# 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

$$D = (RT / F^2)(° / |z|)$$

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

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

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

$$\Lambda° = \Lambda_+ + \Lambda_-$$

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

$$\Lambda° = \nu_+ \Lambda_+ + \nu_- \Lambda_-$$

where $\nu_+$ and $\nu_-$ 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.
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| Ion | $\Lambda_\pm$ $10^{-4}$ m² S mol⁻¹ | $D$ $10^{-5}$ cm² s⁻¹ |
|---|---|---|
| *Inorganic Cations* | | |
| Ag⁺ | 61.9 | 1.648 |
| 1/3Al³⁺ | 61 | 0.541 |
| 1/2Ba²⁺ | 63.6 | 0.847 |
| 1/2Be²⁺ | 45 | 0.599 |
| 1/2Ca²⁺ | 59.47 | 0.792 |
| 1/2Cd²⁺ | 54 | 0.719 |
| 1/3Ce³⁺ | 69.8 | 0.620 |
| 1/2Co²⁺ | 55 | 0.732 |
| 1/3[Co(NH₃)₆]³⁺ | 101.9 | 0.904 |
| 1/3[Co(en)₃]³⁺ | 74.7 | 0.663 |
| 1/6[Co₂(trien)₃]⁶⁺ | 69 | 0.306 |
| 1/3Cr³⁺ | 67 | 0.595 |
| Cs⁺ | 77.2 | 2.056 |
| 1/2Cu²⁺ | 53.6 | 0.714 |
| D⁺ | 249.9 | 6.655 |
| 1/3Dy³⁺ | 65.6 | 0.582 |
| 1/3Er³⁺ | 65.9 | 0.585 |
| 1/3Eu³⁺ | 67.8 | 0.602 |
| 1/2Fe²⁺ | 54 | 0.719 |
| 1/3Fe³⁺ | 68 | 0.604 |
| 1/3Gd³⁺ | 67.3 | 0.597 |
| H⁺ | 349.65 | 9.311 |
| 1/2Hg²⁺ | 68.6 | 0.913 |
| 1/2Hg²⁺ | 63.6 | 0.847 |
| 1/3Ho³⁺ | 66.3 | 0.589 |
| K⁺ | 73.48 | 1.957 |
| 1/3La³⁺ | 69.7 | 0.619 |
| Li⁺ | 38.66 | 1.029 |
| 1/2Mg²⁺ | 53.0 | 0.706 |
| 1/2Mn²⁺ | 53.5 | 0.712 |
| NH₄⁺ | 73.5 | 1.957 |
| N₂H₅⁺ | 59 | 1.571 |
| Na⁺ | 50.08 | 1.334 |
| 1/3Nd³⁺ | 69.4 | 0.616 |
| 1/2Ni²⁺ | 49.6 | 0.661 |
| 1/4[Ni₂(trien)₃]⁴⁺ | 52 | 0.346 |
| 1/2Pb²⁺ | 71 | 0.945 |
| 1/3Pr³⁺ | 69.5 | 0.617 |
| 1/2Ra²⁺ | 66.8 | 0.889 |
| Rb⁺ | 77.8 | 2.072 |
| 1/3Sc³⁺ | 64.7 | 0.574 |
| 1/3Sm³⁺ | 68.5 | 0.608 |
| 1/2Sr²⁺ | 59.4 | 0.791 |
| Tl⁺ | 74.7 | 1.989 |
| 1/3Tm³⁺ | 65.4 | 0.581 |
| 1/2UO₂²⁺ | 32 | 0.426 |
| 1/3Y³⁺ | 62 | 0.550 |
| 1/3Yb³⁺ | 65.6 | 0.582 |
| 1/2Zn²⁺ | 52.8 | 0.703 |
| | | |
| *Inorganic Anions* | | |
| Au(CN)₂⁻ | 50 | 1.331 |
| Au(CN)₄⁻ | 36 | 0.959 |
| B(C₆H₅)₄⁻ | 21 | 0.559 |
| Br⁻ | 78.1 | 2.080 |
| Br₃⁻ | 43 | 1.145 |
| BrO₃⁻ | 55.7 | 1.483 |
| CN⁻ | 78 | 2.077 |
| CNO⁻ | 64.6 | 1.720 |
| 1/2CO₃²⁻ | 69.3 | 0.923 |
| Cl⁻ | 76.31 | 2.032 |
| ClO₂⁻ | 52 | 1.385 |
| ClO₃⁻ | 64.6 | 1.720 |
| ClO₄⁻ | 67.3 | 1.792 |
| 1/3[Co(CN)₆]³⁻ | 98.9 | 0.878 |
| 1/2CrO₄²⁻ | 85 | 1.132 |

