO_4$; activity coefficients from Debye-Hückel equation	O6	L18
1·97	19–20	c = 0·001 − 0·1 M $NaClO_2$; extrapolation against $I^{\frac{1}{2}}$	E3bg	D5
1·96	20			H66
1·99	23	"Practical" constant; concentration of $HClO_2$ ∼ 0·25 M Other measurements: L20, T1	E3bg, R2a	L36
27. Chromic acid, H_2CrO_4				
6·444	5		E3bg	L35a
6·478	15			
6·488	25			
6·524	35			
6·569	45			
6·642	60			
6·472	15		O5	L35a
6·500	25			
6·533	35			
6·593	45			
6·40	18	Titration of 0·025 M H_2CrO_4	E3bg	B81
6·47	18	Titration of 0·04 M K_2CrO_4	E3bg	B88
6·52	25	I = 0·0018 to 0·0028; $f\,\pm$ calculated from Davies' equation	E3bg	H72
6·52	25	I = 0·002 to 0·004	O5	
6·50	25	I = 0·01 to 0·16; extrapolated to I = 0; K = 0·023 for $Cr_2O_7^{2+} + H_2O \rightleftharpoons 2HCrO_4^-$	E3ag	N16
0·74	25	I about 0·16; HCl/KCl solutions	E3ch	
6·60	20 ± 2	I = 0·1; corrected to I = 0 by Davies' equation, tracer concentrations	DISTRIB	H13

−0·83		15	Concentration constants corrected for formation of CrO_3Cl^-; $I = 1(LiClO_4, LiCl, HClO_4, HCl)$	O6	T11b
−0·61		25			
−0·42		35			
	6·49	25	$c = 2·5 \times 10^{-5}$ M	O5	B5
−0·98		25	In $HClO_4$ solutions		
0·51		25	In H_2SO_4 solutions, using H_- scale	O6	L14
0·76		25	In HCl solutions, using H_- scale	O6	
−1·91		25	In HNO_3 solutions, using H_0 scale	O6	
1·74		25	In H_3PO_4 solutions, using H_0 scale	O6	
−1·01		25	In $HClO_4$ solutions, using H_- scale	O6	
			pK_1 varies with the proton source because of the formation of species such as $HCrO_3Cl$ and $HCrO_3(OSO_3H)$		
−0·81		25	$I = 1·0$; in HCl solutions, correcting for the formation of CrO_3Cl^-	O6	H12
			The equilibrium constant for $Cr_2O_7^{2-} + H_2O \rightleftharpoons 2HCrO_4^-$ is 0·0265 at 20° and 0·0303 at 25°		D13
			Other measurements: B24, B100, H78, J1a, J6, M18, S7, S41, S43a, S66, T11a, T12		

28. (Aquo) **Chromium(III) ion,** Cr^{3+}

3·66		25	pK for hydrolysis of Cr^{3+}; $I = 0·0014 - 0·04$; extrapolated to $^6 = 0$	E3ag	H41
3·95		25	pK for hydrolysis of Cr^{3+}; corrected for $Cr^{3+} - SO_4^{2-}$ ion-pair formation; $I = 0$	C1	T19
3·34		46·2	pK for hydrolysis of Cr^{3+}; $I = 0·068$ $(LiClO_4)$; from variation of apparent stability constant of $CrNCS^{2+}$ with pH of $CrNCS^{2+}$ with pH	O5	P36
3·01		63·6			
2·83		73·7			
2·65		84·8			
2·49		94·6			
4·05		15	$I = 0·068$ $(LiClO_4)$; extrapolation from results at 46–95°		P36
3·82		25			
4·66		0	pK for hydrolysis of Cr^{3+}	C1	B53
4·01		25			
3·47		50			
2·99		75			
2·58		100			
4·26		20	pK for hydrolysis of Cr^{3+}; $I = 0·5$ $(NaNO_3)$	E3bg	J15
3·90		15	pK for hydrolysis of Cr^{3+}; $I = 0$	KIN	B94

Name, Formula and p*K value*	T(°C)	*Remarks*	*Methods*	*Reference*
4·1 ~5·6	20	Successive pK values for hydrolysis of Cr^{3+}; I = 0·1 ($NaClO_4$); rapid-flow measurements	E3ag	S30
4·10 5·55	25	Successive "practical" pK values for hydrolysis of Cr^{3+}; I = 0·04 to 0·4	E3ag	E18
3·96	25		O5	
		Other measurements: B54, C15, D23, L4		
29. (Aquo) **Cobalt(II) ion,** Co^{2+}				
9·96	15	pK for hydrolysis of Co^{2+} at I = 0·25 and 0·75($NaClO_4$)	E3bg	B64
9·85	25			
9·62	35			
9·50	45			
8·9	30	pK for hydrolysis of Co^{2+}; I = 0·1(KCl)	E3bg	C12
8·7	100	pK for hydrolysis of Co^{2+}	KIN	K68
		Other measurements: A7, D23, G12, P31		
30. (Aquo) **Cobalt(III) ion,** Co^{3+}				
2·10	12·5	pK for hydrolysis of Co^{3+}; I = 1($NaClO_4$)	O6	S79
1·98	18·5			
1·78	23·6			
1·71	28·2			
		The above values are uncertain because high cobaltic concentrations and low acidities favour formation of polynuclear species		S80
31. (Aquo) **Copper(II) ion,** Cu^{2+}				
		The pK for Cu^{2+} is not known; hydrolysis of Cu^{2+} gives almost entirely polynuclear complexes of the type, $Cu_n(OH)_{2n-2}^{2+}$; formation constants for $Cu_2(OH)_2^{2+}$ from 15–42° are given.		P19
8·0	25	pK for $Cu^{2+} \rightleftharpoons CuOH^+ + H^+$; I = 3($NaClO_4$): the major species formed is $Cu_2(OH)_2^{2+}$, with $-\log K = 10{\cdot}6$	E3bg	B33
7·97	18	pK for $Cu^{2+} \rightleftharpoons CuOH^+ + H^+$; the major species formed is $Cu_2(OH)_2^{2+}$, with $-\log K = 10{\cdot}89$	E3bg	P15
		Hydrolysis of Cu^{2+} gives $Cu_2(OH)_2^{2+}$, with $-\log K$ at 25° ranging from 10·5 to 10·9		H4

~10		25	Prediction of pK for $Cu(OH)_2 \rightleftharpoons HCuO_2^- + H^+$		M3
13·1		25	pK for $HCuO_2^- \rightleftharpoons H^+ + CuO_2^{2-}$	SOLY	
<12·8			pK for $Cu(OH)_2 \rightleftharpoons HCuO_2^- + H^+$	SOLY	J11
			Other measurements: A5, C12, C36, D8, F35, K5, K69, Q3		
32. Cyanic acid, HCNO					
3·76 3·64 3·57 3·46 3·37 3·48		0 10 18 25 35 45	Corrected to $I = 0$ by extended Debye-Hückel equation; extrapolated to zero time to allow for decomposition	E3ag	C5
3·54		18	I varied from 0·06 to 0·2; ionic strength correction doubtful; extrapolated to zero time	E3ag	J4
3·47		25	$I = 0$	E3ag	M60
			Other measurements: A19, B67a, T4		
33. Decahydrodecaboric acid, $H_2B_{10}H_{10}$ For acidity function, see M50					
34. Decavanadic acid, $H_6V_{10}O_{28}$					
3·65		20	pK_5; $I = 0·2$; also log $K = -7·50$ for $10VO_2^+ + 8H_2O \rightleftharpoons H_2V_{10}O_{28}^{4-} + 14H^+$; and log $K = -23·5$ for $2·5\ V_4O_{12}^{4-} + 3H_2O \rightleftharpoons HV_{10}O_{28}^{5-} + 5OH^-$	E3ag	S5
3·6	5·8	25	pK_5, pK_6; $I = 1(NaClO_4)$; total vanadium concentrations $2 \times 10^{-3} - 2 \times 10^{-2}$ M; also log $K = -6·75$ for $10VO_2^+ + 8H_2O \rightleftharpoons H_2V_{10}O_{28}^{4-} + 14H^+$	E3ag	R32
3·5		25	$I = 3(NaClO_4)$	O5	
3·70			$I = 1(NaClO_4)$; 0·025 – 0·1 M in vanadate	E	C17
	6·12		$I = 1(NaClO_4)$; rapid titration	E	
4·45	7·52	20	$I = 0·1(NMe_4Cl)$; rapid-reaction studies; complex formation occurs with alkali cations	O5	S32
2·19		33	Saturated Na_2SO_4 solution; up to 0·1 M Na_3VO_4 solutions; also log $K = 2·4$ for $H_2V_{10}O_{28}^{4-} + 14H^+ \rightleftharpoons 10VO_2^+ + 8H_2O$	CRYOSC	N13
			Other measurements: C16		
35. Deuterium chloride, DCl For Hammett acidity function in D_2O, see H63					
36. Deuterium oxide, D_2O					
15·526 15·136 14·955		10 20 25	Molal scale; extrapolated to $I = 0$	E1ch	C32a, C34a

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
14·784	30			
14·468	40			
14·182	50			
15·439	10	Molar scale		
15·049	20			
14·869	25			
14·699	30			
14·385	40			
14·103	50			
17·224	10	Mole fraction scale		
16·834	20			
16·653	25			
16·482	30			
16·166	40			
15·880	50			
		$pK_m = 4913{\cdot}14/T - 7{\cdot}5117 + 0{\cdot}0200854T$ (T in °K) Thermodynamic quantities are derived from the results.		
15·08	15	Molar scale; $I = 0{\cdot}04$ to $0{\cdot}10$, extrapolated to $I = 0$	E2bh	W35
14·71	25			
14·37	35			
14·807	20	Molal scale, taking $pK_w = 14{\cdot}073$ for H_2O	E3ah	S31
14·812	25	Molal scale	ANALYT	K24
14·81	25	Using 0·01 M $Ba(OH)_2$ in H_2O/D_2O mixtures; molal scale.	E3ag	S3
14·86	25	Molar scale, $I = 0$	E3bh	G31
14·856	25	Molar scale, $I = 0$	E3bh	G31a
14·80	25	$I = 0$	E1cd	A2
		For pK values of H_2O/D_2O mixtures, see G31, G31a		
37. Deuterio-ammonia, ND_3				
9·757	20	$I = 0$; in D_2O; taking pK of NH_3 in H_2O as 9·265	E3ah	S31
4·9		pK_b; rough estimate		L24
38. Deuterio-arsenic acid, D_3AsO_4				
2·596	25	pK_1 in D_2O; $I = 0$; from measurements in D_2O/H_2O mixtures	E3ag	S3

39. Deuteriocarbonic acid, D_2CO_3					
6·77		25	Apparent pK in D_2O; taking pK_1 for CO_2 in H_2O = 6·35	E3a,quin	C40
	10·96	25	In D_2O; meter standardized in H_2O; pK_2 for H_2CO_3 in H_2O taken as 10·33	E3ag	G29
	10·93	25	In D_2O; taking pK_2 for H_2CO_3 in H_2O as 10·33	E3ag	C41
40. Deuteriodisulphuric acid, $D_2S_2O_7$					
			For pK_a in concentrated H_2SO_4, see F21		
41. Deuteriohydrazine, N_2D_4					
	9·08	17	"Practical" constant; in D_2O; I = (KCl)	E3dg	F12
	8·69	30			
	9·11	18	"'Practical" constant, in D_2O; $I = 1$(KCl)	E3dg	B102
42. Deuteriohydrazoic acid, DN_3					
5·01		20	In D_2O; $I = 0$	E3bg	B108
43. Deuterio-iodic acid, DIO_3					
1·15		25	In D_2O; taking pK of HIO_3 in H_2O = 0·85	C1,R1d	M2
44. Deuteriophosphoric acid, D_3PO_4					
2·350		25	In D_2O; $I = 0$; extrapolated from measurements in D_2O/H_2O mixtures	E3ag	S3
2·362		25	In D_2O; taking pK_1 for H_3PO_4 in H_2O as 2·128	C	M2
2·31		25	In D_2O; meter standardised in H_2O; taking pK_1 for H_3PO_4 in H_2O as 2·11	E3ag	G29
	7·8846	5	In D_2O; using KD_2PO_4/Na_2DPO_4 mixtures from 0·005 to 0·025 M, and NaCl 0·005 M); extrapolated to $I = 0$	E1a	G8
	7·8499	10			
	7·8233	15			
	7·7986	20			
	7·7796	25			
	7·7667	30			
	7·7547	35			
	7·7484	40			
	7·7433	45			
	7·7435	50	p$K_2 = 2202{\cdot}11/T - 5{\cdot}9823 + 0{\cdot}021388T$ (T in °K) Thermodynamic quantities are derived from the results.		

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
7·750	25	In D_2O; extrapolated from measurements in D_2O/H_2O mixtures; taking pK_2 for H_3PO_4 in H_2O as 7·290; $I = 0$	E,quin	R38
2·188 7·666	20	In D_2O; $I = 0$; taking pK_1 and pK_2 for H_3PO_4 in water as 1·983, 7·207	E3ah	S31
45. Deuteriosulphuric acid, D_2SO_4				
2·33	25	In D_2O; pK_2; $I = 0$, from plot of solubility of Ag_2SO_4 in dilute D_2SO_4 in D_2O as function of I from 0·1 to 1·0 M D_2SO_4	SOLY	L30
2·69	50			
2·98	75			
3·29	100			
3·59	125			
3·91	150			
4·21	175			
4·52	200			
4·84	225			
		pK_2 = 0·0123175T − 22·86565/T − 1·253986 (T in °K) Thermodynamic quantities are derived from the results. Other measurements of pK_2, see B7, D39 For Hammett acidity function in D_2O, see H63 For self-dissociation constant of D_2SO_4 see F21		
46. Diiamidophosphoric acid, $(NH_2)_2PO_2H$				
4·92	18	$I = 0$	C1	K29
4·83	25			
47. Difluorophosphoric acid, HPO_2F_2		For basic pK in sulphuric acid, see B11		
48. Diimidotriphosphoric acid, $H_2O_3P.NH.PO_2H.NH.PO_3H_2$				
~1 ~2 3·03 6·61 9·84	25	Concentration constants, I = 0·1 (NMe_4Br)	E3bg	I12
~0 ~2 3·83 7·02 9·92		I = 0·2(NMe_4Br)		
~0 ~2 3·94 7·74 9·95		I = 0·3 (NMe_4Br)		
~1 ~2 3·36 6·86 10·00		I = 1(MNe_4Br) $f\pm$ assumed same as for HBr		

						Values of pK_1 and pK_2 could be seriously in error because of experimental limitations		
~1	~2·2	3·24	6·80	9·50	37	$I = 0{\cdot}1$; same remarks as above	E3bg	I11
~1	~2·4	3·59	7·02	9·28	50	$I = 0{\cdot}1$		
49. Diperosmic acid, See Osmic(VIII) acid								
50. Diperruthenic acid, (hydrated RuO_4)								
11·17					20 ?	Distribution between CCl_4 and water	DISTRIB	M15
14·24						pK_b for $H_2RuO_5 \rightleftharpoons HRuO_4^+ + OH_2^-$		
11·9								S48
51. Disulphuric acid, $H_2S_2O_7$								
—12	−8					Theoretical predictions (Ricci's method) of pK_1 and pK_2		G24
−13	−8					Theoretical predictions (Pauling's method) of pK_1 and pK_2		
1·85					10	pK in concentrated H_2SO_4; molal scale	FP	B13
2·52					20	pK in concentrated H_2SO_4; molal scale		B74
52. Dithionic acid, $H_2S_2O_6$								
−3·4	−0·2					Theoretical predictions of pK_1 and pK_2 from structure		K52
53. Dithionous acid, see Hyposulphurous acid								
54. Dodeca-antimonic acid, $H_{12}(Sb(OH)_6)_{12}$								
<1·55	<1·55	<1·55			25	pK_1, pK_2, pK_3	E3b	L17
1·55	2·95	4·35				pK_4, pK_5, pK_6		
5·75	7·15					pK_7, pK_8, all at $I = 0{\cdot}5(NMe_4Cl)$;		
						this acid exists in equilibrium with mononuclear antimony species at Sb(V) concentrations above 10^{-3} M		
55. Dodecahydrododecaboric acid, $H_2B_{12}H_{12}$								
						For acidity function, see M50		
56. Dodecatungstic acid, $H_{10}W_{12}O_{41}$								
~3·6	5·27	6·28			20	pK_8, pK_9, pK_{10}; $I = 0{\cdot}1(NaCl)$; rapid-reaction technique	E3ag	S33

Name, Formula and p*K value*		*T*(°C)	*Remarks*	*Methods*	*Reference*
57. (Aquo) **Dysprosium(III) ion,** Dy^{3+}					
8·10		25	pK_a for hydrolysis of Dy^{3+}; titration of 0·004–0·009 M $Dy(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0·3(NaClO_4)$	E3b	F33a
58. (Aquo) **Erbium(III) ion,** Er^{3+}					
7·99		25	pK_a for hydrolysis of Er^{3+}; titration of 0·004–0·009 M $Er(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0·3(NaClO_4)$	E3b	F33a
59. Aquo) **Europium(III) ion,** Eu^{3+}					
8·31		25	pK_a for hydrolysis of Eu^{3+}; titration of 0·004–0·009 M $Ba(OH)_2$; $I = 0·3(NaClO_4)$	E3b	F33a
~8·8		25	pK for hydrolysis of Eu^{3+}; hydrolysis of "pure" salt; $c = 0·001$–0·01 M $Eu_2(SO_4)_3$	E3ag	M38
60. Ferric ion, see Iron(III) ion					
61. Ferricyanic acid, $H_3Fe(CN)_6$					
<1		25	pK_3; $c \approx 10^{-3}$	E3bg	J14
62. Ferrocyanic acid, $H_4Fe(CN)_6$					
2·2	4·17	25	pK_3, pK_4; $c \approx 10^{-3}$; $I = 0·01$ to 0·5; extrapolated to $I = 0$	E3bg	J14
2·57	4·35	25	pK_3, pK_4; $I = 0$		H74
3	4·3	17	pK_3, pK_4; $I = 0$	E3bg	N14
	4·17	25	pK_4; $I = 0·001$ to 0·25; extrapolated against $I^{\frac{1}{2}}$	E3bg	L7
2·3	4·28	25	pK_3, pK_4 variation of redox potential with pH; extrapolated to $I = 0$	REDOX	H20a
	4·25	25	pK_4; variation of redox potential with pH Other measurements: K37	REDOX	K46
63. Ferrous ion, see Iron(II) ion					
64. Fluorophosphoric acid, H_2PO_3F					
~0·5	4·80	40	"Practical "constants	E3b	D32
	5·12	25		E	R47

