

IONIC CONDUCTIVITY AND DIFFUSION AT INFINITE DILUTION

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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

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

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

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

For solutions of simple, pure electrolytes (one positive and one negative ionic species), such as NaCl, equivalent ionic conductivity Λ° , which is the molar 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, respectively, to which one mole of the electrolyte gives rise in solution.

References

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Ionic Conductivity and Diffusion at Infinite Dilution

Ion	$\Lambda_+ /$	$D /$	Ion	$\Lambda_- /$	$D /$
	$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$	$10^{-5} \text{ cm}^2 \text{ s}^{-1}$		$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$	$10^{-5} \text{ cm}^2 \text{ s}^{-1}$
Inorganic Cations					
Ag ⁺	61.9	1.648	NH ₄ ⁺	73.5	1.957
1/3Al ³⁺	61	0.541	N ₂ H ₅ ⁺	59	1.571
1/2Ba ²⁺	63.6	0.847	Na ⁺	50.08	1.334
1/2Be ²⁺	45	0.599	1/3Nd ³⁺	69.4	0.616
1/2Ca ²⁺	59.47	0.792	1/2Ni ²⁺	49.6	0.661
1/2Cd ²⁺	54	0.719	1/4[Ni ₂ (trien) ₃] ⁴⁺	52	0.346
1/3Ce ³⁺	69.8	0.620	1/2Pb ²⁺	71	0.945
1/2Co ²⁺	55	0.732	1/3Pr ³⁺	69.5	0.617
1/3[Co(NH ₃) ₆] ³⁺	101.9	0.904	1/2Ra ²⁺	66.8	0.889
1/3[Co(en) ₃] ³⁺	74.7	0.663	Rb ⁺	77.8	2.072
1/6[Co ₂ (trien) ₃] ⁶⁺	69	0.306	1/3Sc ³⁺	64.7	0.574
1/3Cr ³⁺	67	0.595	1/3Sm ³⁺	68.5	0.608
Cs ⁺	77.2	2.056	1/2Sr ²⁺	59.4	0.791
1/2Cu ²⁺	53.6	0.714	Tl ⁺	74.7	1.989
D ⁺	249.9	6.655	1/3Tm ³⁺	65.4	0.581
1/3Dy ³⁺	65.6	0.582	1/2UO ₂ ²⁺	32	0.426
1/3Er ³⁺	65.9	0.585	1/3Y ³⁺	62	0.550
1/3Eu ³⁺	67.8	0.602	1/3Yb ³⁺	65.6	0.582
1/2Fe ²⁺	54	0.719	1/2Zn ²⁺	52.8	0.703
1/3Fe ³⁺	68	0.604	Inorganic Anions		
1/3Gd ³⁺	67.3	0.597	Au(CN) ₂ ⁻	50	1.331
H ⁺	349.65	9.311	Au(CN) ₄ ⁻	36	0.959
1/2Hg ²⁺	68.6	0.913	B(C ₆ H ₅) ₄ ⁻	21	0.559
1/2Hg ²⁺	63.6	0.847	Br ⁻	78.1	2.080
1/3Ho ³⁺	66.3	0.589	Br ₃ ⁻	43	1.145
K ⁺	73.48	1.957	BrO ₃ ⁻	55.7	1.483
1/3La ³⁺	69.7	0.619	CN ⁻	78	2.077
Li ⁺	38.66	1.029	CNO ⁻	64.6	1.720
1/2Mg ²⁺	53.0	0.706	1/2CO ₃ ²⁻	69.3	0.923
1/2Mn ²⁺	53.5	0.712	Cl ⁻	76.31	2.032
			ClO ₂ ⁻	52	1.385

