IONIC CONDUCTIVITY AND DIFFUSION AT INFINITE DILUTION

Petr Vanýsek

This table gives the molar (equivalent) conductivity λ for common ions at infinite dilution. All values refer to aqueous solutions at 25°C. It also lists the diffusion coefficient *D* of the ion in dilute aqueous solution, which is related to λ through the equation

$$D = \left(RT / F^2\right)\left(\lambda / |z|\right)$$

where *R* is the molar gas constant, *T* the temperature, *F* the Faraday constant, and *z* the charge on the ion. The variation with temperature is fairly sharp; for typical ions, λ and *D* increase by 2 to 3% per degree as the temperature increases from 25°C.

The diffusion coefficient for a salt, $D_{salt,}$ may be calculated from the D_+ and D_- values of the constituent ions by the relation

$$D_{\text{salt}} = \frac{\left(z_+ + |z_-|\right)D_+ D_-}{z_+ D_+ + |z_-| D_-}$$

For solutions of simple, pure electrolytes (one positive and one negative ionic species), such as NaCl, equivalent ionic conductivity Λ°, which is the conductivity per unit concentration of charge, is defined as

$$\Lambda^\circ = \lambda_+ + \lambda_-$$

where λ_+ and λ_- are equivalent ionic conductivities of the cation and anion. The more general formula is

$$\Lambda^\circ = \nu_+\lambda_+ + \nu_-\lambda_-$$

where ν_+ and ν_- refer to the number of moles of cations and anions to which one mole of the electrolyte gives a rise in the solution.

REFERENCES

1. Gray, D. E., Ed., *American Institute of Physics Handbook*, McGraw-Hill, New York, 1972, 2—226.
2. Robinson, R. A., and Stokes, R. H., *Electrolyte Solutions*, Butterworths, London, 1959.
3. Lobo, V. M. M., and Quaresma, J. L., *Handbook of Electrolyte Solutions*, Physical Science Data Series 41, Elsevier, Amsterdam, 1989.
4. Conway, B. E., *Electrochemical Data*, Elsevier, Amsterdam, 1952.
5. Milazzo, G., *Electrochemistry: Theoretical Principles and Practical Applications*, Elsevier, Amsterdam, 1963.

Ion	λ 10^{-4} m² S mol⁻¹	*D* 10^{-5} cm² s⁻¹	Ion	λ 10^{-4} m² S mol⁻¹	*D* 10^{-5} cm² s⁻¹
Inorganic Cations					
			$1/3Ho^{3+}$	66.3	0.589
Ag^+	61.9	1.648	K^+	73.48	1.957
$1/3Al^{3+}$	61	0.541	$1/3La^{3+}$	69.7	0.619
$1/2Ba^{2+}$	63.6	0.847	Li^+	38.66	1.029
$1/2Be^{2+}$	45	0.599	$1/2Mg^{2+}$	53.0	0.706
$1/2Ca^{2+}$	59.47	0.792	$1/2Mn^{2+}$	53.5	0.712
$1/2Cd^{2+}$	54	0.719	NH_4^+	73.5	1.957
$1/3Ce^{3+}$	69.8	0.620	$N_2H_5^+$	59	1.571
$1/2Co^{2+}$	55	0.732	Na^+	50.08	1.334
$1/3[Co(NH_3)_6]^{3+}$	101.9	0.904	$1/3Nd^{3+}$	69.4	0.616
$1/3[Co(en)_3]^{3+}$	74.7	0.663	$1/2Ni^{2+}$	49.6	0.661
$1/6[Co_2(trien)_3]^{6+}$	69	0.306	$1/4[Ni_2(trien)_3]^{4+}$	52	0.346
$1/3Cr^{3+}$	67	0.595	$1/2Pb^{2+}$	71	0.945
Cs^+	77.2	2.056	$1/3Pr^{3+}$	69.5	0.617
$1/2Cu^{2+}$	53.6	0.714	$1/2Ra^{2+}$	66.8	0.889
D^+	249.9	6.655	Rb^+	77.8	2.072
$1/3Dy^{3+}$	65.6	0.582	$1/3Sc^{3+}$	64.7	0.574
$1/3Er^{3+}$	65.9	0.585	$1/3Sm^{3+}$	68.5	0.608
$1/3Eu^{3+}$	67.8	0.602	$1/2Sr^{2+}$	59.4	0.791
$1/2Fe^{2+}$	54	0.719	Tl^+	74.7	1.989
$1/3Fe^{3+}$	68	0.604	$1/3Tm^{3+}$	65.4	0.581
$1/3Gd^{3+}$	67.3	0.597	$1/2UO_2^{2+}$	32	0.426
H^+	349.65	9.311	$1/3Y^{3+}$	62	0.550
$1/2Hg^{2+}$	68.6	0.913	$1/3Yb^{3+}$	65.6	0.582
$1/2Hg^{2+}$	63.6	0.847	$1/2Zn^{2+}$	52.8	0.703