65. Fluorosulphuric acid, $HFSO_3$						
				For pK_a in sulphuric acid, see B11		
66. (Aquo) **Gadolinium(III) ion,** Gd^{3+}						
~8·8			25	pK for hydrolysis of Gd^{3+}; hydrolysis of "pure" salt; c = 0·001–0·01 M $Gd_2(SO_4)_3$	E3ag	M38
8·35			25	pK_a for hydrolysis of Gd^{3+}; titration of 0·004–0·009 M $Gd(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3(NaClO_4)$	E3b	F33a
67. (Aquo) **Gallium(III)ion,** Ga^{3+}						
3·34–3·43			25	pK for hydrolysis of Ga^{3+}; $c = 0{\cdot}004$–$0{\cdot}25$ M in Ga^{3+}	E3bg	M39
2·95			25	pK for hydrolysis of Ga^{3+}; $I = 0{\cdot}5(NaClO)_4$	O6	W20
2·8	3·5		18	Successive pK values for hydrolysis of Ga^{3+}	E3ah	F32
10·3	11·7		18	Successive pK values for hydrolysis of $Ga(OH)_4^-$ to $Ga(OH)_5^{2-}$ and $Ga(OH)_6^{3-}$		
6·85			20	pK for $Ga(OH)_3 + H_2O \rightleftharpoons Ga(OH)_4^- + H^+$; $c = 0{\cdot}005$–$0{\cdot}025$ M in $Ga(OH)_4^-$; from pH of hydrolysed alkali-metal salts		I22
1·40	1·75	2·12	20	Successive pK values for hydrolysis of Ga^{3+} to $GaOH^{2+}$, $Ga(OH)_2^+$ and $Ga(OH)_3$; $I = 1(NaCl)$	DISTRIB	A17
68. Germanic acid, H_4GeO_4 (H_2GeO_3)						
9·02	12·82		25	pK_1, pK_2; $I = 0{\cdot}5(NaClO_4)$	E3bg	H1
8·98	11·74		25	$I = 1(NaClO_4)$		
				Below 0·004 M, germanic acid is mainly monomeric; at higher concentrations an octagermanic anion is also formed		
9·03	12·33		25	pK_1, pK_2; $I = 0{\cdot}5(NaCl)$; log $K = 29{\cdot}14$ for $8Ge(OH)_4 + 3OH^- \rightleftharpoons (Ge(OH)_4)_8(OH)_3^{3-}$	E3bg,h	I7
8·98			15	$I = 0$	E3cg	A25
8.92			20			
8·73			25			
8·62			30			
9·1	12·7		12	$I = 2(KCl)$	E3b	C9
9·08				In 0·5 M Na_2SO_4	E	L42
	12·43		25	$I = 3(NaCl)$	E3bh	I10
	12·31		32	In saturated Na_2SO_4 solution	CRYOSC	K63
				Other measurements: G15, G52, P43, R35, S26		
69. Gold(III) hydroxide, $Au(OH)_3$						
<11·7	13·36	>15·3	25	Successive Kp values for ionization to $H_2AuO_3^{2-}$, $HauO_3^{2-}$ and AuO_3^{3-},	SOLY	J11

Name, Formula and p*K value*	T(°C)	*Remarks*	*Methods*	*Reference*
70. (Aquo) **Hafnium(IV) ion,** Hf^{4+}				
−0·12 0·23 0·42 0·52	25	Successive pK values for hydrolysis of Hf^{4+}; $I = 1(HClO_4)$; using low (radio-isotope) Hf^{4+} concentrations; at concentrations above 10^{-3} M polymers (mainly trimers and tetramers) are also formed	DISTRIB	P24
71. Heptamolybdic acid, $H_6Mo_7O_{24}$				
∼3·7 4·33	25	pK_5, pK_6; $I = 3(NaClO_4)$; concentration constants; also log $K = 57·7$ for $7MoO_4{}^{2-} + 8H^+ \rightleftharpoons Mo_7O_{24}{}^{6-} + 4H_2O$	E1cg,h	S8
72. Hexadecapolyphosphoric acid, $H_{18}P_{16}O_{49}$				
∼2 2·92 6·48 6·08	25	Concentration constants: $I = 1(NMe_4Br)$; $f\pm$ assumed same as for HBr; first two of these pK values may be seriously in error because of experimental difficulties	E3bg	I11
∼2 2·64 6·48 8·02	37			
∼2 2·52 6·50 8·18	50			
73. Hexametaphosphoric acid, $H_6P_6O_{18}$				
2 5·60 7·82		No details		K3a
74. Hexaminotriphosphazene, $N_3P_3(NH_2)_6$				
<3·2 7·65	25	pK_1, pK_2; $I = 0$	E	F10
7·70	25	pK_2; $I = 0$	E	F11
75. Hexapolyphosphoric acid, $H_8P_6O_{19}$				
∼2·1 2·19 5·98 8·13	25	Concentration constants; $I = 1(NMe_4Br)$; $f\pm$ assumed same as for HBr; lowest two pK values uncertain because of experimental difficulty	E3bg	I12
∼1·3 2·22 5·83 8·02	37	Concentration constants, as above	E3bg	I11
∼1·3 2·22 5·81 8·00	50			
76. (Aquo) **Holmium(III) ion,** Ho^{3+}				
8·04	25	pK_a for hydrolysis of Ho^{3+}; titration of 0·004–0·009 M $Ho(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0·3(NaClO_4)$	E3b	F33a

77. Hydrazine, N_2H_4

−0·88	8·11	20	$I = 0$	O2,E	S28
0·27	7·94	25	$I = 0$	E3bg	Y15
	8·24	15	I from 0·01 to 0·15; extrapolated to $I = 0$	E3dg	W2
	7·99	25			
	7·82	35			
	8·60	10	"Practical" constant; $I = 1$(KCl)	E3dg	B102
	8·40	18			
	8·20	25			
	8·15	25	"Practical" constant; $I = 0{\cdot}3(NaClO_4)$	E3bg	J5
	8·07	30	"Practical" constant; 0·02–0·05 M hydrazine	E3dg	H59
			Other measurements: B78, G21, H78		
			For H_- acidity function of hydrazine see D26, F8, S12, S73		

78. Hydrazinosulphuric acid, $^+NH_3NHSO_3^-$

3·85		0·0075 M solution	E3bg	A39

79. Hydrazoic acid, HN_3

4·72	25	$I = 0$	E1cg	Y16
4·65, 4·68	25	$I = 0{\cdot}01$ to 0·03	E3bg	
4·62	22	$I = 0{\cdot}03$ to 1·0; pK corrected using Debye-Hückel equation and extrapolated against I	O5	B110
4·59	25		E3ag	H78
4·68	20	$I = 0$	E3bg	B108
4·692	15	$I = 0{\cdot}02$	E3cg	S36
4·686	17·5			
4·684	20			
4·682	22·5			
4·680	25			
4·680	27·5			
4·680	30			
4·70	20	$I = 0{\cdot}01$ to 0·04, extrapolated to $I = 0$	E3bg	B67*a*
4·64	26			
4·58	33			
4·55	20	$I = 0{\cdot}1$ to 1·3(KCl); extrapolated against $I^{\frac{1}{2}}$	E3b	Q4
−6·21	25	pK of monocation, $H_2N_3^+$, using H_0 function for H_2SO_4	DISTRIB	B6
−10·1		pK of dication, $H_3N_3^{2+}$, using H_0 function for H_2SO_4 and data by A. Hantzsch (*Ber.*, **63B** 1782 (1930))		
		Other measurements: B88, H21, H64, O9, W15		

Name, Formula and p*K value*	T(°C)	*Remarks*	*Methods*	*Reference*
80. Hydriodic acid, HI				
∼−9	25	Using Raoult's law	VAP	B25
∼−9·5	25	Calculation from thermodynamic data		M1
81. Hydrobromic acid, HBr				
∼−8	25	Using Raoult's law	VAP	B25
∼−9	25	Calculation from thermodynamic data		M1
		For Hammett acidity function of HBr, see P11, V8		
82. Hydrochloric acid, HCl				
−7·3	0		VAP	R21
−6·8	10			
−6·4	20			
−6·1	25			
−5·9	30			
−5·4	40			
−5·1	50			
∼−7·4	0		VAP	W33
∼−7	25	Assuming free HCl is like free HCN		B25
−7	25	Calculation from thermodynamic data		
∼−7	25	Calculation from thermodynamic data		M1
∼−7		Assuming solubilities of free HCl and RCl (where R = CH_3, C_2H_5, etc.) in water fall in regular sequence		E2
∼−6		Assuming $K_{HF}/K_{HCl} \approx K_{H_2O}/K_{H_2S} \approx 10^{-9}$		S22
3·26	360	$I = 0$; in superheated steam, density 0·525 g/ml	C1	P12
3·42	373	0·525		
3·47	378	0·525		
4·11	370	0·447		
4·14	373	0·447		
4·24	378	0·447		
4·32	383	0·447		
4·61	373	0·399		
4·74	378	0·399		

~−10		p*K* of H_2Cl^+; theoretical prediction		S29
~− 3		p*K* of HCl; theoretical prediction		
		For p*K* values of HCl in superheated steam between 400 and 700°, with densities from 0·3 to 0·8 g/cm³, see F26 For p*K* value in absolute ethanol, see S22 For Hammett acidity function of HCl see B27, B75, D21 (in the presence of LiCl and NaCl), G17 and G18 (temperature range), P10 (in the presence of added salts), P11, V8. For H_A acidity function, see Y5 For H_- acidity function, see P27 For H_0', H_0''', H_R and H_R' acidity functions of HCl, see A36		
83. Hydrocyanic acid, HCN				
9·216	25	Taking p*K* of *m*-bromophenol as 9·004; 0·01–0·05 M borax buffers; extrapolation to $I = 0$, using extended Debye-Hückel equation; freshly prepared cyanide solutions	O2	A22
9·63	10	$I = 0{\cdot}002$ to 0·024; extrapolation to $I = 0$ using extended Debye-Hückel equation, freshly prepared cyanide solutions	E3bg	I23
9·49	15			
9·36	20			
9·21	25			
9·11	30			
8·99	35			
8·88	40			
8·78	45	Thermodynamic quantities are derived from the results		
9·36	20	$I = 0{\cdot}01$ to 0·04, extrapolated to $I = 0$	E3bg	B67a
9·19	26			
9·05	33			
9·30	28		E3b	G10
		Other measurements: A20, B84, B87, B88, H28, K36		
84. Hydrofluoric acid, HF (H_2F_2)				
3·18	25	for $I = 0$; 0·01–0·1 M in HF, 0·002–0·01 M in KF; over these temperatures, K_1 for $F^- + HF \rightleftharpoons HF_2^-$ is 3·4, 4·0, 4·7, 4·8, 4·9, 5·7, 5·8, 8, respectively	C1,R1b	E11
3·40	50			
3·64	75			
3·85	100			
4·09	125			
4·34	150			

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
4·58	175			
4.89	200			
		Data fit p$K = 2·75 + 295/T - 1·91 \log T + 0·014\ T$ (T in °K)		
		Thermodynamic quantities are derived from the results		
3·21	25	for $I = 0$; 0·001 M in NaF; dilute HF solutions	C1	E21
3·10	15	for $I = 0$; using Pb-Hg/PbF_2 instead of Ag/AgCl, 0·001–1·0 M in HF, K_1 for $F^- + HF \rightleftharpoons HF_2^-$ was 3·94, 3·86, 4·32 at 15, 25, 35°	E1ch	B90
3·17	25			
3·25	35			
2·96	0	Recalculation of data by E. Deussen (*Z. Anorg. Allgem. Chem.*, **44** 312 (1905)); K_1 for $F^- + HF \rightleftharpoons HF_2^-$ was 2·43, 2·70 at 0, 25°	C	W28
3·16	25			
3·16	25	Taking ${}^{a}HF_2^-/({}^{a}HF.{}^{a}F^-) = 5·4$	E	B95
~−9		pK of H_2F^+; theoretical prediction		S29
		Other measurements: A15, A41, B67, B98, B99, C24, C30, C31, D10, D41, F3, F29, P28, R33, R34, R50 (at 100, 156, 218°), S78		
		For Hammett acidity function of HF, see B26, H80, N2 (in ethanol-water mixtures), P11		
85. Hydrogen peroxide, H_2O_2				
11·86	15	$I = 0·05$ to 4·8($NaClO_4$); extrapolated against $I^{\frac{1}{2}}$; $c = 0·55$ M H_2O_2	E3ag	E22
11·75	20			
11·65	25			
11·55	30			
11·45	35			
11·81	20		E3bg	K4
11.92	10		CALOR	S2
11·62	25			
11·34	35			
11·21	50			
12·11	0		KIN	J22
12·23	0		DISTRIB	
12·19	0		C1	
11·85	19		O1	J17

11·58		30	$I = 0{\cdot}1$ (phosphate buffers) corrected to $I = 0$ by Debye-Hückel equation	O1	M51
			In strong hydrogen peroxide solutions (above several per cent H_2O_2 in water), superacidity is observed, giving lower values of p*K* which pass through a flat minimum (8·7) near 50% Other measurements: E24		M34, K32
86. Hydrogen polysulphide					
3·8	6·3	20	For H_2S_4; $I = 0{\cdot}1$ ($NaClO_4$); rapid-flow measurements; 3.4 and 5·6 for H_2S_5	E3ag	S30
87. Hydrogen selenide, H_2Se					
	15·0	22	Estimated uncertainty ± 0·6 pH units; the direct titration of H_2Se with KOH gives low pK_2 values because of aerial oxidation	SOLY	W27
	14	25	Value needed to fit experimental $E_{\frac{1}{2}}$/pH plot	POLAROG	L35
3·89	11·0	25	$I \sim 0{\cdot}03$; titration of H_2Se in the dark	E3bg	H9
3·73		25·9	$c = 0{\cdot}008\text{–}0{\cdot}1$ M H_2Se	C1	H61
3·77					B104
88. Hydrogen sesquioxide, H_2O_3					
9–10			Theoretical prediction		C46
89. Hydrogen sulphide, H_2S					
7·33		5		C1	W30
7·24		10			
7·13		15			
7·05		20			
6·97		25			
6.90		30			
6·79		40			
6·69		50			
6·62		60			
7·57		0	$c = 0{\cdot}001$ to $0{\cdot}017$ M in H_2S	C1,R1b	L44
7·06		25			
6.82		50			
7·02		25	I varied from 0·01 to 0·17, phosphate buffers	O1	E14
	14·0	20	Extrapolation of measured p*K* versus alkali concentration	O7	
7·0	14·7	0		FP,C	J3a
7·0	13·85	30		O5	M54

Name, Formula and p*K value*		*T*(°C)	*Remarks*	*Methods*	*Reference*
7·26		10	Values of pK_2 (obtained from titrations) given in this reference are probably too low	E3bg	T20
7·07		25			
6·99		35			
6·91		50			
6·96		18	c = 0·001–0·04 M in H_2S	E3ag, VAP	G35
6·87		20			
6·79		25			
6·66		35			
6·54		45			
6·91		25		E3bg	Y17
6·81		25	1 atmosphere pressure	Cl	E13
6·68		25	500 atmosphere pressure		
6·56		25	1000 atmosphere pressure		
6·45		25	1500 atmosphere pressure		
6·37		25	2000 atmosphere pressure		
	14·75	0	Calculated from thermodynamic data and potential measurements		M13
	13·90	25			
6·88	14·15	20	$I = 1$(KCl); Hg electrode versus calomel	E	W18
6.99	12·89	25	Calculated from published thermodynamic data		P32
6·81	12·24	40			
6·54	10·68	80			
6·52		90			
6·59	9·27	120			
	8·55	138			
			Other measurements: A40, E20, K31, K49, K66, K71, P9, S29, S62, S71, T6a, W1, W3, Z1		
90. Hydrogen telluride, H_2Te					
2·64		18	c = 0·003–0·09 M H_2Te	Cl	H61
2					B104
	11	25	Value of pK_2 needed to fit $E_{\frac{1}{2}}$/pH plot	POLAROG	L35
	12·16	25	Value of pK_2 needed to fit $E_{\frac{1}{2}}$/pH plot	POLAROG	P7