Ion	Λ_{∞}^0	D^0	Ion	Λ_{∞}^0	D^0
	$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$	$10^{-5} \text{ cm}^2 \text{ s}^{-1}$		$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$	$10^{-5} \text{ cm}^2 \text{ s}^{-1}$
ClO_3^-	64.6	1.720	Ethyltrimethylammonium ⁺	40.5	1.078
ClO_4^-	67.3	1.792	Hexadecyltrimethylammonium ⁺	20.9	0.557
$1/3[\text{Co}(\text{CN})_6]^{3-}$	98.9	0.878	Hexyltrimethylammonium ⁺	29.6	0.788
$1/2\text{CrO}_4^{2-}$	85	1.132	Histidyl ⁺	23.0	0.612
F^-	55.4	1.475	Hydroxyethyltrimethylarsonium ⁺	39.4	1.049
$1/4[\text{Fe}(\text{CN})_6]^{4-}$	110.4	0.735	Isobutylammonium	38	1.012
$1/3[\text{Fe}(\text{CN})_6]^{3-}$	100.9	0.896	Methylammonium ⁺	58.7	1.563
H_2AsO_4^-	34	0.905	Octadecylpyridinium ⁺	20	0.533
HCO_3^-	44.5	1.185	Octadecyltributylammonium ⁺	16.6	0.442
HF_2^-	75	1.997	Octadecyltriethylammonium ⁺	17.9	0.477
$1/2\text{HPO}_4^{2-}$	57	0.759	Octadecyltrimethylammonium ⁺	19.9	0.530
H_2PO_4^-	36	0.959	Octadecyltripropylammonium ⁺	17.2	0.458
H_2PO_2^-	46	1.225	Octyltrimethylammonium ⁺	26.5	0.706
HS^-	65	1.731	Pentylammonium ⁺	37	0.985
HSO_3^-	58	1.545	Piperidinium ⁺	37.2	0.991
HSO_4^-	52	1.385	Propylammonium ⁺	40.8	1.086
H_2SbO_4^-	31	0.825	Pyridinium ⁺	24.3	0.647
I^-	76.8	2.045	Tetrabutylammonium ⁺	19.5	0.519
IO_3^-	40.5	1.078	Tetradecyltrimethylammonium ⁺	21.5	0.573
IO_4^-	54.5	1.451	Tetraethylammonium ⁺	32.6	0.868
MnO_4^-	61.3	1.632	Tetramethylammonium ⁺	44.9	1.196
$1/2\text{MoO}_4^{2-}$	74.5	1.984	Tetraisopentylammonium ⁺	17.9	0.477
$\text{N}(\text{CN})_2^-$	54.5	1.451	Tetrapentylammonium ⁺	17.5	0.466
NO_2^-	71.8	1.912	Tetrapropylammonium ⁺	23.4	0.623
NO_3^-	71.42	1.902	Triethylammonium ⁺	34.3	0.913
NH_2SO_3^-	48.3	1.286	Triethylsulfonium ⁺	36.1	0.961
N_3^-	69	1.837	Trimethylammonium ⁺	47.23	1.258
OCN^-	64.6	1.720	Trimethylhexylammonium ⁺	34.6	0.921
OD^-	119	3.169	Trimethylsulfonium ⁺	51.4	1.369
OH^-	198	5.273	Tripentylammonium ⁺	26.1	0.695
PF_6^-	56.9	1.515			
$1/2\text{PO}_3\text{F}^{2-}$	63.3	0.843	Organic Anions		
$1/3\text{PO}_4^{3-}$	92.8	0.824	Acetate ⁻	40.9	1.089
$1/4\text{P}_2\text{O}_7^{4-}$	96	0.639	<i>p</i> -Anisate ⁻	29.0	0.772
$1/3\text{P}_3\text{O}_9^{3-}$	83.6	0.742	$1/2$ Azelate ²⁻	40.6	0.541
$1/5\text{P}_3\text{O}_{10}^{5-}$	109	0.581	Benzoate ⁻	32.4	0.863
ReO_4^-	54.9	1.462	Bromoacetate ⁻	39.2	1.044
SCN^-	66	1.758	Bromobenzoate ⁻	30	0.799
$1/2\text{SO}_3^{2-}$	72	0.959	Butyrate ⁻	32.6	0.868
$1/2\text{SO}_4^{2-}$	80.0	1.065	Chloroacetate ⁻	39.8	1.060
$1/2\text{S}_2\text{O}_3^{2-}$	85.0	1.132	<i>m</i> -Chlorobenzoate ⁻	31	0.825
$1/2\text{S}_2\text{O}_4^{2-}$	66.5	0.885	<i>o</i> -Chlorobenzoate ⁻	30.2	0.804
$1/2\text{S}_2\text{O}_6^{2-}$	93	1.238	$1/3$ Citrate ³⁻	70.2	0.623
$1/2\text{S}_2\text{O}_8^{2-}$	86	1.145	Crotonate ⁻	33.2	0.884
$\text{Sb}(\text{OH})_6^-$	31.9	0.849	Cyanoacetate ⁻	43.4	1.156
SeCN^-	64.7	1.723	Cyclohexane carboxylate ⁻	28.7	0.764
$1/2\text{SeO}_4^{2-}$	75.7	1.008	$1/2$ 1,1-Cyclopropanedicarboxylate ²⁻	53.4	0.711
$1/2\text{WO}_4^{2-}$	69	0.919	Decylsulfate ⁻	26	0.692
			Dichloroacetate ⁻	38.3	1.020
Organic Cations			$1/2$ Diethylbarbiturate ²⁻	26.3	0.350
Benzyltrimethylammonium ⁺	34.6	0.921	Dihydrogencitrate ⁻	30	0.799
Butyltrimethylammonium ⁺	33.6	0.895	$1/2$ Dimethylmalonate ²⁻	49.4	0.658
Decylpyridinium ⁺	29.5	0.786	3,5-Dinitrobenzoate ⁻	28.3	0.754
Decyltrimethylammonium ⁺	24.4	0.650	Dodecylsulfate ⁻	24	0.639
Diethylammonium ⁺	42.0	1.118	Ethylmalonate ⁻	49.3	1.313
Dimethylammonium ⁺	51.8	1.379	Ethylsulfate ⁻	39.6	1.055
Dipropylammonium ⁺	30.1	0.802	Fluoroacetate ⁻	44.4	1.182
Dodecylammonium ⁺	23.8	0.634	Fluorobenzoate ⁻	33	0.879
Dodecyltrimethylammonium ⁺	22.6	0.602	Formate ⁻	54.6	1.454
Ethanolammonium ⁺	42.2	1.124	$1/2$ Fumarate ²⁻	61.8	0.823
Ethylammonium ⁺	47.2	1.257	$1/2$ Glutarate ²⁻	52.6	0.700

Ion	$\Lambda_{\infty}^0 / 10^{-4} \text{ m}^2 \text{ S mol}^{-1}$	$D / 10^{-5} \text{ cm}^2 \text{ s}^{-1}$
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

Ion	$\Lambda_{\infty}^0 / 10^{-4} \text{ m}^2 \text{ S mol}^{-1}$	$D / 10^{-5} \text{ cm}^2 \text{ s}^{-1}$
1/2 <i>o</i> -Phthalate ²⁻	52.3	0.696
1/2 <i>m</i> -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
<i>p</i> -Sulfonate	29.3	0.780
1/2Tartarate ²⁻	59.6	0.794
Trichloroacetate ⁻	35	0.932