IONIC CONDUCTIVITY AND DIFFUSION AT INFINITE DILUTION (continued)

Ion	λ 10^{-4} m^2 S mol^{-1}	*D* 10^{-5} cm^2 s^{-1}
Inorganic Anions		
$Au(CN)_2^-$	50	1.331
$Au(CN)_4^-$	36	0.959
$B(C_6H_5)_4^-$	21	0.559
Br^-	78.1	2.080
Br_3^-	43	1.145
BrO_3^-	55.7	1.483
CN^-	78	2.077
CNO^-	64.6	1.720
$1/2CO_3^{2-}$	69.3	0.923
Cl^-	76.31	2.032
ClO_2^-	52	1.385
ClO_3^-	64.6	1.720
ClO_4^-	67.3	1.792
$1/3[Co(CN)_6]^{3-}$	98.9	0.878
$1/2CrO_4^{2-}$	85	1.132
F^-	55.4	1.475
$1/4[Fe(CN)_6]^{4-}$	110.4	0.735
$1/3[Fe(CN)_6]^{3-}$	100.9	0.896
$H_2AsO_4^-$	34	0.905
HCO_3^-	44.5	1.185
HF_2^-	75	1.997
$1/2HPO_4^{2-}$	57	0.759
$H_2PO_4^-$	36	0.959
$H_2PO_2^-$	46	1.225
HS^-	65	1.731
HSO_3^-	58	1.545
HSO_4^-	52	1.385
$H_2SbO_4^-$	31	0.825
I^-	76.8	2.045
IO_3^-	40.5	1.078
IO_4^-	54.5	1.451
MnO_4^-	61.3	1.632
$1/2MoO_4^{2-}$	74.5	1.984
$N(CN)_2^-$	54.5	1.451
NO_2^-	71.8	1.912
NO_3^-	71.42	1.902
$NH_2SO_3^-$	48.3	1.286
N_3^-	69	1.837
OCN^-	64.6	1.720
OD^-	119	3.169
OH^-	198	5.273
PF_6^-	56.9	1.515
$1/2PO_3F^{2-}$	63.3	0.843
$1/3PO_4^{3-}$	92.8	0.824
$1/4P_2O_7^{4-}$	96	0.639
$1/3P_3O_9^{3-}$	83.6	0.742
$1/5P_3O_{10}^{5-}$	109	0.581
ReO_4^-	54.9	1.462
SCN^-	66	1.758
$1/2SO_3^{2-}$	72	0.959
$1/2SO_4^{2-}$	80.0	1.065
$1/2S_2O_3^{2-}$	85.0	1.132
$1/2S_2O_4^{2-}$	66.5	0.885
$1/2S_2O_6^{2-}$	93	1.238
$1/2S_2O_8^{2-}$	86	1.145
$Sb(OH)_6^-$	31.9	0.849
$SeCN^-$	64.7	1.723
$1/2SeO_4^{2-}$	75.7	1.008
$1/2WO_4^{2-}$	69	0.919
Organic Cations		
Benzyltrimethylammonium$^+$	34.6	0.921
Isobutylammonium$^+$	38	1.012
Butyltrimethylammonium$^+$	33.6	0.895
Decylpyridinium$^+$	29.5	0.786
Decyltrimethylammonium$^+$	24.4	0.650
Diethylammonium$^+$	42.0	1.118
Dimethylammonium$^+$	51.8	1.379
Dipropylammonium$^+$	30.1	0.802
Dodecylammonium$^+$	23.8	0.634
Dodecyltrimethylammonium$^+$	22.6	0.602
Ethanolammonium$^+$	42.2	1.124
Ethylammonium$^+$	47.2	1.257
Ethyltrimethylammonium$^+$	40.5	1.078
Hexadecyltrimethylammonium$^+$	20.9	0.557
Hexyltrimethylammonium$^+$	29.6	0.788
Histidyl$^+$	23.0	0.612
Hydroxyethyltrimethylarsonium$^+$	39.4	1.049
Methylammonium$^+$	58.7	1.563
Octadecylpyridinium$^+$	20	0.533
Octadecyltributylammonium$^+$	16.6	0.442
Octadecyltriethylammonium$^+$	17.9	0.477
Octadecyltrimethylammonium$^+$	19.9	0.530
Octadecyltripropylammonium$^+$	17.2	0.458
Octyltrimethylammonium$^+$	26.5	0.706
Pentylammonium$^+$	37	0.985
Piperidinium$^+$	37.2	0.991
Propylammonium$^+$	40.8	1.086
Pyrilammonium$^+$	24.3	0.647
Tetrabutylammonium$^+$	19.5	0.519
Tetradecyltrimethylammonium$^+$	21.5	0.573
Tetraethylammonium$^+$	32.6	0.868
Tetramethylammonium$^+$	44.9	1.196
Tetraisopentylammonium$^+$	17.9	0.477
Tetrapentylammmonium$^+$	17.5	0.466
Tetrapropylammonium$^+$	23.4	0.623
Triethylammonium$^+$	34.3	0.913
Triethylsulfonium$^+$	36.1	0.961
Trimethylammonium$^+$	47.23	1.258
Trimethylhexylammonium$^+$	34.6	0.921
Trimethylsulfonium$^+$	51.4	1.369
Tripropylammonium$^+$	26.1	0.695
Organic Anions		
Acetate$^-$	40.9	1.089
p-Anisate$^-$	29.0	0.772
1/2Azelate^{2-}	40.6	0.541
Benzoate$^-$	32.4	0.863
Bromoacetate$^-$	39.2	1.044
Bromobenzoate$^-$	30	0.799
Butyrate$^-$	32.6	0.868
Chloroacetate$^-$	39.8	1.060
m-Chlorobenzoate$^-$	31	0.825
o-Chlorobenzoate$^-$	30.2	0.804