91. Hydroperoxy radical, HO_2				
4·4	23	pK for $HO_2^{\cdot} \rightleftharpoons H^+ + O_2^-$; from pH-dependence of reaction with tetranitromethane; species generated by electron irradiation	KIN	C46
4·45	23	pH-dependence of rate of reaction with tetranitromethane	O	R1a
4·5		pulsed radiolysis experiments	O	C46a
~2		estimate		U1
~6	20	estimate		W11
92. Hydrosulphuric acid, see Hydrogen sulphide				
93. Hydroxylamine, NH_2OH				
6·186	15	$I = 0{\cdot}25, 1, 2{\cdot}25(NaClO_4)$; extrapolated to $I = 0$ using Debye Hückel equation	E3bg	L47
6·063	20			
5·948	25			
5·730	35			
		p$K = 2775{\cdot}7/T - 5{\cdot}8899 + 0{\cdot}0084782T$ (T in °K)		
6·04	20	Thermodynamic quantities are calculated from the results for $I = 0$; taking pK of 3,4-dinitrophenol as 5·46, 5·42, and 5·38	O2	R22
5·96	25			
5·84	30			
5·98	25	For $I = 0$	E3ag	H8
5·93	25		DISTRIB	
5·97	25	$I = 0{\cdot}0023$ to $0{\cdot}023$; extrapolated against $I^{\frac{1}{2}}$	E3bg	B51
6·04	30	"Practical" constant; $I = 1(KCl)$	E3ag	B103
6·49	30	"Practical" constant; $I = 1(KCl)$; in D_2O	E3ag	
		Other measurements: F28, I15, M16, M52, M53, R28, S83, W21		
94. Hydroxylamine-*N*,*N*-disulphonic acid, $HON(HSO_3)_2$				
11·85	25	pK_3; $I = 1{\cdot}6(K_2SO_4?)$	E3ag	A8a
95. Hydroxylamine-*N*-sulphonic acid, $HO.NH.OSO_2H$				
~12·5	Room	pK_2; $I = 1{\cdot}5(K_2SO_4)$	E3ag	A8a
12·38	64·2	$I = 1{\cdot}6(Na_2CO_3$ or $Na_2SO_4)$		
12·20	73·8			
12·10	83·5			
96. Hydroxylamine O-sulphonate, $^+NH_3OSO_3^-$				
1·48	45	$I = 1(NaClO_4)$	E3ag	C3

Name, Formula and p*K* *value*	T(°C)	*Remarks*	*Methods*	*Reference*
97. Hydroxyl radical, ·OH				
11·9	23	Pulse radiolytic method		R1
11·8	~23	Pulse radiolysis; pK obtained from pH-dependence of rate of formation of radical ion, $\cdot CO_3^-$		W9a
98. Hypobromous acid, HOBr				
8·91	10		O	F 18
8·66	25			
8·49	25			
8·23	50			
8·80	15·65		E3bg	K11
8·60	25·28			
8·47	35·55			
8·36	45·55			
8·68	22	$I = 0{\cdot}02$ to $0{\cdot}1$	E3bg	S44
8·69	20	$c = 0{\cdot}01$–$0{\cdot}02$ M BrO^-	E3bg	S45
		Other measurements: C14, F2, K16, L29, S53, S64		
99. Hypochlorous acid, HOCl				
7·825	0	Measured relative to pK_2 of H_3PO_4; $I = 0{\cdot}05$ to $0{\cdot}2$; extrapolated to $I = 0$	O3	M46a
7·754	5			
7·690	10			
7·633	15			
7·582	20			
7·537	25			
7·497	30			
7·463	35			
7·49	10	For $I = 0$; $c = 0{\cdot}01$ M HOCl	E3bg	F16
7·30	25			
7·18	35			
7·05	50			
7·50	10	For $I = 0$; $c = 0{\cdot}003$ M HOCl	O5	O13
7·31	25			
7.19	35			
7·06	50			

7.82		0	Extrapolated to zero time, and to $I = 0$ using Debye-Hückel equation	E3ag	C4
7·72		10			
7.65		15			
7·53		25			
7·49		35			
7·46		45			
7·53		25		E3bg	H7
7·50		20		E3bg	S45
7·49		25			M59
7·66		0·6	For $I = 0$; using Debye-Hückel equation	E3bg	A38
7·55		20			
7·42		27	"Practical" constant; $c = 0{\cdot}25$ M HOCl Other measurements: B85, D4, G2, G27, H65, H73, I2, K17, S4, S46, S52, S53, S58, Y11	E3bg, R2a	L36
100. Hypoiodous acid, HOI					
10·64		25	Also pK = 14·48 for $I_2OH^- \rightleftharpoons I_2O^{2-} + H^+$	E,h	C21
9·7		22		E3bg	J19
~11		25			F39
12.4		20		KIN	S51
9·49		25	pK_b for $HOI \rightleftharpoons I^+ + OH^-$; iodine electrode	E	M57
1·35		25	pK of H_2OI^+	O5	A18
1·54		25	pK of H_2OI^+; cells of type $Pt,I_2, Ag^+, H^+/Sat.KNO_3/I^-, I_2, H^+, Pt$	E	B28
101. Hyponitrous acid, $H_2N_2O_2$					
7·51		0	$I \leqslant 0{\cdot}06$; from rates of decomposition	KIN	P34
7·22		20			
7·09		30			
	11·35	25			
	11·09	50			
	10·97	55			
	11·1	18		E3ag	
7·32		15	For $I = 0$	KIN	H79
7·21	11·54	25			
7·17		35			
6·92	10·90	45	Using borate buffers in determining K_2		
	11·10	45	Using NaOH solutions		

Name, Formula and p*K value*				*T*(°C)	*Remarks*	*Methods*	*Reference*
7·05				25	For $I = 0$	E3bg	L10
	11·4			25		O3	
6·75	10·85			25	$I = 1$ Other measurements: A3, P33	KIN	B106
102. Hypophosphoric acid, $H_4P_2O_6$							
	2·19	6·77	9·48	20	"Practical" constants, $I = 0{\cdot}1$ (KCl)	E3bh	S35
<2	2·81	7·27	10·03		Concentration constants; titration of 0·01 M $Na_4P_2O_6$ in 0·049 M HCl with 0·1 M NaOH	E3bh	T16
103. Hypophosphorous acid, H_3PO_2							
1·23				25	For $I = 0$	C1, R1c	P8
1·07				18	"Practical" constant; titration of 0·11 N H_3PO_2 with 0·11 N NaOH	E3bg	M48
1·02				16	$I = 0{\cdot}16$	E3a	G44a
1·12				30	$I = 0{\cdot}16$		
1·2				45	$I = 0{\cdot}57$		
1·03				16	$I = 1{\cdot}13$(KCl); concentration constant Other measurements: B89, G43, K41, M33, N26		
104. Hyposulphurous acid, $H_2S_2O_4$							
0·35		2·45		25		C1	J3
105. Imidodiphosphoric acid, $H_2O_3P.NH.\ PO_3H_2$							
~1·5	2·66	7·32	10·22	25	Concentration constants; $I = 0{\cdot}1(NMe_4Br)$; $f\pm$ assumed same as for HBr; pK_1 may be seriously in error because of experimental difficulties	E3bg	I12
~2	2·85	7·08	9·72	25	$I = 0{\cdot}2$		
~2	2·81	7·05	9·77	25	$I = 0{\cdot}3$		
~1·5	3·05	7·62	10·36	25	$I = 1{\cdot}0$		
~1·8	2·60	7·16	9·79	37	$I = 0{\cdot}1$; as above		I11
~1·8	2·68	6·99	9·52	37	$I = 0{\cdot}3$		
~1·8	2·81	6·90	9·41	50	$I = 0{\cdot}1$		
~1·8	2.83	6·88	9·32	50	$I = 0{\cdot}3$		

106. (Aquo) **Indium(III) ion,** In^{3+}						
4·43	3·9		25	Successive pK values for hydrolysis of In^{3+} to $InOH^{2+}$ and $In(OH)_2{}^+$; $I = 3(NaClO_4)$; using In-Hg electrode; above 0·001 M, indium forms $In[(OH)_2In]_n{}^{(3+n)+}$		B41
4·4	4·4		25	Successive pK values for hydrolysis of In^{3+}; $I = 3(NaClO_4)$; tracer amounts of In^{3+}	DISTRIB	R31
11·89	11·55	11·32	20 ± 2	Successive pK_b values for hydrolysis of In^{3+} to $InOH^{2+}$, $In(OH)_2{}^+$ and $In(OH)_3$; $I = 1$	DISTRIB	H19
6·95			25	pK for hydrolysis of In^{3+} to form a mixed hydroxy-chloro complex; $I = 3(NaCl)$; $c = 0·001–0·04$ M In^{3+}; a binuclear $In_2(OH)_2$ chloro complex is also formed Other measurements: H43, H51, M36, M37	E3ag	B48
107. Iodic acid, HIO_3 (H_5IO_6)						
0·804			25	Obtained by three independent methods, taking ion-size parameter of 5Å; value depends on ion-size assumed; emf method due to A. K. Covington and J. E. Prue, *J. Chem. Soc.* **1955**, 3701	Cl,E, and KIN	P26a
0·785			25	Solubility of $AgIO_3$ in HNO_3 and KNO_3, extrapolated against $I^{\frac{1}{2}}$; $I = 0·008 - 0·5$	SOLY	L25
0·815			30			
0·84			35			
0·788			25	Solubility of $Ba(IO_3)_2$ in 1:1 electrolyte solutions, extrapolated against $I^{\frac{1}{2}}$; $I = 0·0025$ to 1	SOLY	N3
0·773			25	$I = 0·0026$ to 0·01; extrapolated against $I^{\frac{1}{2}}$	O4	H14
0·773			25	Calculated from data of C. A. Kraus and H. C. Parker, *J. Am. Chem. Soc.*, **44**, 2429 (1922)	Cl, Rlc	F38
0·807			25	Calculated from data of C. A. Kraus and H. C. Parker, *J. Am. Chem. Soc.* **44**, 2429 (1922), taking an ion size of 3Å	Cl, Rlc	L17a
0·58			0		FP	A4
0·72			18		Cl	
0·74			30	For $I = 0$ Other measurements: D44a, K18, K60, M2, O12, R36. For H_0 acidity function of aqueous HIO_3, see D18	NMR	H67
108. (Aquo) **Iron(II) ion,** Fe^{2+}						
6.93			20	pK for hydrolysis of Fe^{2+}; $I = 0·5–2(NaClO_4)$	E3bg	B65
6·74			25			
6·49			35			

Name, Formula and pK value	T(°C)	Remarks	Methods	Reference
6·34	40			
7·15	20	pK for hydrolysis of Fe^{2+}; $I = 1(NaClO_4)$	E3bg	B63
6·8	25			
8·3	25	pK for hydrolysis of Fe^{2+}	SOLY	L19
7·9	25	pK for hydrolysis of Fe^{2+}; $c = 0·02–0·08$ M $FeCl_2$; hydrolysis of "pure" salts	E3ag	G13
7·2		Concentration constants; $I = 0·5(KCl)$		
3·3	25	pK for hydrolysis of Fe^{2+}, from rate of H_2O_2 decomposition as function of pH in presence of Fe^{2+}; $I = 1(NaClO_4)$	KIN	W14
		log K for $Fe^{2+} + 3OH^- \rightleftharpoons Fe(OH)_3^-$ is estimated from polarography to be 7·85 in 1·375 N NaOH		S21
		Other measurements: H45, L34		
109. (Aquo) **Iron(III) ion**, Fe^{3+}				
2·71	15	pK for hydrolysis of Fe^{3+}; concentration constant; $I = 0·01$	O5	T21
2·46	25			
2·29	35			
2·30	20	pK for hydrolysis of Fe^{3+}; $I = 0·025$ to 0·15 ($NaClO_4$, $HClO_4$); extrapolated to $I = 0$	O6	R16
2·34	25			
2·38	18	pK for hydrolysis of Fe^{3+}; $I = 0·01$ to 0·03; extrapolated to $I = 0$	O6	M30
2·19	25			
2·02	32			
2·96	18	$I = 1(NaClO_4)$; constants are also given for $2FeOH^{2+} \rightleftharpoons Fe_2(OH)_2^{4+}$		
2·79	25			
2·61	32			
2·17	25	pK for hydrolysis of Fe^{3+}; $I = 0·015$ to 3·0; extrapolated to $I = 0$ using Debye-Hückel equation; constants are also given for $2FeOH^{2+} \rightleftharpoons Fe_2(OH)_2^{4+}$	O6	M31
2·19	25	For $I = 0$	O6	S47
2·63	20–22	$I = 0·1(KNO_3)$	O5	P35
2·80	25	$I = 0·5(NaClO_4)$	O6	W20
2·92	21	$I = 0·55$; in D_2O	O6	H75
2·74 3·31	20	Successive pK values for hydrolysis of Fe^{3+}; $I = 1(NaClO_4)$; $-\log K = 2·85$ for $2Fe^{3+} + 2H_2O \rightleftharpoons Fe_2(OH)_2^{4+} + 2H^+$	REDOX	P18
2·83 4·59	25	Successive pK values for hydrolysis of Fe^{3+}	E	I18
2·83	25		C	

3·05	3·26		25	Successive p*K* values for hydrolysis of Fe^{3+}; $I = 3(NaClO_4)$; also $-\log K = 2{\cdot}91$ for $2Fe^{3+} + 2H_2O \rightleftharpoons Fe_2(OH)_2{}^{4+} + 2H^+$	REDOX	H46
				Values of $-\log K$ for $2Fe^{3+} + 2H_2O \rightleftharpoons Fe_2(OH)_2{}^{4+} + 2H^+$, from 15–41°, are estimated from magnetic measurements		M56
				Other measurements: A31, B10, B52, B53, B76, B91, B94, C30, I20, L5, L33, O10, S81	..	
110. Isohypophosphoric acid, $H_4P_2O_6$						
4·5	8·5			pK_2, pK_3; $c = 0{\cdot}02$ M	E3bg	B60
1·67	6·26		25	pK_2, pK_3; $I = 0{\cdot}1$ to $1{\cdot}0$ (Et_4NCl); extrapolated to $I = 0$; pK_1 estimated as 0·6	E3bg	C10a
111. (Aquo) **Lanthanum(III) ion**, La^{3+}						
~10			25	p*K* for hydrolysis of La^{3+}; from hydrolysis of "pure" salt; $c = 0{\cdot}001–0{\cdot}01$ M $La_2(SO)_3$	E3ag	M38
9·06			25	pK_a for hydrolysis of La^{3+}; titration of 0·004–0·009 M $La(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3$ ($NaClO_4$)	E3b	F33a
8·98			25	ditto, using 0·02 M NaOH		
10·1			25	p*K* for hydrolysis of La^{3+}; $I = 3(LiClO_4)$; $c = 0{\cdot}1–1{\cdot}0$ M $La(ClO_4)_3$; also $-\log K = 9{\cdot}95$ for $2La^{3+} + H_2O \rightleftharpoons La_2OH^{5+} + H^+$; other species include $La_5(OH)_9{}^{6+}$ and $La_6(OH)_{10}{}^{8+}$	E3bg	B43
5·6			20	pK_b; $c = 0{\cdot}01$ M $LaCl_3$	E3bg	W17
3·3			25	pK_b; estimated from solubility measurements of I. M. Kolthoff and R. Elmquist, *J. Am. Chem. Soc.*, **53**, 1217 (1931)		D8
~5			18	pK_b	DISTRIB	V6
112. (Aquo) **Lead(II) ion**, Pb^{2+}						
7·78			18	p*K* for hydrolysis of Pb^{2+}; for $I = 0$; $c = 0{\cdot}005–0{\cdot}4$ M $(PbNO_3)_2$; also $\log K = -7{\cdot}30$ for $2Pb^{2+} + H_2O \rightleftharpoons Pb_2OH^{3+} + H^+$, and $\log K = -20{\cdot}93$ for $4Pb^{2+} + 4H_2O \rightleftharpoons Pb_4(OH)_4{}^{4+} + 4H^+$	E3bg	P16
8·66			20	p*K* for hydrolysis of Pb^{2+}; $Pb_4(OH)_4{}^{4+}$ is also formed	E3bg	F4
7·93			25	p*K* for hydrolysis of Pb^{2+}; $I = 2(NaClO_4)$; also $\log K = -19{\cdot}35$ for $4Pb^{2+} + 4H_2O \rightleftharpoons Pb_4(OH)_4{}^{4+} + 4H^+$		H76
8·84			25	p*K* for hydrolysis of Pb^{2+}; $I = 2(NaNO_3)$; also $\log K = -7{\cdot}11$ for $2Pb^{2+} + H_2O \rightleftharpoons Pb_2OH^{3+} + H^+$; $\log K = -21{\cdot}72$ for $4Pb^{2+} + 4H_2O \rightleftharpoons Pb_4(OH)_4{}^{4+} + 4H^+$	E3ag	H77
7·1	10·1	11·5	25	p*K* values for stepwise hydrolysis of Pb^{2+} to $PbOH^+$, $(PbOH)_2$ and $(Pb(OH)_3{}^-$; $I = 1(KNO_3)$	POLAROG	G38

Name, Formula and pK value			T(°C)	Remarks	Methods	Reference
7·8	9·4	10·8	25	pK values for stepwise hydrolysis of Pb^{2+}; $I = 0{\cdot}3(NaClO_4)$; Pb-Hg electrode		C6
7·9	9·6	11·5	25	$I = 3(NaClO_4)$		
7·8			25	pK_b for $PbOH^+ \rightleftharpoons Pb^{2+} + OH^-$	SOLY	G7
5.99			100	pK for hydrolysis of Pb^{2+}	KIN	K69
				At high lead concentrations, Pb^{2+} also hydrolyses to Pb_2OH^{3+} and $Pb_4(OH)_4{}^{4+}$ (constants are given)		O8,P4
				At 25° and $I = 2(NaClO_4)$, $\log K = 12{\cdot}62$ for $Pb^{2+} + 3OH^- \rightleftharpoons Pb(OH)_3{}^-$	POLAROG	O11
				At 25° and $I = 0$, $\log K = 13{\cdot}90$ for $Pb^{2+} + 3OH^- \rightleftharpoons Pb(OH)_3{}^-$	POLAROG	N27
				At 25° and $I = 0$, $\log K = 13{\cdot}95$ for $Pb^{2+} + 3OH^- \rightleftharpoons Pb(OH_3{}^-$	POLAROG	V9
				At 20°, $\log K = 12{\cdot}15$ for $Pb^{2+} + 3OH^- \rightleftharpoons Pb(OH)_3{}^-$	POLAROG	H52
				Other measurements: C36, G49, G51, T14, W26		
113. (Aquo) **Lithium ion,** Li^+						
0·26			5	pK_b; $I = 0{\cdot}02$ to $0{\cdot}1$; $f\pm$ calculated using Davies' equation; e.m.f. data from H. S. Harned and H. R. Copson, *J. Am. Chem. Soc.*, **55**, 2206 (1933), and H. S. Harned and J. G. Donelson, *J. Am. Chem. Soc.*, **59**, 1280 (1937)	E1ch	G26
0·20			15			
0·18			25			
0·20			35			
0·19			45			
−0·08			25	pK_b; $f\pm$ from Davies' equation	C2,R1b	D3
−0·53			25	pK_b	C2,R1d	S65
0·32			25	pK_b	C2,R1e	
−0·18			25	pK_b; concentration constant; $I = 3(NaClO_4)$; taking ${}^fOH^- = {}^fCl^-$	E2ah	O2
0·36				pK_b; concentration constant; from salt effect on indicator; $I = 1(LiCl)$	O3	K38
0·13				$I = 0{\cdot}2(LiCl)$		
0·89			49	pK_b; for $I = 0$	C2	W29
1·13			93			
1·51			138			

1·42	182			
1·59	227			
1·76	271			
		For alkalinity function of LiOH solutions, see L12a, M40, S73		
114. (Aquo) **Lutecium(III) ion,** Lu^{3+}				
6·6	20	pK_b for $LuOH^{2+} \rightleftharpoons Lu^{3+} + OH^-$; c = 0·01 M $LuCl_3$	E3bg	W17
7·90	25	pK_a for hydrolysis of Lu^{3+}; titration of 0·004–0·009 M $Lu(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; I = 0·3($NaClO_4$)	E3b	F33a
7·98	25	ditto, using 0·02 M NaOH		
115. (Aquo) **Magnesium ion,** Mg^{2+}				
2·58	25	pK_b; for I = 0; c = 0·03 M $MgCl_2$	E3bg	S74
2·1	18	pK_b	SOLY	G28
2·60	25	pK_b; I = 0	E3bg	H71
2·4	18	pK_b; concentration constant; c = 0·1–0·5 N $MgCl_2$; salt effect on indicator	O3	K39
12·2	25	pK for hydrolysis of Mg^{2+}; I = 3(NaCl, $MgCl_2$)	E3bg, h	L22
12·8	30	pK for hydrolysis of Mg^{2+}, I = 0·1(KCl); c = 0·01 M	E3bg	C12
9·76	100	pK for hydrolysis of Mg^{2+}; taking pKw = 12·38; c = 0·06 M $MgCl_2$; rate of inversion of sucrose	KIN	K69
116. (Aquo) **Manganese(II) ion,** Mn^{2+}				
10·93	15	pK for hydrolysis of Mn^{2+}; I = 0·002 to 0·04; extrapolated to I = 0 by fitting extended Debye-Hückel equation	E3bg	P20
10·76	20			
10·59	25			
10·38	30			
10·19	36			
10·10	42			
10·6	30	pK for hydrolysis of Mn^{2+}; I = 0·1(KCl)	E3bg	C12
9·54	100	pK for hydrolysis of Mn^{2+}	KIN	K69
117. (Aquo) **Manganese(III) ion,** Mn^{3+}				
0·06	25	pK for hydrolysis of Mn^{3+}; I = 4($Mn(ClO_4)_2$,$HClO_4$)	O6	W13
∼−0·2	23	I = 5·3 to 6·1 ($Mn(ClO_4)_2$,$HClO_4$)	O6	F1
∼−0·7	23	I = 6($HClO_4$, $NaClO_4$)	O6	D34
118. Manganic acid, H_2MnO_4				
10·15	35	pK_2; $I \approx 0{\cdot}1$	KIN	L37

Name, Formula and p*K value*		*T*(°C)	*Remarks*	*Methods*	*Reference*
119. (Aquo) **Mercury(I) ion,** Hg_2^{2+}					
5·0		25	pK for hydrolysis of Hg_2^{2+}; $I = 0{\cdot}5(NaClO_4)$; measurements included Hg electrode; allowed for equilibrium, $Hg + Hg^{2+} \rightleftharpoons Hg_2^{2+}$; earlier reported values are too low because of the hydrolysis of Hg^{2+} also present	E3bg	F23
4·6			$c = 0{\cdot}006$ M, as perchlorate	E3ag	N17
120. (Aquo) **Mercury(II) ion,** Hg^{2+}					
3·49	2·47	25	Successive pK values for the hydrolysis of Hg^{2+}; $I = 3(Ca(ClO_4)_2, Mg(ClO_4)_2)$	E3bg	A12
3·55	2·66	25	$I = 3(NaClO_4)$		
			Constants are also given for Hg_2OH^{3+}, $Hg_2(OH)_2^{2+}$ and $Hg_4(OH)_3^{5+}$		
3·70	2·65	25	$I = 0{\cdot}5(NaClO_4)$	E3bg	H54
3·23	2·93	25	$I = 3(NaClO_4)$	SOLY	D48
2·49	2·85	25		SOLY	G6
6·72		13	$-\log K$ for $Hg^{2+} \rightleftharpoons Hg(OH)_2 + 2H^+$; $I = 0{\cdot}1(NaNO_3)$	E3bg	A21
6·52		20			
6·26		30			
6·00		40			
6·22		20	$I = 0$, by extrapolation against $I^{\frac{1}{2}}$		
			Ratio of successive constants for hydrolysis of Hg^{2+} is about 0·04		
6·26		25	$-\log K$ for $Hg^{2+} \rightleftharpoons Hg(OH)_2 + 2H^+$	SOLY	G4
14·85		25	pK for $Hg(OH)_2 + H_2O \rightleftharpoons Hg(OH)_3^- + H^+$		
14·77		25	pK for $Hg(OH)_2 + H_2O \rightleftharpoons Hg(OH)_3^- + H^+$	SOLY	F40
21·4		30	$\log K$ for $Hg^{2+} + 2OH^- \rightleftharpoons Hg(OH)_2$; $I = 2(NaNO_3)$	POLAROG	N18
			Other measurements: B56, D2, G38, G49, K33		
121. Molybdic acid, H_2MoO_4			See also Heptamolybdic acid, Tetramolybdic acid		
			Acidification of molybdate solutions gives polymeric species, of which $Mo_7O_{24}^{6-}$ is believed to be the simplest to be formed in appreciable amounts. See A43, G30		
	4·08	25	Concentration constant; $I = 3(NaClO_4)$; formation of $Mo_7O_{24}^{6-}$ is important even down to $c = 6 \times 10^{-4}$ M	E1cg,h	S8
~3·6	3·89	25	$I = 3(NaClO_4)$; more refined values from data given in S8	Elcg,h	S9

4·00	4·21	20	$I = 0{\cdot}0023$; $c = 10^{-4}$ M molybdate	O5	R24
3·52	4·84	22	$I = 0{\cdot}1$; from electromigration in $NaNO_3$ solutions		C22
3·57	4·75	22	$I = 0{\cdot}1$; from electromigration in $NaClO_4$ solutions		
1·15	3·75	21	$I = 0{\cdot}465$	O5	Y9
0·9		25	p*K* for proton addition; $I = 0{\cdot}5(NaClO_4, HClO_4)$ $c = 10^{-4}$ M molybdate	O6	R25
0·3		22	p*K* for proton addition, from electromigration in $NaNO_3$ solutions		C22
0·8		22	p*K* for proton addition, $NaClO_4$ solutions		
			Other measurements: N23, S59		
122. Monobromamine, NH_2Br					
6·39			$I = 0$	O5	J7
123. Monochloramine, NH_2Cl					
15		25	pK_b; estimate based on p*K*-lowering by chlorine substitution in dialkylamines		W10
124. (Aquo) **Neodymium(III) ion,** Nd^{3+}					
8·5		25	p*K* for hydrolysis of Nd^{3+} to $NdOH^{2+}$; $I = 3(NaClO_4)$	E3b, quin	T10
~9		25	p*K* for hydrolysis of Nd^{3+}; hydrolysis of “pure” salts; $c = 0{\cdot}001 - 0{\cdot}01$ M $Nd_2(SO_4)_3$	E3ag	M38
8·43		25	pK_a for hydrolysis of Nd^{3+}; titration of 0·004–0·009 M $Nd(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3(NaClO_4)$	E3b	F33a
125. (Aquo) **Neptunium(IV) ion,** Np^{4+}					
2·30		25	p*K* for hydrolysis of Np^{4+}; $I = 2(NaClO_4)$	O5	S76
2·49		25	$I = 2(NaClO_4)$; D_2O solution		
			At low acidities, polymerization becomes important		
126. (Aquo) **Neptunium(V) ion,** Np^{5+}					
8·9			p*K* for $NpO_2^+ + H_2O \rightleftharpoons NpO_2OH + H^+$		K57
127. (Aquo) **Nickel(II) ion,** Ni^{2+}					
10·22		15	p*K* for hydrolysis of Ni^{2+}; $I = 0{\cdot}0016$ to $0{\cdot}043$; extrapolated to $I = 0$ by fitting to extended Debye-Hückel equation	E3bg	P22
10·05		20			
9·86		25			
9·75		30			

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
9·58	36			
9·43	42			
8·94	25	pK for hydrolysis of Ni^{2+}; $I = 0{\cdot}007$ to 0·55, extrapolated to $I = 0$	E3bg	C43
9·23–9·49	25	pK for hydrolysis of Ni^{2+}, as nitrate, sulphate, chloride and perchlorate	E3bg	K65
9·4	30	$I = 0{\cdot}1$ (KCl)	E3bg	C12
8·60	100		KIN	K69
		At 25°, $I = 3(NaClO_4)$, and $c = 0{\cdot}1–0{\cdot}8$ M Ni^{2+}, the main hydrolysed species is $Ni_4(OH)_4^{4+}$		B109
		Other measurements: A6, D23, G12, S25		
128. Niobic acid, $H_8Nb_6O_{19}$				
10·88 13·8	25	pK_7, pK_8; $I = 3$(KCl); $c = 0{\cdot}05–0{\cdot}14$ M in niobate	E3bh	N15
7·4	18–20	acidic pK		B1
14·6		basic pK		
129. Nitramide, No_2NH_2				
6·48	25	Based on pK = 7·17 for *o*-nitrophenol	O2	T13
6·59	15	For $I = 0$; $c = 0{\cdot}002–0{\cdot}03$ M	C1	B92
6·5	~20		O5	
130. Nitric acid, HNO_3				
−1·27	25	Molal scale; from vapour pressure and activity coefficient data for 2–14 M HNO_3	VAP	D16
−1·19	25	Molar scale		
−1·65	0		RAMAN	K61
−1·37	25			
−1·24	50			
−1·68	0		NMR	H69
−1·44	25			
−1·18	70			
−1·32	26±2		RAMAN	R13
−1·53	25	Molal scale; from vapour pressure and isopiestic measurements; 2–28 mol. $kg.^{-1}$	VAP	H2
−1·31	50			
−1·16	75			

−1·0 to −1·3		25	From vapour pressure and activity coefficient data	VAP	K2
−1·60			From dielectric constant; extrapolating from non-aqueous solutions		W34
−1·44		25	Assuming species formed is $HNO_3.3H_2O$	RAMAN and NMR	H62
−2·09		25	Calculated p*K* for a 1:1 HNO_3:H_2O species		
−3·78		25	Calculated p*K* for unhydrated nitric acid		
			Other measurements: H68, K52, M7, N23a, P23, R12, W33		
			Ref. H49a gives an equation fitting literature values of p*K* from 0° to 300°		
			For Hammett acidity function of HNO_3, see B12, D19, D21 (in presence of $LiNO_3$ and $NaNO_3$), L13 (in presence of $NaClO_4$), and P11.		
			For H_R (J_0) acidity function of HNO_3, see D27		
			For H_R* acidity function of HNO_3, see Y4.		
131. Nitrous acid, HNO_2					
3·230		15	For $I = 0$; extrapolated from results in 0·01 M $NaNO_2$, 0·03 M $NaNO_3$, and 0·21 M $NaClO_4$	E3bg	L47
3·203		20			
3·113		35			
3·49		0	$I = 0{\cdot}001$	O1	K27
3·34		12·5			
3·22		30			
3·46		0	$I = 0{\cdot}002$; using flowing solutions	O1	S15
3·29		25			
3·15		50			
3·148		25	$I = 0{\cdot}04$ to 2·0 ($NaClO_4$); extrapolated to $I = 0$	E3bg	L48
3·15		20	"Practical" constant; $I = 0{\cdot}012$	E3bg	B83
3·26		25	For $I = 0$; from $I = 0{\cdot}17$, assuming $\gamma_{+} = 0{\cdot}773$	KIN	L27
3·29		25	"Practical" constant; $I = 0{\cdot}07$($NaClO_4$)	O5	V4
2·80		25	$I = 1$($NaClO_4$)		
−8·1		25	p*K* for nitrosonium ion (NO^+) formation from HNO_2, using H_R function for $HClO_4$ solutions	O6	D28
−7·86		20	p*K* for nitrosonium ion (NO^+) formation from HNO_2, using C_0 function for H_2SO_4 solutions	O6	S37
			Other measurements: A33, B22, B59, D33, L26, R11, S23		
132. Octaminotetraphosphazene, $N_4P_4(NH_2)_8$					
5·22	7·55	25	$I = 0$	E	F10
5·15	7·50	25	$I = 0$	E	F11

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
133. Orthophosphoric acid, see Phosphoric acid				
134. Osmic acid, H_2OsO_5				
12·0 14·5	25	Apparent pK values; $I = 1$; the neutral species is mainly osmium tetroxide	O7	S11
12·0 $\leqslant$15	25		DISTRIB	
~10	25	Estimated true pK of osmic acid		
12·1	25	Distribution between CCl_4 and water	DISTRIB	Y12
135. Osmium tetroxide, see Osmic acid				
136. α-Oxyhyponitrous acid, $H_2N_2O_3$				
2·51 9·70	1	For $I = 0$; from $I = 0{\cdot}02$ to 1·0	E3bg	S75
137. (Aquo) **Palladium(II) ion**, Pd^{2+}				
13·0 12·8	25	Stepwise pK_b values for Pd^{2+}	E3bg	I24
12·4 14·1	25		O6	
138. Paramolybdic acid, see Heptamolybdic acid				
139. Perboric acid				
7·91	25	Apparent pK for $H_3BO_3 + H_2O_2 \rightleftharpoons H^+ + (H_2BO_3.H_2O_2)^-$; $I = 0$; from results in 0·1 M KCl	E3cg	A24
7·71	25	Apparent pK for $H_3BO_3 + 2H_2O_2 \rightleftharpoons H^+ + (H_2BO_3.2H_2O_2)^-$; $I = 0$		
<8	0	$c = 0{\cdot}02$–0·07 M borate	DISTRIB	M25
7·77	18			
140. Perchloric acid, $HClO_4$				
		From Raman spectroscopy, the dissociation constant is greater than 38		H49
		Perchloric acid is completely dissociated up to 6–8 M		A16
		From Raman spectroscopy, perchloric acid is completely dissociated up to 10 M		C35

−2·4 to −3·1			25		VAP	K2
−2·12			25	Assuming species is $HClO_4.7H_2O$	RAMAN, NMR	H62
−4·8			25	Assuming species is $HClO_4·3H_2O$		
−1·61			10	Molal scale; vapour pressure and isopiestic measurements; 0·1–14 mol kg^{-1}	VAP	H2
−1·54						
−1·47			40			
−1·70			0		NMR	H69
−1·58			25			
−1·42			70			
−7				Theoretical prediction (Ricci's method)		G24
−8				Theoretical prediction (Pauling's method)		
−7·3				Theoretical prediction		K52
−8·6				Theoretical prediction		S29
−14				pK of $H_2ClO_4^+$; theoretical prediction Other measurements: H68, W33 For Hammett acidity function of $HClO_4$, see B66, D21 (in presence of $LiClO_4$ and $NaClO_4$) H20, H22, P11, P17, Y8. For $H_R(J_0)$ acidity function of $HClO_4$ see D27 For H_R^* acidity function of $HClO_4$ see Y4 For H_- acidity function of $HClO_4$ see B69 For H_I acidity function of $HClO_4$ see H60		
141. Perchloryl amide, H_2NClO_3						
3·7	8·6			Titration of 0·015 M dipotassium salt with 0·1 N mineral acids	E3bg	M10
142. Perchromic acid, H_2CrO_5						
4·30			22	Also $K = 1·4$ for $H_2CrO_4 + H_2O_2 \rightleftharpoons H_2CrO_5 + H_2O$	E3ag	F20
4·95			22	Also $K = 0·73$ for $H_2CrO_4 + H_2O_2 \rightleftharpoons H_2CrO_5 + H_2O$	O5	
143. Perhydroxyl radical, see Hydroperoxy radical						
144. Periodic acid, H_5IO_6						
1·64	8·36	14·98	25	$c = 10^{-4}$ M periodate	O5	C38
1·55	8·27		25	$I = 0·006$ to $0·01$; $c = 0·005–0·008$ M periodate; Debye-Hückel equation for extrapolation	E3bg	N8
2·23	8·01		10	$I = 0·2$ to $1·3$ ($NaNO_3$); extrapolated against I	E,quin	I21
2·21	8·01		20			
2·20	8·02		30			