IONIC CONDUCTIVITY AND DIFFUSION AT INFINITE DILUTION (continued)

Ion	λ 10^{-4} m^2 S mol^{-1}	*D* 10^{-5} cm^2 s^{-1}
1/3Citrate^{3-}	70.2	0.623
Crotonate^{-}	33.2	0.884
Cyanoacetate^{-}	43.4	1.156
Cyclohexane carboxylate^{-}	28.7	0.764
1/2 1,1-Cyclopropanedicarboxylate^{2-}	53.4	0.711
Decylsulfate^{-}	26	0.692
Dichloroacetate^{-}	38.3	1.020
1/2Diethylbarbiturate^{2-}	26.3	0.350
Dihydrogencitrate^{-}	30	0.799
1/2Dimethylmalonate^{2-}	49.4	0.658
3,5-Dinitrobenzoate^{-}	28.3	0.754
Dodecylsulfate^{-}	24	0.639
Ethylmalonate^{-}	49.3	1.313
Ethylsulfate^{-}	39.6	1.055
Fluoroacetate^{-}	44.4	1.182
Fluorobenzoate^{-}	33	0.879
Formate^{-}	54.6	1.454
1/2Fumarate^{2-}	61.8	0.823
1/2Glutarate^{2-}	52.6	0.700
Hydrogenoxalate^{-}	40.2	1.070
Isovalerate^{-}	32.7	0.871
Iodoacetate^{-}	40.6	1.081
Lactate^{-}	38.8	1.033
1/2Malate^{2-}	58.8	0.783
1/2Maleate^{2-}	61.9	0.824
1/2Malonate^{2-}	63.5	0.845
Methylsulfate^{-}	48.8	1.299
Naphthylacetate^{-}	28.4	0.756
1/2Oxalate^{2-}	74.11	0.987
Octylsulfate^{-}	29	0.772
Phenylacetate^{-}	30.6	0.815
1/2*o*-Phthalate^{2-}	52.3	0.696
1/2*m*-Phthalate^{2-}	54.7	0.728
Picrate^{-}	30.37	0.809
Pivalate^{-}	31.9	0.849
Propionate^{-}	35.8	0.953
Propylsulfate^{-}	37.1	0.988
Salicylate^{-}	36	0.959
1/2Suberate^{2-}	36	0.479
1/2Succinate^{2-}	58.8	0.783
p-Sulfonate	29.3	0.780
1/2Tartarate^{2-}	59.6	0.794
Trichloroacetate^{-}	35	0.932