Name, Formula and p*K value*			*T*(°C)	*Remarks*	*Methods*	*Reference*
2·21	8·04		40			
2·22	8·07		50			
	8·34		0	$c = 0{\cdot}002$–$0{\cdot}05$ M periodate;	E3b	B107
	8·33		25	taking $K = 2400$ for dimerization constant of periodate dianion		
	8·43		45			
		12·5	16	Titration of 0·2 M $K_2H_3IO_2$	E3bg	S61
~−0·8				pK for $H_5IO_6 + H^+ \rightleftharpoons I(OH)_6{}^+$	O6	M32
−1·0				value predicted by Ricci's method		
				True pK values of H_5IO_6 have been calculated from experimental results by assuming $K = 40$ for $H_4IO_6{}^- \rightleftharpoons 2H_2O + IO_4{}^-$		C37
				Other measurements: C37, L11, R36		
				For H_0 acidity function of aqueous periodic acid see D18		
145. Permanganic acid, $HMnO_4$						
−2·25			25	In $HClO_4$ solutions	O6	B5
146. Peroxydideuteriomonosulphuric acid, D_2SO_5						
10·40			19	In D_2O		K72
147. Peroxydiphosphoric acid, $H_4P_2O_3$						
		5·18 7·67	25	$I = 0{\cdot}01$ to 1; extrapolated against $I^{\frac{1}{2}}$, $NMe_4{}^+$ salt titrated with HCl	E3bg	C39
−0·3	0·5			estimates, by analogy with similar acids		
148. Peroxymonophosphoric acid, H_3PO_5						
1·1	5·5	12·8	25	"Practical" constants; $I = \sim 0{\cdot}2$ (for K_1) 0·14 (for K_2), $\sim 0{\cdot}15$ (for K_3)	O5	B21
⩽1·3	~4·85		25	$I = 1{\cdot}5$	KIN	F24
		12·5	35·8		KIN	K53
149. Peroxymonosulphuric acid, H_2SO_5						
1·0			25		ANALYT	M41
0·7			75			
		9·3	25	$I \sim 0{\cdot}2$	E3bg	G36
		9·4	25	$I > 1$; poor endpoint; decomposition	E3bg	B9

150. Peroxynitrous acid, HO.ONO						
<6			23			Y2
151. Perrhenic acid, $HReO_4$						
−1·25			25	In $HClO_4$ solutions	O6	B5
152. Pertechnetic acid, $HTcO_4$						
0·3			25·4			R39
−1·5				Predicted from pK values of $HReO_4$(− 1·25) and $HMnO_4$ (− 2·25)		C26
153. Perxenic acid, H_4XeO_6						
~2	~6			Estimate		A30
		10·5	24	$c = 0{\cdot}003$ M	E3bg	
		~10			O5	
154. Phosphine, PH_3						
29			27	pK for $PH_3 + H_2O \rightleftharpoons PH_2^- + H_3O^+$; isotope exchange	KIN	W16
28				pK_b for $PH_4^+ + OH^- \rightleftharpoons PH_3 + H_2O$		
155. Phosphoramidic acid, see Amidophosphoric acid						
156. Phosphoric acid, H_3PO_4						
2·056			0	$I = 0{\cdot}01$ to $0{\cdot}31$; extrapolated to $I = 0$	E1ch	B14
2·073			5			
2·088			10			
2·107			15			
2·127			20			
2·148			25			
2·171			30			
2·196			35			
2·224			40			
2·251			45			
2·277			50			
2·308			55			
2·338			60			
				$pK_1 = 799{\cdot}31/T - 4{\cdot}5535 + 0{\cdot}013486T$ (T in °K)		
				Thermodynamic values are derived from the results		
2·120	7·227	12·465	18	For $I = 0$	E3ah	B57
2·161	7·207	12·325	25			

Name, Formula and pK value			T(°C)	Remarks	Methods	Reference
2·232	7·165	12·180	37			
2·048			0·3	$I = 0{\cdot}01$ to 0·10; extrapolated using Debye-Hückel equation	E1ch	N22
2·076			12·5			
2·124			25			
2·185			37·5			
2·260			50			
2·172			25			H50
2·126			25	For $I = 0$	C1	M17
2·128			25		C	M2
1·983	7·207		20	For $I = 0$	E3ah	S31
2·12			25	For $I = 0$	CALORIM	I13
2·15			25	$c = 0{\cdot}0058$ M; 1 atmosphere	C1	E12
2·01				500 atmosphere		
1·88				1000 atmosphere		
1·77				1500 atmosphere		
1·58				2000 atmosphere		
	7·3131		0	$I = 0{\cdot}02$ to 0·45; extrapolated using Debye-Hückel equation;	E1a	B15, B16
	7·2817		5	$c = 0{\cdot}003$–0·09 M (NaH_2PO_4 or KH_2PO_4),		
	7·2537		10	0·003–0·06 M(Na_2HPO_4);		
	7·2312		15	0·003–0·09 M (NaCl)		
	7·2130		20			
	7·1976		25			
	7·1891		30			
	7·1850		35			
	7·1809		40			
	7·1809		45			
	7·1831		50			
	7·1870		55			
	7·1944		60			
				Between 0° and 50°, $pK_2 = 2073{\cdot}0/T - 5{\cdot}9884 + 0{\cdot}020912T$ (T in °K)		
				Thermodynamic values are derived from the results		
	7·2178		20	$I = 0{\cdot}013$ to 0·166, extrapolated to $I = 0$;	E1a	N21
	7·2058		25	$c = 0{\cdot}03$ and 0·06 M Na_2HPO_4,		
	7·1973		30	0·04 and 0·06 M NaH_2PO_4, 0·03 and 0·06 M NaCl		

7·1918		35			
7·1890		40			
7·1888		45			
7·1912		50			
7·2797		5	$I = 0{\cdot}024$ to $0{\cdot}108$; extrapolated to $I = 0$; $c = 0{\cdot}006$–$0{\cdot}026$ M KH_2PO_4, $0{\cdot}003$–$0{\cdot}013$ M $KNaHPO_4$, $0{\cdot}010$–$0{\cdot}043$ M NaCl	E1a	G45
7·2525		10			
7·2305		15			
7·2129		20			
7·2004		25			
7·1902		30			
7·1828		35			
7·1783		40			
7·1758		45			
7·1764		50			
			$pK_2 = 1775{\cdot}812/T - 3{\cdot}9762 + 0{\cdot}0175089T$ (T in °K) Thermodynamic values are derived from the results		
7·1988		25	$I = 0{\cdot}03$ to $0{\cdot}25$; extrapolated to $I = 0$	E1a	E19
7·1891		30			
7·1814		35			
7·1777		40			
7·1776		45			
7·1796		50			
7·1859		55			
7·1918		60			
			Results are also given for 10% and 20% methanol-water solutions Thermodynamic values are derived from the results		
7·21		60		E,g	C44
7·24		70			
7·24		80			
7·24		90			
	12·375	25	$I = 0{\cdot}01$ to $0{\cdot}51$; extrapolated to $I = 0$; taking $pK = 10{\cdot}329$ for HCO_3^-	O3	V2
			For values of pK_1 in H_2O/D_2O mixtures, see S3		
			For values of pK_2 in H_2O/D_2O mixtures, see R38		
			On the assumption that some H_3PO_4 dimerizes to $H_6P_2O_4$ in strong solutions, a pK_1 value of $0{\cdot}52$ is derived for the latter from conductance measurements		E17

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
		Other measurements: A1, B58, B82, B88, B98, B101, C20, C27, D1, D38, E8, F27, G1, G44, G46, H11, I12, J20, J21, K41, K48, K68, L8, L45, L46, M8, M9a, M27, M28, M48, P38, P40, R38, S32, S39, S43, S49, T6, W12 For Hammett acidity function of H_3PO_4, see D37, G17 and G18 (temperature range), H48, L13 (in the presence of $NaClO_4$), P11 For H_0', H_0''', H_R and H_R' acidity functions of H_3PO_4, see A36		
157. Phosphoric triamide, $PO(NH_2)_3$				
$<3{\cdot}6$	25	$c = 0{\cdot}1$M	E	F10
158. Phosphorous acid, H_3PO_3				
1·94 6·73		$c = 0{\cdot}01$–$0{\cdot}04$M; extrapolated to $I = 0$		T2
~1·8 6·70	18	For $I = 0$	E,quin	K41
1·20 6·70 >14	20	For $I = 0$; measurements at three concentrations were assumed to fit a curve, $pK = pK_0 + aI^b$	E3ah	F30
$-5{\cdot}0$	20	$c = 1$M H_3PO_3 in H_2SO_4; phenolphthalein cation as indicator Other measurements: B58, G44, M48, N26 For Hammett acidity function of H_3PO_3, see B12	O6	
159. (Aquo) **Plutonium(III) ion,** Pu^{3+}				
7·22	25	p*K* for hydrolysis of Pu^{3+}; $I = 0{\cdot}07$ ($HClO_4$)	E3bg	K58
7·37	25	$I = 0{\cdot}02$ (HCl)		
160. (Aquo) **Plutonium(IV) ion,** Pu^{4+}				
1·77	0	p*K* for hydrolysis of Pu^{4+}; $I = 2(NaClO_4)$		R3
1·51	12.5			
1·27	25			
1·41	15	p*K* for hydrolysis of Pu^{4+}; $I = 2(LiClO_4, HClO_4)$	REDOX	R2
1·26	25			
1·06	34·4			
1·51	25	$I = 1(NaClO_4)$	REDOX	R6
1·60	25	$I = 0{\cdot}5(NaClO_4)$	O6	K58
0·70	25	For $I = 0$		

1·9	15·4	$I = 2(NaClO_4)$	O6	R5
1·73	25			
1·94	25	In D_2O, $I = 2(NaClO_4)$		
1·6	25	$I = 1·1(NaCl)$	O6	H58
1·05	25	In D_2O; $I = 1(NaClO_4)$	KIN	R4
161. (Aquo) **Plutonium(V) ion,** PuO_2^+				
9·6	25	p*K* for hydrolysis of PuO_2^+; $I = 0·003$ (HCl)	E3b	K55
9·7		$I = 0·003$ ($HClO_4$)		
162. (Aquo) **Plutonyl ion,** PuO_2^{2+}				
3·39 5·25 9·52	20	Successive p*K* values for hydrolysis of PuO_2^{2+}; $(PuO_2)_2(OH)_3^+$ and $(PuO_2)_2(OH)^+$; are also formed	SOLY	M49
3·33 4·05		p*K* values for hydrolysis of PuO_2^{2+} in dilute HNO_3	E3ag	K62
5·71 5·71 9·7	25	p*K* values for hydrolysis of PuO_2^{2+}, ignoring polynuclear complexes	E,g	K54
5·3				O1
163. Polyphosphoric acid, $H_{62}P_{60}O_{181}$. See also Hexadeca-, Hexa-, Tri- and Tetra-polyphosphoric acids				
7·22 8·17	25	Concentration constants; $I = 1(NMe_4Br)$; $f\pm$ assumed same as for HBr	E3bg	I12
7·28 8·03	37	Concentration constants, as above	E3bg	I11
7·28 8·03	50			
164. (Aquo) **Potassium ion,** K^+				
−2·0 to −2·5	25	pK_b For p*K* values of KOH in superheated steam between 400 and 700°, with densities from 0·3 to 0·8 g/cm³, see F26 For H– acidity function of KOH see S34, Y1	VAP	K2
165. (Aquo) **Praseodymium(III) ion,** Pr^{3+}				
8·5	25	p*K* for hydrolysis of Pr^{3+} to $PrOH^{2+}$; $I = 3(NaClO_4)$	E3b,quin	T10
8·55	25	pK_a for hydrolysis of Pr^{3+}; titration of 0·004–0·009 M $Pr(ClO_4)_3$ with 0·02M $Ba(OH)_2$; $I = 0·3$ ($NaClO_4$)	E3b	F33a
~9	25	p*K* for hydrolysis of Pr^{3+}; hydrolysis of "pure" salts; $c = 0·001$–$0·025$M $Pr_2(SO_4)_3$	E3ag	M38

Name, Formula and p*K value*				*T*(°C)	*Remarks*	*Methods*	*Reference*
166. (Aquo) **Protoactinium(IV) ion,** Pa^{4+}							
0.14	0·38	1·25			Successive pK values for hydrolysis to $PaOH^{3+}$, $Pa(OH)_2^{2+}$ and $Pa(OH)_3^+$; $I = 3(HClO_4, LiClO_4)$	DISTRIB	G48
167. (Aquo) **Protoactinium(V) ion,** Pa^{5+}							
1·05				25	pK for $Pa(OH)_3^{2+} + H_2O \rightleftharpoons Pa(OH)_4^+ + H^+$; $I = 3(LiClO_4$ $HClO_4)$	DISTRIB	G47
168. Pyrophosphoric acid, $H_4P_2O_7$							
	2·28	6·70	9·37	25	For $I = 0$	E3bg	N9
			9·53	25	$I = 0·005$ to 0·035; extrapolated to $I = 0$	E3bh	W24
			9·57	40			
		6·68	9·39	18	For $I = 0$; calculated from measured pH values of pairs of salts on progressive dilution; corrected for hydrolysis	E3ah	K44
		6·57	9·62	25	For $I = 0$; $I = 0·0015$ to 0·0019 (for K_3) $I = 0·004$ to 0·018 (for K_4); activity coefficients calculated by Debye-Hückel equation	E3bg	M42
		6·70	9·88	30	For $I = 0$; salts added to sodium pyrophosphate, HCl mixtures to vary I (0·0015 to 0·24 for K_3, 0·021 to 0·34 for K_4); extrapolation using Debye-Hückel equation	E3ah	M47
1·52	2·36	6·60	9·25	25	For $I = 0$	E3bg	D15
0.44				25	For $I = 0$	CALORIM	I13
	2·27	6·63	9·29	25	For $I = 0$; extrapolated from results for $I \sim 0·01$ (K^+ salt), using Debye-Hückel equation	E3bg	B40
	2·64	6·76	9·42	25	NMe_4^+ salt solutions; extrapolation to $I = 0$ against (concentration)$^{\frac{1}{2}}$; $P_2O_7^{4-}$ forms complexes with K^+, Na^+ and Li^+	E3bg	L6
	2·22	6·36	9·11	25	"Practical" constants; $I = 0·1$ (NMe_4Cl);		
0·82	1·81	6·13	8·93	25	"Practical" constants; $I = 1(NMe_4Cl)$; pK_1 value is experimentally uncertain		
2·3	2·5	6·17	9·08	0	Concentration constants; $f\pm$ assumed same as for HBr; $I = 0·1$ (NMe_4Br); the pK_1 values are uncertain	E3bg	I11
2·2	2·3	6·03	8·97	10			
2·0	2·0	6·12	8·95	25	$I = 0·1$		
1·9	1·95	6·13	8·94	37	$I = 0·1$		
1·7	1·97	6·12	8·93	37	$I = 0·2$		

1·7	1·91	6·08	8·88	37	I = 0·3		
1·9	1·98	6·13	8·97	50	I = 0·1		
1·3	1·92	6·06	8·90	50	I = 0·2		
1·2	2·12	6·04	8·88	50	I = 0·3		
1·3	2·12	6·16	8·92	65	I = 0·1		
1·2	2·17	6·01	8·72	65	I = 1·0		
0·88	2·00	6·28	9·10	25	Probably "practical" constants; NMe_4^+ pyrophosphate solutions: I = 0·05(NMe_4Br); values of pK_1 are experimentally uncertain	E3bg	M35
0·84	1·96	6·12	9·01		I = 0·10		
0·82	1·83	6·05	8·87		I = 0·42		
0·79	1·72	5·76	8·71		I = 1·00		
1·04	2·04	6·37	9·18	50	I = 0·05		
0·95	1·99	6·34	9·11		I = 0·10		
0·86	1·82	5·90	8·77		I = 0·42		
0·83	1·64	5·74	8·64		I = 1·14		
1·14	2·55	6·38	9·26	60	I = 0·05		
1·05	2·02	6·33	9·19		I = 0·10		
0·98	1·76	5·94	8·79		I = 0·42		
0·98	1·60	5·72	8·62		I = 1·14		
1·04	1·97	6·26	9·23	65	I = 0·05		
0·97	1·94	6·26	9·16		I = 0·10		
0·92	1·71	5·90	8·77		I = 0·42		
0·91	1·54	5·72	8·61		I = 1·14		
1·00	1·91	6·17	9·16	70	I = 0·05		
0·94	1·89	6·14	9·06		I = 0·10		
0·89	1·66	5·87	8·71		I = 0·42		
0·97	1·50	5·72	8·58		I = 1·14		
0·97	2·12	5·84	8·01	65·5	"Practical" constants; c = 0·08–0·18M pyrophosphate	E3b	M4
		5·68	8·00	27·4	"Practical" constants; I = 0·75($NaNO_3$)	E3bg	Y3
2·5	2·7	6·0	8·3	25	Probably "practical" constants; I = 0·1($NaNO_3$)	E3bg	J8
~1·7	1·75	5·98	8·74	25	Concentration constants: I = 1(NMe_4Br); NMe_4^+ pyrophosphate solutions; $f\pm$ assumed same as for HBr	E3bg	I12
	2·52	6·08	8·45	20	"Practical" constants; I = 0·1(KCl)	E3bh	S35
		5·61	7·68	25	"Practical" constants; I = 1(KNO_3)	E3bg	W6
					Other measurements: A1, F26, K22, K35, M48, M58, O14		

169. (Aquo) **Rhodium(III) ion,** Rh^{3+}

3·43	pK for $Rh^{3+} \rightleftharpoons RhOH^{2+} + H^+$; c = 0·0015M; polymerized species probably form slowly	E3bg	F22

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
2·92	20	$I = 1(\mathrm{NaClO_4})$; bridged complexes probably form slowly	O5	C28
3·40	25	pK for hydrolysis of Rh^{3+}; hydrolysis of "pure" salts	E3ag	S82a
3·20	45			
3·08	60			
170. Ruthenium tetroxide, see Diperruthenic acid				
171. (Aquo) **Samarium(III) ion,** Sm^{3+}				
8·34	25	pK_a for hydrolysis of Sm^{3+}; titration of 0·004–0·009 M $Sm(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3(\mathrm{NaClO_4})$	E3b	F33a
172. (Aquo) **Scandium(III) ion,** Sc^{3+}				
4·93	25	pK for hydrolysis of Sc^{3+}; $I = 1(\mathrm{NaClO_4})$; $c = 0{\cdot}001$–$0{\cdot}02$M $Sc(ClO_4)_3$; also log $K = 3{\cdot}87$ for $2ScOH^{2+} \rightleftharpoons Sc_2(OH)_2^{4+}$	E3a,quin	K19
5·09	10	pK for hydrolysis of Sc^{3+}; $I = 1(\mathrm{NaClO_4})$;	E3a,quin	K20
4·41	40	log K for dimerization is 3·53 at 10°, 3·33 at 40°		
4·61	25	$I = 0{\cdot}01$		
5·1 5·1	25	Successive pK values for hydrolysis of Sc^{3+} to $ScOH^{2+}$ and $Sc(OH)_2^{+}$; $I = 1(\mathrm{NaClO_4})$; the main species are polynuclear species, $Sc[(OH)_2Sc]_n^{(3+n)+}$; from re-examination of data of M. Kilpatrick and L. Pokras, *J. Electrochem. Soc.* **100**, 85 (1953); **101**, 39 (1954)		B47
5·11	25	pK for hydrolysis of Sc^{3+}; $I = 1(\mathrm{NaClO_4})$; also $-\log K = 6{\cdot}14$ for $2Sc^{3+} + 2H_2O \rightleftharpoons Sc_2(OH)_2^{4+} + 2H^+$; $-\log K = 13{\cdot}00$ for $3Sc^{3+} + 4H_2O \rightleftharpoons Sc_3(OH)_4^{5+} + 4H^+$; $-\log K = 17{\cdot}47$ for $3Sc^{3+} + 5H_2O \rightleftharpoons Sc_3(OH)_5^{4+} + 5H^+$.	E3bg	A42a
173. Selenic acid, H_2SeO_4				
1·36	0	$I = 0{\cdot}007$ to $0{\cdot}019$; extrapolated to $I = 0$ using Davies' equation	E1ch	N4
1·46	10			
1·52	15			
1·58	20			
1·66	25			
1·73	30			

	1·82	35			
	1·89	40			
	1·96	45	Thermodynamic quantities are derived from the results.		
	1·83	0	Extrapolated to $I = 0$, using the Debye-Hückel limiting expression for activity coefficients	E1c,quin	P5
	1·845	5			
	1·86	10			
	1·87	15			
	1·90	20			
	1·92	25			
	1·95	30			
	1·70 to 1·78	25	Recalculation of data by V. S. K. Nair (*J. Inorg. Nuclear Chem.*, **26**, 1911 (1964)), using an extended Debye-Hückel equation; the value of pK_2 is sensitive to the choice of ion size parameter For H_0 values of selenic acid, see M1a, W5a Other measurements: G16		C33
174. Selenious acid, H_2SeO_3					
2·62	8·32	25	For $I = 0$	E,g	H6
2·54	8·02	18	Titration of 0·04M H_2SeO_3	E3bg	B88
2·42	8·08			E3bg	R40
2·40	8·06		$c = 0·05$M H_2SeO_3; added NaOH	O4	W19
2·46		25		C1	R27
2·40			0·01N solutions	O4	
2·64	8·27	25	$I = 0·1$ (KCl); concentration constants Values are also given for methanol-, ethanol-, and 2-propanol-water mixtures	E3bg	K10a
2·33		25	concentration constant, $I = 0·1$ Other measurements: B58, G20	DISTRIB	S38a
175. Selenocyanic acid, HSeCN					
<1		25	from hydrolysis of salts	E,g	B67a
176. Silicic acid, H_4SiO_4					
9·77		25	pK_1; extrapolated against $I^{\frac{1}{2}}$ to $I = 0$	SOLY	G41
9·70		35			
9·85	11·8	20	pK_1, pK_2; calculated from published e.m.f. data;		G40

Name, Formula and p*K* value		*T*(°C)	Remarks	Methods	Reference
9·7	11·9	25	$I = 0{\cdot}02$ to $0{\cdot}04$; extrapolated against I to $I = 0$		
9·1	11·9	30			
9·9		25		C1	
9·51	11·77	25	pK_1, pK_2	E3bh	O3
9·66	11·70	30	pK_1, pK_2; $pK_3 \sim pK_4 \sim 12$	E3ah	F15
9·4	11·4	20	pK_1, pK_2; $pK_3 = 13{\cdot}7$	E,g,h	M29
9·91		25	pK_1; H_4SiO_4 prepared by hydrolysis of its methyl ester; $I = 0$	C1	S26
9·46		25	pK_1; $I = 0{\cdot}5$ ($NaClO_4$)	E	B50a
9·3		60	In 0·01M borax solutions; equilibrated with powdered quartz	SOLY	V3
9·1		70			
9·1		80			
9·1		90			
9·1		100			
9·2		90	In unbuffered solutions of alkali	SOLY	
8·83		346	160 atmospheres	SOLY	V47
9·32		355	180 atmospheres		
10·33		364	200 atmospheres		
			Other measurements: B62, H3, H10, H27, I3 (in 0·5 M NaCl), J18, L2 (in 0·5 M $NaClO_4$ and 3M $NaClO_4$), M55 (colloidal silicic acid), R27 (colloidal silicic acid)		
177. (Aquo) **Silver ion**, Ag^+					
$\geqslant$11·1		25	p*K* for hydrolysis of Ag^+; $I = 1(AgNO_3)$	E,g	B46
			Hydrolysis of Ag^+ gives $AgOH$, $Ag(OH)_2^-$ and possibly polynuclear species		
3·50		25	$\log K$ for $Ag^+ + 2OH^- \rightleftharpoons Ag(OH)_2^-$; $I = 3(NaClO_4)$; no appreciable amounts of AgOH formed	DISTRIB	A27
3·60		25	$I = 3(NaClO_4)$	SOLY	
3·99		25	$\log K$ for $Ag^+ + 2OH^- \rightleftharpoons Ag(OH)_2^-$	SOLY	B50
3·64		25	$\log K$ for $Ag^+ + 2OH^- \rightleftharpoons Ag(OH)_2^-$; calculated from data given in J10	SOLY	R14
12·1		25	Estimated p*K* of $AgOH \rightleftharpoons AgO^- + H^+$	SOLY	J10
3·02		25	$I = 1(NaClO_4)$; $\log K$ for $Ag^+ + OH^- \rightleftharpoons AgOH$	SOLY	G45a
			$\log K$ for $Ag^+ + 2OH^- \rightleftharpoons Ag(OH)_2^-$		
4·69			Other measurements C10, F5, G49, K50, L21, L39.		

178. (Aquo) **Sodium ion,** Na^+				
−0·81	5	pK_b; $I = 0{\cdot}02$ to $0{\cdot}1$; $f\pm$ calculated using Davies' equation; e.m.f. data of H. S. Harned and G. E. Mannweiler, *J. Am. Chem. Soc.*, **57**, 1873 (1935)	E1ch	G26
−0·81	15			
−0·77	25			
−0·88	35			
−0·81	45			
−0·45	5	pK_b; $I = 0{\cdot}02$ to $0{\cdot}1$; $f\pm$ calculated using Davies' equation; e.m.f. data of H. S. Harned and W. J. Hamer, *J. Am. Chem. Soc.*, **55**, 4496 (1933)	E1ch	
−0·46	15			
−0·57	25			
−0·72	35			
−0·62	45			
∼−0·7	25	pK_b	CAT,KIN	B31
−1·9	25	pK_b	VAP	K2
		For alkalinity function for NaOH solutions, see M40		
		For indicator acidity function H_- for NaOH solutions, see E4, S34, Y1		
		For J_- function for NaOH solutions see B68, G32		
179. (Aquo) **Stannous ion,** see (Aquo) Tin(II) ion				
180. (Aquo) **Strontium ion,** Sr^{2+}				
0·78	5	pK_b of $SrOH^+$; $I = 0{\cdot}02$ to $0{\cdot}1$; $f\pm$ calculated using Davies' equation; from e.m.f. data due to H. S. Harned and T. R. Paxton, *J. Phys. Chem.*, **57**, 531 (1953)	E1ch	G26
0·80	15			
0·82	25			
0·86	35			
0·89	45			
		Thermodynamic quantities are derived from the results		
0·82		pK_b of $SrOH^+$; concentration constant; $c = 0{\cdot}2 - 1$N($SrCl_2$ and $Sr(NO_3)_2$); salt effect on indicator	O3	K39
0·23	25	pK_b of $SrOH^+$; $I = 3(NaClO_4)$	E2ah	C7
0·96	25	$I = 0{\cdot}02$ to $0{\cdot}065$; extrapolation to $I = 0$ using Davies' equation; solubility of $Sr(IO_3)_2$ in NaOH solutions	SOLY	C29
181. Sulphamic acid, NH_2SO_3H				
1·03	10	For $I = 0$; in most of the cells, concentration of NH_2SO_3H, NH_2SO_3Na and NaCl were approximately the same (0·005–0·054M)	E1a	K23
1·02	15			
0·99	20			
0·99	25			
0·98	30			

Name, Formula and p*K value*	T(°C)	*Remarks*	*Methods*	*Reference*
0·98	35			
1·00	40			
1·025	45			
1·04	50			
0·979–1·013	25	For $I = 0$; value varies slightly with method of calculation	CI	S65
1·00	25	For $I = 0$	CI,R1d	T5
0·58	95	$I = 1(NaClO_4)$	KIN	C2
182. Sulphuric acid, H_2SO_4				
1·58	0	pK_2; $I = 0{\cdot}005$ to $0{\cdot}02$; $\gamma\pm$ calculated from extended Debye-Hückel equation; values of pK_2 are sensitive to the parameters used in the Debye-Hückel equation	E1ch	N5
1·63	5			
1·80	15			
1·96	25			
2·09	35			
2·22	45			
1·91	18	pK_2; for $I = 0$; re-examination of literature values obtained from conductivity data		K15
1·99	25			
2·28	50			
1·76	5	pK_2; $I = 0{\cdot}01$ to $0{\cdot}04$; extrapolated using extended Debye-Hückel equation	E1ch	D11
1·80	10			
1·84	15			
1·92	20			
1·99	25			
2·05	30			
2·11	35			
2·17	40			
2·30	50			
1·66	0	$I = 0$; from published conductivity data, using limiting Onsager equation		
1·68	0	$I = 0$; from published freezing point depression data	FP	
1·90	10	pK_2; for $I = 0$	E2bg	K21
2·00	20			
2·04	25			
2·13	30			
2·17	35			
2·22	40			

1·987	25	For $I = 0$; re-examination of literature values from conductometry, spectrophotometry and potentiometry		D44
1·975	25	For $I = 0$; Ag/AgCl electrode replaced by Hg/Hg_2SO_4; ion parameter in Debye-Hückel equation taken as 1·9	Elch	C34
1·94	25	For $I = 0$; Ag_2SO_4 in $NaClO_4/HClO_4$ solutions	SOLY	K13
1·99	25		RAMAN	Y13
1·89	25	pK_2; $I = 0$; molal scale; solubility of Ag_2SO_4 in dilute H_2SO_4 plotted as function of ionic strength	SOLY	L31
2·37	50			
2·70	75			
3·01	100			
3·33	125			
3·69	150			
4·09	175			
4·49	200			
4·94	225			
		$pK_2 = 1283{\cdot}108/T - 12{\cdot}31995 + 0{\cdot}04223215\ T$ (T in °K) Thermodynamic values are derived from the results		
2·60	100	pK_2; molar scale; at density of 1 $g.cm^{-3}$; values at lower densities are also given	Cl	Q5
2·83	150			
3·13	200			
3·35	250			
3·58	300			
3·08	100	Molal scale	Cl	
4·03	200			
1·88	25	pK_2; for $I = 0$; using cation-permselective membrane	ION	W1a
2·03	35			
2·21	50			
1·99	25	pK_2; $I = 0$; molal scale; solubility of $CaSO_4$ in dilute H_2SO_4 over a range of ionic strengths	SOLY	M13a
2·03	30			
2·14	40			
2·18	45			
2·27	50			
2·36	60			
3·15	125			
3·56	150			
3·90	175			
4·24	200			
4·58	225			
4·98	250			

Name, Formula and pK value	T(°C)	Remarks	Methods	Reference
5·34	275			
5·71	300			
6·06	325			
6·41	350			
		$pK_2 = 19{\cdot}8858 \log T + 0{\cdot}006473T - 56{\cdot}889 - 2307{\cdot}9/T$ (T in °K)		
~−3·1		pK_1; theoretical prediction		S29
~−8·3		pK of $H_3SO_4^+$; theoretical prediction		
−3·3 to −3·5		pK_1; mole fraction equilibrium constant; prediction		W31
−3·0		pK_1; prediction, based on structure		K52
−1·7		pK_1; prediction; mole fraction equilibrium constant for $H_2O + H_2SO_4 \rightleftharpoons H_3O^+ + HSO_4^-$		D30
−3·0		pK_1; prediction (Pauling's method)		G24
−2·0		pK_1; prediction		B5
−3·59		pK_1; from water activity data		W32
		For pK_1 values of H_2SO_4 from 400–800°C and densities from 0·40 to 0·85 g.cm^{-3} (pressures to 4700 bars), see Q5		
		For effect of pressure on pK_2, see H70		
−8·3		pK of $H_3SO_4^+$ (not hydrated)	RAMAN	H62
−4·95	25	pK for 1:1 H_2SO_4:H_2O species		
		For self-dissociation constants of H_2SO_4 at 10, 25, 40°, see B13, G25, K25, S24		
		At 10·36°, autoprotolysis constant of $H_2SO_4 = 1{\cdot}7 \times 10^{-4}$, for $2H_2SO_4 \rightleftharpoons H_3SO_4^+ + HSO_4^-$		G23
		At 10·36°, ionic self-dehydration constant of $H_2SO_4 = 7 \times 10^{-5}$, for $2H_2SO_4 \rightleftharpoons H_3O^+ + HS_2O_7^-$		
		For computed pK values for the reactions $H_2SO_4 + nH_2O \rightleftharpoons H^+ . nH_2O + HSO_4^-$, and $HSO_4^- + nH_2O \rightleftharpoons H^+ . nH_2O + SO_4^{2-}$, see R20		
		Other measurements of pK_2 values: A37, B2, B77, D17, E5, E7, F14, F17, G44, H18, K14, K30, L50, M9a, N23a, R6, R9, R15, S43, S50, S77, Z3		
		For Hammett acidity function of H_2SO_4, see B12, B72, D30, G17 and G19 (temperature range), H20, J16, P11, R44, S10 ($KHSO_4$)		

			For $H_R(J_0)$ acidity function of H_2SO_4, see A34, D29		
			For C_0 acidity function of H_2SO_4, see D29		
			For $H_R{}^*$ acidity function of H_2SO_4, see Y4		
			For H_+ acidity function of H_2SO_4, see B73		
			For H_A acidity function of H_2SO_4, see Y6, Y7		
			For H_0''' acidity function of H_2SO_4, see A35		
			For H_0' acidity function of H_2SO_4, see J16		
			For H_R' acidity function of H_2SO_4, see B70		
			For H_- acidity function of H_2SO_4, see B69		
			For H_I acidity function of H_2SO_4, see H60		
			For H_0 acidity function of alcoholic H_2SO_4, see J1		
			For H_+ acidity function of alcoholic H_2SO_4, see I14		
183. Sulphurous acid, H_2SO_3					
1·63		0	For $I = 0$; recalculation of data given in references C1 and M45	C1,R1b	J12
1·74		10			
1·81		18			
1·89		25			
1·98		35			
2·12		50			
1·51		0			D14
1·58		5			
1·64		10			
1·70		15			
1·77		20			
1·82		25			
1·76		25			R46
2·34		70			
2·62		100			
3·1		130			
3·5		150			
1·86		25	Apparent pK value; 1 atmosphere	C1	E12
1·69			500 atmospheres		
1·51			1000 atmospheres		
1·34			1500 atmospheres		
1·20			2000 atmospheres		
1·764	7·205	25	$I = 0{\cdot}02$ to $0{\cdot}13$ (for pK_1), $0{\cdot}014$ to $0{\cdot}12$ (for pK_2); extrapolated to $I = 0$	E1cg	T3
1·90	7·205	25		E3bg	Y14

Name, Formula and p*K value*		T(°C)	*Remarks*	*Methods*	*Reference*
7·17		10	For $I = 0$; $c \leqslant 0{\cdot}05$; extrapolation by Debye-Hückel equation	E3bg	A32
7·30		25			
7·45		50			
6·96				E3bg	R40
			In aqueous solutions, bisulphite ions are in equilibrium with pyrosulphite ion; at 25°, $K = 7 \times 10^{-2}$ for $[S_2O_5^{2-}]/[HSO_3^-]^2$ Other measurements: B84, B87, B88, C1, C42, F7, F13, F34, K34, M8, M45, S38a, S43.		G34
184. Tantalic acid					
9·6		18–20	Acidic pK	SOLY	B1
13			Basic pK		
185. Telluric acid, H_6TeO_6					
8·03	11·45	5	$c = 0{\cdot}005$M H_6TeO_6; extrapolated to $I = 0$ using simple Debye-Hückel relation	E3bg	E15
7·70	10·95	25			
7·59	10·80	35			
7·28	10·27	61			
			Thermodynamic quantities are derived from the results		
7·68	11·19	18	Titration of 0·04M acid	E3bg	B88
7·70	11·04	25	For $I = 0$; at high concentrations, polytellurates are formed	E3ag	E1
	14·25	25	pK_3	07	
8·19		0	For $I = 0$	E3b,quin	A26
7·98		10			
7·61		25			
7·43		35			
7·12		45			
7·60		25	p$K_1 = 8{\cdot}180 - 2{\cdot}36 \times 10^{-2}\, t$ (t in °C) $c = 0{\cdot}01$M; polytellurates are formed when c is greater than 0·1	E3ag	J2
8·00		12	$c = 0{\cdot}06$M H_6TeO_6	C1	F25
7·81		22			
7·63		32			
7·48		42			
7·37		50			

7·61				25	For $I = 0$	E3b,R2a	A23
	>15				pK_3		S61
					Other measurements: B58, B79c, L43, R26		
186. Tellurous acid, H_2TeO_3							
2·46	3·16			25	concentration constants, $I = 0{\cdot}1$ pK_1 for protonation of H_2TeO_3 pK_2 for mono-anion formation	DISTRIB	S38a
3·5	5·4–5·8			25	pK_1 for protonation of H_2TeO_3; pK_2 for mono-anion formation	SOLY	I17
2					For protonation of H_2TeO_3; from thermodynamic data		L9
2·7	7·7			25	From hydrolysis of salts	O3	B58
187. (Aquo) **Terbium(III) ion,** Tb^{3+}							
8·16				25	pK_a for hydrolysis of Tb^{3+}; titration of 0·004–0·009 M $Tb(ClO_4)_3$ with 0·02M $Ba(OH)_2$; $I = 0{\cdot}3$ ($NaClO_4$)	E3b	F33a
188. Tetra(hydrogen sulphato)arsenious acid, $HAs(HSO_4)_4$							
					For pK in H_2SO_4, see B11		
189. Tetra(hydrogen sulphato)boric acid, $HB(HSO_4)_4$							
					For pK in H_2SO_4, see B11		
190. Tetrametaphosphoric acid, $H_4P_4O_{12}$							
2·78				25	pK_4; for $I = 0$; from results at $I \sim 0{\cdot}01$ (K^+ salt), using Debye-Hückel equation	E3bg	B40
2·74				25	pK_4; for $I = 0$; using assumed value for mobility of $HP_4O_{12}^{3-}$ ion	C2	D12
2·60	6·4	8·22	11·4		No details		K3a
191. Tetramolybdic acid, $H_2Mo_4O_{13}$							
1·4	1·5				$I = 1$($NaClO_4$)	DISTRIB	C18
192. Tetraperoxychromic acid, H_3CrO_8							
7·16				30	pK_3; $I = 3$($NaClO_4$)	KIN	Q1
7·40				40			
7·60				50			

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
193. Tetrapolyphosphoric acid, $H_6P_4O_{13}$				
1·36 2·23 6·63 8·34	25	pK_3, pK_4, pK_5, pK_6; "practical" constants; $I = 1(NMe_4NO_3)$; NMe_4^+ salt; extrapolated against (concentration)$^{\frac{1}{2}}$; complex formation occurs with Na^+, K^+, or guanidinium ion	E3bg	W8
7·38 9·11	25	pK_5, pK_6; for $I = 0$		
194. (Aquo) **Thallium(I) ion,** Tl^+				
0·81	0	pK_b; $I = 0·005$ to 0·09; extrapolation to $I = 0$ using Davies' equation; solubility of $TlIO_3$ in KOH solutions	SOLY	B29
0·82	25			
0·85	40			
		Thermodynamic quantities are derived from the results.		
0·85	25	pK_b; $I = 0·02$ to 0·05; extrapolation to $I = 0$ using Davies' equation	KIN	B30
0·42	25	pK_b; $I = 0·08$ to 0·25	CAT,KIN	B31
0·48	25	pK_b; molal scale; $c = 0·0009$–0·009	C2	L32
195. (Aquo) **Thallium(III) ion,** Tl^{3+}				
1·07	25	pK for hydrolysis of Tl^{3+}; $I = 1·5(NaClO_4)$	O6	R23
1·16	25	$I = 3(NaClO_4)$		
1·01	40	$I = 1·5(NaClO_4)$		
1·10	40	$I = 3(NaClO_4)$		
−0·5	25	pK for hydrolysis of Tl^{3+}, assuming $TlOH^{2+}$, but not Tl^{3+}, can exchange with Tl^+; $I = 6(HClO_4 + NaClO_4)$	KIN	H23
−0·7	32·2			
−0·8	41·8			
−0·8	25	pK for hydrolysis of Tl^{3+}, assuming $TlOH^{2+}$, but not Tl^{3+}, can exchange with Tl^+; $I = 3(HClO_4 + NaClO_4)$; data of R. J. Prestwood and A. C. Wahl, *J. Am. Chem. Soc.*, **71**, 3137 (1949).	KIN	J9
−1·0	35			
−1·1	45			
1·14 1·49	25	pK values for successive hydrolysis of Tl^{3+}; $I = 3(NaClO_4)$; from potentials of Tl^+/Tl^{3+} electrode		B41
196. Thiocyanic acid, HCNS				
∼−2		By interpolation from pK values in water for HBr, HCl, HNO_3, and HF, and in ethanol for HBr, HCl, HNO_3, HCNS and HF		M46
−1·85	25	From solvent (CCl_4) extraction of a series of $NaClO_4$, $HClO_4$ mixtures at constant I; extrapolated against I	DISTRIB	

~−1·4				25	From H_- dependence of Fe^{3+} − CNS^- reaction and hydrolysis of NONCS	O6	
−0·7					$I = 3$; 2·3 M in $HClO_4$	KIN	T18
					Other measurements: B67a, S82		

197. Thiosulphuric acid, $H_2S_2O_3$

0·6	1·74			25	$I = 0{\cdot}09$ to 0·91, extrapolated to $I = 0$ using Davies' equation	E3bg	P2
	1·46			25	Concentration constant; $I = 0{\cdot}016$ to 0·07	E3ag	D25
	1·56			25		E3bg	Y18
					Other measurements: J3, K40		

198. (Aquo) **Thorium(IV) ion**, Th^{4+}

3·89	4·20			25	Successive pK values for hydrolysis of Th^{4+}, assuming only mononuclear species: $I = 0{\cdot}05$ to $0{\cdot}5(NaClO_4)$; $c = 0{\cdot}0001$–0·01 M $Th(NO_3)_4$; extrapolated to $I = 0$	E3ag	P6
4·3	3·4			25	Successive pK values for hydrolysis of Th^{4+} at very slight degrees of hydrolysis; $I = 1(NaClO_4)$; also $-\log K = 4{\cdot}7$ for $2Th^{4+} + 2H_2O \rightleftharpoons Th_2(OH)_2^{6+} + 2H^+$	E3ag	K56
4·32	4·16			0	Successive pK values for hydrolysis of Th^{4+}; $I = 1(NaClO_4)$; also $-\log K = 5{\cdot}60$ for $2Th^{4+} + 2H_2O \rightleftharpoons Th_2(OH)_2^{6+} + 2H^+$; $-\log K = 22{\cdot}79$ for $Th_4(OH)_6^{10+}$; $-\log K = 43{\cdot}84$ for $Th_6(OH)_{15}^{9+}$	E2a,quin	B4
4·12	3·69			25	$-\log K = 4{\cdot}61$ for $Th_2(OH)_2^{6+}$; $-\log K = 19{\cdot}01$ for $Th_4(OH)_6^{10+}$; $-\log K = 36{\cdot}76$ for $Th_6(OH)_{15}^{9+}$		
2·29	2·21			95	$-\log K = 2{\cdot}55$ for $Th_2(OH)_2^{6+}$; $-\log K = 10{\cdot}49$ for $Th_4(OH)_6^{10+}$; $-\log K = 20{\cdot}63$ for $Th_6(OH)_{15}^{9+}$	E2ag	
11·64	10·80	10·62	10·45	25	$I = 0{\cdot}5(NaClO_4)$, radio-tracer Concentration of Th(IV); successive pK_b values.	ION	B32a
9·40	9·35	8·99	8·08		$I = 0{\cdot}1(NaClO_4)$; successive pK_b values	SOLY	N1a
					At 25° and $I = 3(NaCl)$, $c = 0{\cdot}0001$–0·1 M in Th^{4+}, $-\log K = {\sim}9{\cdot}1$ for $Th^{4+} + 2H_2O \rightleftharpoons Th(OH)_2^{2+} + 2H^+$; $ThOH^{3+}$ is negligible; Th_2OH^{7+}, $Th_2(OH)_2^{6+}$, $Th_3(OH)_2^{10+}$ and higher complexes are important; constants are given.		H57
					At high thorium concentrations (0·5 M) formation of $Th_2(OH)_2^{6+}$ and Th_2OH^{7+} is important; constants are given		H55
					Other measurements: K5, L16		

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
199. (Aquo) **Thulium(III) ion,** Tm^{3+}	25	pK_a for hydrolysis of Tm^{3+}; titration of 0·004–0·009 M $Tm(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3(NaClO_4)$	E3b	F33a
200. (Aquo) **Tin(II) ion,** Sn^{2+}				
1·70	25	pK for hydrolysis of Sn^{2+}; $I = 0{\cdot}14$ to 0·5, extrapolated against $I^{\frac{1}{2}}$; $c = 0{\cdot}004$–0·12 M Sn^{2+}	E3ah	G37
11·93	25	pK_b for $SnOH^+ \rightleftharpoons Sn^{2+} + OH^+$	SOLY	G3
1·82	0	pK for hydrolysis of Sn^{2+}; $I = 3(NaClO_4)$; Sn-Hg electrode potentials		V1
1·70	25			
1·64	35			
1·60	45			
3·92	25	pK for hydrolysis of Sn^{2+}; $I = 3(NaClO_4)$; also $-\log K = 4{\cdot}45$ for $2Sn^{2+} + 2H_2O \rightleftharpoons Sn_2(OH)_2{}^{2+} + 2H^+$, $-\log K = 6{\cdot}77$ for $3Sn^{2+} + 4H_2O \rightleftharpoons Sn_3(OH)_4{}^{2+} + 4H^+$.	E3bg	T8
3·2	25	pK for hydrolysis of Sn^{2+}; $I = 2(NaNO_3)$ Other measurements: P41, S56	E3bg	D15
201. (Aquo) **Titanium(III) ion,** Ti^{3+}				
1·41	15	pK for $Ti^{3+} + H_2O \rightleftharpoons TiOH_2{}^+ + H^+$; $I = 0{\cdot}25$ to 1·5(KBr); extrapolated to $I = 0$ using modified Debye-Hückel equation. At pH values above 3·5 polynuclear species are rapidly formed	E3bg	P14
1·29	25			
1·36	35			
202. (Aquo) **Titanium(IV) ion,** Ti^{4+}				
1·8 2·4 2·1	25	Successive pK values for hydrolysis of $TiOH^{3+}$; $I = 0{\cdot}1(NaClO_4)$; $c = 10^{-4}$–5×10^{-4} M in Ti(IV)	DISTRIB	L28
1·3	18	pK for $TiO^{2+} \rightleftharpoons TiO(OH)^+ + H^+$	ION	N1
0·3		pK for $TiO^{2+} \rightleftharpoons TiO(OH)^+ + H^+$; in $HClO_4$ solutions; in dilute H_2SO_4 basic sulphates are also formed Other measurements: N1b	ION	B39
203. Trimetaphosphoric acid, $H_3P_3O_9$				
1·74	25	pK_3; inversion of sucrose	KIN	I1
2·05	25	pK_3; for $I = 0$; using as assumed value for the mobility of $HP_3O_9{}^{2-}$ ion	C2	D12

204. Tripolyphosphoric acid, $H_5P_3O_{10}$

0·51	1·20				25	For $I = 0$	CALORIM	I13
~1	2·2	2·3	5·7	8·51	0	Concentration constants; pK_1 and pK_2 are very uncertain;	E3bg	I11
~1	2·2	2·31	5·84	8·70	10	NMe_4^+ salts; $I = 0\cdot1$ (NMe_4Br); $f\pm$ assumed same as for HBr		
~1	2	2·13	5·75	8·65	25			
~1	1·7	1·89	5·77	8·50	37			
~1	1·7	1·95	5·77	8·51	37	$I = 0\cdot2$		
~1	1·7	1·98	5·78	8·52	37	$I = 0\cdot3$		
~1	1·7	2·12	5·90	8·55	50	$I = 0\cdot1$		
~1	1·7	1·95	5·80	8·48	50	$I = 0\cdot2$		
~1	1·7	2.62	5·84	8·48	50	$I = 0\cdot3$		
~1	1·7	2·15	5·88	8·48	65	$I = 0\cdot1$		
~1	1·7	2·10	5·80	8·39	65	$I = 1\cdot0$		
~0·5	1·15	2·04	5·69	8·56	25	$I = 1$ (NMe_4Br); as for I11	E3bg	I12
	1·06	2·11	5·83	8·81	25	"Practical" constants; NMe_4^+ salt; $I = 1\cdot0$ (NMe_4Cl)	E3bg	L6, W7
		2·15	6·00	8·73		$I = 0\cdot1$ (NMe_4Cl)		
		2·30	6·50	9·24		For $I = 0$, by extrapolation against (concentration)$^{\frac{1}{2}}$		
	2·2	2·6	5·6	7·9	25	"Practical" constants; $I = 0\cdot1$ ($NaNO_3$); $c = 10^{-3}$ M	E3bg	J8
		2·79	6·47	9·24	25	At $I = 0$, extrapolated from $I \sim 0\cdot01$ (K^+ salt), using Debye-Hückel equation	E3bg	B40
			5·29	7·58	27·4	"Practical" constants; $I = 0\cdot75$ ($NaNO_3$)	E3bg	Y3
			5·43	8·06	25	Concentration constants; $I = 0\cdot1$(KCl); $c = 0\cdot001$ M	E3bg	E16
			5·43	7·87	20	Concentration constants; $I = 0\cdot1$(KCl); $c = 0\cdot001$ M	E3bg	M14
9·54					25	pK_5; $I = 0\cdot005$ to $0\cdot04$, extrapolated to $I = 0$	E3bh	W24
9·62					40			

205. Trithiocarbonic acid, H_2CS_3

2·81		4·5	$c = 0\cdot005$–$0\cdot02$ N; extrapolated against $I^{\frac{1}{2}}$	C1	G9
2·76		8			
2·72		14			
2·68		20			
	8·18	20	Hydrolysis of 0·005 and 0·01 M Na_2CS_3 and K_2CS_3 solutions	E3ag	

206. Tungstic acid, H_2WO_4. See also Dodecatungstic acid

~3·5	~4·6	20	$I = 0\cdot1$($NaClO_4$); rapid-reaction technique Under ordinary conditions, WO_4^{2-} is in equilibrium with $HW_6O_{11}^{5-}$; log $K = 65\cdot5$ at 25° for $(HW_6O_{21}^{5-})(H_2O)^3/(H^+)^7(WO_4^{2-})^6$ (ref. D42) or $= 60\cdot7$ at 25° in 3 M $NaClO_4$	E3ag	S33

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
		(ref. S6). Least-squares refined equilibrium constants (for 3 M LiCl at 50°) are $7H^+ + 6WO_4^{2-} \rightleftharpoons 3H_2O + HW_6O_{21}^{5-}$, $\log K = 53{\cdot}98$ $14H^+ + 12WO_4^{2-} \rightleftharpoons 7H_2O + W_{12}O_{41}^{10-}$, $\log K = 110{\cdot}03$ $18H^+ + 12WO_4^{2-} \rightleftharpoons 9H_2O + W_{12}O_{39}^{6-}$, $\log K = 132{\cdot}51$		A42
207. (Aquo) **Uranium(IV) ion,** U^{4+}				
1·90	10	p*K* for hydrolysis of U^{4+} to UOH^{3+}; $I = 0{\cdot}5(NaClO_4, HClO_4)$	O6	K59
1·00	43	$c = 7 \times 10^{-4}$ M U^{4+}		
~1·12	10	Extrapolation to $I = 0$, using modified Debye-Hückel equation		
0·68	25	at $I = 0$		
~0·18	43	at $I = 0$		
0·68	25	p*K* for hydrolysis of U^{4+}; $I = 0{\cdot}02$ to $2{\cdot}0$; extrapolated to $I = 0$ by fitting to extended Debye-Hückel equation	O6	K58
1·38	15·2	p*K* for hydrolysis of U^{4+}; $I = 0{\cdot}19(HClO_4)$	O6	B38
1·12	24·7			
1·68	25	$I = 2(NaClO_4)$	O5	S76
1·74	25	$I = 2(NaClO_4)$; D_2O solution		
2·00	25	$I = 3(NaClO_4)$; similar value from redox potentials; polynuclear complexes are also formed	E3bg,h	H53
12·5		PK_b for hydrolysis of U^{4+}; from spin-lattice relaxation time *vs* pH in 0·03 M solutions	NMR	V5
		For p*K* values in ethanol-water mixtures, see R18		
		Other measurements: L12		
208. (Aquo) **Uranyl ion,** UO_2^{2+}				
5·82	25	p*K* for hydrolysis of UO_2^{2+}; from hydrolysis of pure salts; corrected for formation of $(UO_2)_2(OH)_2^{2+}$; $I = 0{\cdot}035(NaClO_4)$	E3ag	H44
5·05	16	p*K* for hydrolysis of UO_2^{2+}; from hydrolysis of pure salts; $c = 0{\cdot}001$–$0{\cdot}015$ M uranyl nitrate; at higher concentrations hydroxonitrato complexes are formed	E3ag	P37
4·59	27			
5·70	25	p*K* for hydrolysis of UO_2^{2+}; $I = 0{\cdot}5(KNO_3)$; constants are also given for $(UO_2)_2(OH)_2^{2+}$ and $(UO_2)_3(OH)_5^{+}$, which are major species in 0·01 M solutions	E3bg	B3
4·19	94·4			

6·10			25	pK for hydrolysis of UO_2^{2+}; allowance was made for formation of $(UO_2)_2(OH)_2^{2+}$	E3bg	G53
6·34				pK_b for $UO_2(OH)_2 + OH^- \rightleftharpoons UO_2OH^- + H_2O$; corrected for formation of $(UO_2)_2(OH)_2^{2+}$, $(UO_2)_4(OH)_6^{2+}$ and $U_2O_7^{2-}$	E3b	I16
9·2	8·0	8·3	20	Successive pK_b values for formation of UO_2OH^+, $UO_2(OH)_2$ and $UO_2(OH)_3^-$; $I = 0·1(NaClO_4)$	DISTRIB	S70
5·98			25	pK for hydrolysis of UO_2^{2+}; determined by dissociation field effect relaxation method	KIN	C28a
				The major species in hydrolysed UO_2^{2+} solutions, 1 M in KCl or $NaClO_4$, are $(UO_2)_2(OH)_2^{2+}$, $(UO_2)_3(OH)_4^{2+}$ and $(UO_2)_3(OH)^{5+}$; constants are given		R42
				Results in 3 M NaCl, $Mg(ClO_4)_2$, $Ca(ClO_4)_2$, and $NaClO_4$, 1 M KNO_3, and 1·5 M Na_2SO_4 are interpreted in terms of five or more polynuclear complexes for which equilibrium constants are given		D43,P26
				Other measurements: A13, G11, G49, G50, H40, H47, K47, R43, R45		
209. Vanadic acid, H_3VO_4 (HVO_3). See also Decavanadic acid						
				At pH values less than 1, pentavalent vanadium exists as the cation VO_2^+. In less acid solutions it undergoes extensive aggregation to polynuclear species, including decavanadates.		
3·78			25	$I = 0·5(NaClO_4)$; using tracer concentrations of ^{48}V; $-\log K = 3·20$ for $VO_2^+ + H_2O \rightleftharpoons HVO_3 + H^+$	DISTRIB	D47
3·4	8·23		20	Rapid-reaction studies; vanadate solutions initially at pH 9–10; final vanadate concentration 2–4 × 10^{-4} M; apparent pK; $I = 0·1(NaClO_4)$	O5	S32
	8·31		20	ditto; $I = 0·1(NMe_4Cl)$		
	7·8		25	$I = 0·5(NaCl)$; $\log K = 7·6$ for $3H_2VO_4^- \rightleftharpoons V_3O_9^{3-} + 3H_2O$; $-\log K = 5·0$ for $2H_2VO_4^- \rightleftharpoons HV_2O_7^{3-} + H^+ + H_2O$		
		13·2	25	$I = 3(NaClO_4)$; $K \sim 50$ for $2HVO_4^{2-} \rightleftharpoons V_2O_7^{4-} + H_2O$		
	7·72	13·0	25	$I = 0·5(NaCl)$; $\log K = -3·18$ for $2HVO_4^{2-} \rightleftharpoons HV_2O_7^{3-} + OH^-$; $\log K = -10·42$ for $3HVO_4^{2-} \rightleftharpoons V_3O_9^{3-} + 3OH^-$	E3bg	I8
	7·83		25	$I = 0·5$; recalculation of earlier data; constants are given for several condensed species		B80,I8
	8·44			Also $\log K = -5·22$ for $V_3O_9^{3-} \rightleftharpoons 3VO_3^-$; $-\log K = 3·5$ to $4·0$ for $VO_2^+ \rightleftharpoons H^+ + HVO_3$; $-\log K = 4·3$ to $4·8$ for $HVO_3 \rightleftharpoons H^+ + VO_3^-$	O5	S14
	8·95		25	Dilute solutions	O5	B5

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
14·4	25		O7	
9·62 12·72	32·4	$I = 9$; in saturated Na_2SO_4 solutions	CRYOSC	S16
11·13	20	$I = 0{\cdot}2$; in acid solutions V exists as VO_2^+ and VO^{3+}, polymerizing in neutral solutions to decavanadates. In alkaline solutions, mononuclear species predominate if $c \leqslant 10^{-3}$ M; $\log K = 25{\cdot}05$ for $2VO_4^{3-} + 2H^+ \rightleftharpoons V_2O_7^{4-} + H_2O$; $\log K = -2{\cdot}79$ for $2HVO_4^{2-} \rightleftharpoons V_2O_7^{4-} + H_2O$; $\log K = -10{\cdot}99$ for $\frac{1}{4}V_4O_{12}^{4-} + H_2O \rightleftharpoons HVO_4^{2-} + H^+$	E3ag	S5
12·99	25	Concentration constant; $I = 3(NaClO_4)$; $K = 48$ for $2HVO_4^{2-} \rightleftharpoons V_2O_7^{4-} + H_2O$	O5	N19
13·15	33	$I = 9$; saturated Na_2SO_4 solutions	CRYOSC	S63
		$K = 2{\cdot}0 \times 10^{-4}$ for $H_3V_2O_7^- + 3H^+ \rightleftharpoons 2VO_2^+ + H_2O$; important between pH2 and pH4.		T11
		$K = 1{\cdot}2 \times 10^3$ for $H_3V_2O_7^- + 3H^+ \rightleftharpoons 2VO_2^+ + H_2O$		D40
		$K = 2{\cdot}8 \times 10^{-4}$ for $H_3V_2O_7^- + H^+ \rightleftharpoons 2HVO_3 + H_2O$, at $I = 0{\cdot}006$ and 25°		Y10
		$K = 1{\cdot}64 \times 10^3$ for $HVO_3 + H^+ \rightleftharpoons VO_2^+ + H_2O$		
		$\log K = -30{\cdot}48$ for $V_3O_9^{3-} \rightleftharpoons 3H^+ + 3HVO_4^{2-}$		S60
		Other measurements: B79a, D40, L15, Z4		
210. (Aquo) **Vanadium(III) ion,** V^{3+}				
2·92 3·5	25	Successive p*K* values for hydrolysis of V^{3+}; calculated from data of G. Jones and W. A. Ray, *J. Am. Chem. Soc.*, **66**, 1571 (1944); $c = 0{\cdot}0004–0{\cdot}04$ M $V_2(SO_4)_3$	E3ag	M23
2·85 3·85		Successive p*K* values for hydrolysis of V^{3+}; $I = 1(NaCl)$; also $-\log K = 3{\cdot}90$ for $2V^{3+} + 2H_2O \rightleftharpoons V_2(OH)_2^{4+} + 2H^+$	E	P3
2·7				F37
		Other measurements: B79b		
211. (Aquo) **Vanadyl ion,** VO^{2+} (= $V(OH)_2^{2+}$)				
4·77	20	p*K* for $VO^{2+} + H_2O \rightleftharpoons VO{\cdot}OH^+ + H^+$; $c = 0{\cdot}012$ M VO^{2+}; no correction for dimerization	E3bg	D40
5·36	25	p*K* for VO^{2+}; $c = 0{\cdot}0001–0{\cdot}05$ M $VOSO_4$; calculated from data of G. Jones and W. A. Ray, *J. Am. Chem. Soc.*, **66**, 1571 (1944)	E3ag	M23

6·88	25	p*K* for VO^{2+}; $I = 3(NaClO_4)$; log $K = 5{\cdot}1$ for dimerization of $VO{\cdot}OH^+$ to $(VO)_2(OH)_2{}^{2+}$	E3bg	R30
−0·5	Room	p*K* for $VOH^{3+} \rightleftharpoons VO^{2+} + H^+$; from changes in nuclear relaxation times; in dilute H_2SO_4		R17
−0·6		in dilute HNO_3		
−0·9		in dilute $HClO_4$		
212. Water, H_2O				
14·9435	0	$I = 0$ re-examination of data by Harned and co-workers; molal scale	Elch	H38
14·7338	5			
14·5346	10			
14·3463	15			
14·1669	20			
13·9965	25			
13·8330	30			
13·6801	35			
13·5348	40			
13·3960	45			
13·2617	50			
13·1369	55			
13·0171	60			
14·535	10	Molar scale		
14·169	20			
14·000	25			
13·837	30			
13·542	40			
13·272	50			
16·279	10	Mole fraction scale		
15·911	20			
15·741	25			
15·577	30			
15·279	40			
15·006	50			
14·946	0	LiBr solutions; $I = 0{\cdot}01$ to $3{\cdot}0$; E corrected using Debye-Hückel equation and extrapolated against I to $I = 0$	Elch	H32
14·735	5			
14·535	10			
14·346	15			
14·167	20			
13·997	25			

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
13·834	30			
13·680	35			
13.539	40			
14·945	0	NaCl solutions; as for H32	Elch	H36
14·535	10			
14·167	20			
13·997	25			
13·833	30			
13·536	40			
13·261	50			
13·015	60			
14·939	0	KCl solutions; $I = 0{\cdot}01$ to 3·5 as for H32	Elch	H34
14·730	5			
14·533	10			
14·345	15			
14·167	20			
13·997	25			
13·832	30			
13·620	35			
13·535	40			
13·396	45			
13·262	50			
13·139	55			
13·017	60			
		$\mathrm{p}K = 4787{\cdot}3/T + 7{\cdot}1321 \log T + 0{\cdot}010365T - 22{\cdot}801$ (T in °K) Thermodynamic quantities are calculated from the results		
14·955	0	For $I = 0$; from calorimetric measurements on electrolyte solutions		A8
14·534	10			
14·161	20			
13·999	25			
13·833	30			
13·533	40			
13·262	50			
13·015	60			
12·800	70			

12·598	80			
12·422	90			
12·259	100			
12·126	110			
12·002	120			
11·907	130			
14·926	0	I = 0·0001 to 1·5; potentials corrected to I = 0 using equations of the form, $E_{corr} = E_{obs} + \alpha I^{\frac{1}{2}} - \beta I$	E3ah	B57
14·222	18			
13·980	25			
13·590	37			
13·05	60	Predicted from thermodynamic data, taking pK_w = 13·997 at 25°		C25
12·21	100			
11·65	150			
11·30	200			
11·18	250			
11·19	300			
11·33	350			
12·32	100	From measurements of the degree of hydrolysis of ammonium acetate	C1	N24
11·65	156			
11·34	218			
11·77	306			
13·907	25	I = 0·1, taking pK_w = 13·997 at 1 atmosphere;	E1cg	H16
		250 atmospheres		
13·824		500 atmospheres		
13·747		750 atmospheres		
13·667		1000 atmospheres		
13·585		1250 atmospheres		
13·524		1500 atmospheres		
13·449		1750 atmospheres		
13·394		2000 atmospheres		
		For predictions of pK_w from 350–700° at superheated-steam densities of 0·3 to 0·7 g.cm^{-3}., see F26		
		Ref. H49a gives an equation for the variation of pK_w with temperature from 0° to 306°		
		For values of pK_w in H_2O/D_2O mixtures, see S3		
29		pK of OH^-; theoretical prediction		S29
23·2		pK of OH^-, assuming the difference between pK_1 and pK_2 of H_2O is the same as for H_2S		B55

Name, Formula and p*K value*	*T*(°C)	*Remarks*	*Methods*	*Reference*
20·8		p*K* of OH^-, same assumption, but more recent values for H_2S, H_2Se and H_2Te For the basic p*K* of H_2O in concentrated H_2SO_4, see G22 Other measurements: A11, A14, B23 (for pre-1916 references), B96, C6, D20, H30, H33, H35, H51a, I3, I9, L2, L23, N10, N11, N20, O5, R19, W35		E3
213. Xenon trioxide, XeO_3				
10·5	25	p*K* for XeO_3.aq. $\rightleftharpoons HXeO_4^- + H^+$; $I = 0{\cdot}5(NaClO_4)$	E3bg	A30
10·8		$I = 0{\cdot}1$		
214. (Aquo) **Ytterbium(III) ion**, Yb^{3+}				
7·92	25	pK_a for hydrolysis of Yb^{3+}; titration of 0·004–0·009 M $Yb(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3(NaClO_4)$	E3b	F33a
8·03	25	ditto, using 0·02 M NaOH		
215. (Aquo) **Yttrium(III) ion**, Y^{3+}				
9·10	25	p*K* for hydrolysis of Y^{3+}; $I = 3(LiClO_4)$; $c = 0{\cdot}01$–1 M $Y(ClO_4)_3$; $Y_2(OH)_2{}^{4+}$ (log $K = -14{\cdot}28$) and $Y_3(OH)_5{}^{4+}$ (log $K = -33{\cdot}8$) are also formed	E3ag,quin	B45
8·34	25	pK_a for hydrolysis of Y^{3+}; titration of 0·004–0·009 M $Y(ClO_4)_3$ with 0·02 M $Ba(OH)_2$; $I = 0{\cdot}3(NaClO_4)$	E3b	F33a
216. (Aquo) **Zinc ion**, Zn^{2+}				
9·30	15	p*K* for hydrolysis of Zn^{2+} to $ZnOH^+$; $I = 0{\cdot}0015$ to 0·04 (KNO_3); extrapolated to $I = 0$	E3bg	P21
9·15	20			
8·96	25			
8·79	30			
8·62	36			
8·46	42			
8·7	30	p*K* for hydrolysis of Zn^{2+}; $I = 0{\cdot}1(KCl)$	E3bg	C12
9·01	25	p*K* for hydrolysis of Zn^{2+}; $I = 2(KCl)$; $c = 0{\cdot}1$ M $ZnCl_2$, also $-\log K = 7{\cdot}20$ for $2Zn^{2+} + H_2O \rightleftharpoons Zn_2OH^{3+} + H^+$	E3ag	S19
9·12	25	ditto; $I = 2(NaCl)$; $-\log K = 7{\cdot}48$ for $2Zn^{2+} + H_2O \rightleftharpoons Zn_2OH^{3+} + H^+$		

6·31	4·88	3·12	3·39	25	Stepwise pK_b values for Zn^{2+}, $I = 1(NaClO_4)$	SOLY	G45a
9·05				25		E3bg	D45
7·87				100	pK for hydrolysis of Zn^{2+}; $c = 0{\cdot}02$ M $Zn(NO_3)_2$	KIN	K69
5·7					pK_b for $ZnOH^+$; $c = 0{\cdot}1$ M $ZnSO_4$	E3bg	S25
8·73					pK for $Zn(OH)_2 \rightleftharpoons Zn(OH)_3^- + H^+$; $I = 3(NaClO_4)$	DISTRIB	S38
9·89					pK for $Zn(OH)_3^- \rightleftharpoons Zn(OH)_4^{2-} + H^+$; $I = 3(NaClO_4)$; also log $K = -20{\cdot}10$ for $[Zn(OH)_2][H^+]^2/[Zn^{2+}]$		
8·7				25	log K for $2Zn^{2+} + OH^- \rightleftharpoons Zn_2OH^{3+}$; $I = 3(LiClO_4)$; $c = 0{\cdot}25 - 1{\cdot}45$M Zn^{2+}		B42
16·84	16·91			0	log K for $Zn^{2+} + 3OH^- \rightleftharpoons Zn(OH)_3^-$, and log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$	POLAROG	K51
15·86	15·95			20			
15·45	15·55			30			
15·15				25	log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$; zinc electrode potential measurements		D36
16·9					log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$	POLAROG	S68
15·45				25	log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$; zinc electrode potential measurements		D35
15·3				25	log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$; $I = 2(KCl)$	POLAROG	M20
14·5				18	log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$; zinc electrode potential measurements		S67
13·35				25	log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$; $I = 3(NaCl)$; Zn-Hg electrode		S20
26·77				25	log K for $2Zn^{2+} + 6OH^- \rightleftharpoons Zn_2(OH)_6^{2-}$		
15·04				20	log K for $Zn^{2+} + 4OH^- \rightleftharpoons Zn(OH)_4^{2-}$; Zn-Hg electrode		B36
16·08				20	log K for $Zn^{2+} + 3OH^- \rightleftharpoons Zn(OH)_3^-$		
13·58				20	log K for $Zn^{2+} + 3OH^- \rightleftharpoons Zn(OH)_3^-$; $I = 0{\cdot}1$	DISTRIB	B61
					Polynuclear hydrolysed species in zinc solutions at pH above 8 are postulated from coagulation studies		M19
					Other measurements: A5, B100, D8, D24, F36, H5, K5, K45, K70, P42, Q2, S18, S56, W26		

217. (Aquo) **Zirconium(IV) ion,** Zr^{4+}

−0·32	0·06	0·35	0·64	25	Successive pK values for the hydrolysis of Zr^{4+}; $I = 1(HClO_4)$; low Zr^{4+} concentrations; at higher concentrations polymers are also formed	DISTRIB	P25
0·22	0·62	1·05	1·17	25	Successive pK values for the hydrolysis of Zr^{4+}; $I = 2(HCl, HNO_3)$	DISTRIB	S57
14·58	14·80	14·34	14·13	25	Successive pK_b values for hydrolysis of Zr^{4+}; $I = 1$ $(LiClO_4, NaClO_4)$; tracer concentrations of Zr(IV)	DISTRIB	S57a

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