| Ion | $\Lambda_{\pm}$ $10^{-4}$ m² S mol⁻¹ | $D$ $10^{-5}$ cm² s⁻¹ | Ion | $\Lambda_{\pm}$ $10^{-4}$ m² S mol⁻¹ | $D$ $10^{-5}$ cm² s⁻¹ |
|---|---|---|---|---|---|
| F⁻ | 55.4 | 1.475 | Histidyl⁺ | 23.0 | 0.612 |
| 1/4[Fe(CN)$_6$]⁴⁻ | 110.4 | 0.735 | Hydroxyethyltrimethylarsonium⁺ | 39.4 | 1.049 |
| 1/3[Fe(CN)$_6$]³⁻ | 100.9 | 0.896 | Methylammonium⁺ | 58.7 | 1.563 |
| H$_2$AsO$_4$⁻ | 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 |
| 1/2HPO$_4$²⁻ | 57 | 0.759 | Octadecyltrimethylammonium⁺ | 19.9 | 0.530 |
| H$_2$PO$_4$⁻ | 36 | 0.959 | Octadecyltripropylammonium⁺ | 17.2 | 0.458 |
| H$_2$PO$_2$⁻ | 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$_2$SbO$_4$⁻ | 31 | 0.825 | Pyrilammonium⁺ | 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 |
| 1/2MoO$_4$²⁻ | 74.5 | 1.984 | Tetraisopentylammonium⁺ | 17.9 | 0.477 |
| N(CN)$_2$⁻ | 54.5 | 1.451 | Tetrapentylammmonium⁺ | 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$_2$SO$_3$⁻ | 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 | Tripropylammonium⁺ | 26.1 | 0.695 |
| PF$_6$⁻ | 56.9 | 1.515 | | | |
| 1/2PO$_3$F²⁻ | 63.3 | 0.843 | ***Organic Anions*** | | |
| 1/3PO$_4$³⁻ | 92.8 | 0.824 | Acetate⁻ | 40.9 | 1.089 |
| 1/4P$_2$O$_7$⁴⁻ | 96 | 0.639 | p-Anisate⁻ | 29.0 | 0.772 |
| 1/3P$_3$O$_9$³⁻ | 83.6 | 0.742 | 1/2Azelate²⁻ | 40.6 | 0.541 |
| 1/5P$_3$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 |
| 1/2SO$_3$²⁻ | 72 | 0.959 | Butyrate⁻ | 32.6 | 0.868 |
| 1/2SO$_4$²⁻ | 80.0 | 1.065 | Chloroacetate⁻ | 39.8 | 1.060 |
| 1/2S$_2$O$_3$²⁻ | 85.0 | 1.132 | m-Chlorobenzoate⁻ | 31 | 0.825 |
| 1/2S$_2$O$_4$²⁻ | 66.5 | 0.885 | o-Chlorobenzoate⁻ | 30.2 | 0.804 |
| 1/2S$_2$O$_6$²⁻ | 93 | 1.238 | 1/3Citrate³⁻ | 70.2 | 0.623 |
| 1/2S$_2$O$_8$²⁻ | 86 | 1.145 | Crotonate⁻ | 33.2 | 0.884 |
| Sb(OH)$_6$⁻ | 31.9 | 0.849 | Cyanoacetate⁻ | 43.4 | 1.156 |
| SeCN⁻ | 64.7 | 1.723 | Cyclohexane carboxylate⁻ | 28.7 | 0.764 |
| 1/2SeO$_4$²⁻ | 75.7 | 1.008 | 1/2 1,1-Cyclopropanedicarboxylate²⁻ | 53.4 | 0.711 |
| 1/2WO$_4$²⁻ | 69 | 0.919 | Decylsulfate⁻ | 26 | 0.692 |
| | | | Dichloroacetate⁻ | 38.3 | 1.020 |
| ***Organic Cations*** | | | 1/2Diethylbarbiturate²⁻ | 26.3 | 0.350 |
| Benzyltrimethylammonium⁺ | 34.6 | 0.921 | Dihydrogencitrate⁻ | 30 | 0.799 |
| Isobutylammonium⁺ | 38 | 1.012 | 1/2Dimethylmalonate²⁻ | 49.4 | 0.658 |
| Butyltrimethylammonium⁺ | 33.6 | 0.895 | 3,5-Dinitrobenzoate⁻ | 28.3 | 0.754 |
| Decylpyridinium⁺ | 29.5 | 0.786 | Dodecylsulfate⁻ | 24 | 0.639 |
| Decyltrimethylammonium⁺ | 24.4 | 0.650 | Ethylmalonate⁻ | 49.3 | 1.313 |
| Diethylammonium⁺ | 42.0 | 1.118 | Ethylsulfate⁻ | 39.6 | 1.055 |
| Dimethylammonium⁺ | 51.8 | 1.379 | Fluoroacetate⁻ | 44.4 | 1.182 |
| Dipropylammonium⁺ | 30.1 | 0.802 | Fluorobenzoate⁻ | 33 | 0.879 |
| Dodecylammonium⁺ | 23.8 | 0.634 | Formate⁻ | 54.6 | 1.454 |
| Dodecyltrimethylammonium⁺ | 22.6 | 0.602 | 1/2Fumarate²⁻ | 61.8 | 0.823 |
| Ethanolammonium⁺ | 42.2 | 1.124 | 1/2Glutarate²⁻ | 52.6 | 0.700 |
| Ethylammonium⁺ | 47.2 | 1.257 | Hydrogenoxalate⁻ | 40.2 | 1.070 |
| Ethyltrimethylammonium⁺ | 40.5 | 1.078 | Isovalerate⁻ | 32.7 | 0.871 |
| Hexadecyltrimethylammonium⁺ | 20.9 | 0.557 | Iodoacetate⁻ | 40.6 | 1.081 |
| Hexyltrimethylammonium⁺ | 29.6 | 0.788 | Lactate⁻ | 38.8 | 1.033 |

| Ion | $\Lambda_{\pm}$ $10^{-4}$ m² S mol⁻¹ | $D$ $10^{-5}$ cm² s⁻¹ | Ion | $\Lambda_{\pm}$ $10^{-4}$ m² S mol⁻¹ | $D$ $10^{-5}$ cm² s⁻¹ |
|---|---|---|---|---|---|
| 1/2Malate²⁻ | 58.8 | 0.783 | Picrate⁻ | 30.37 | 0.809 |
| 1/2Maleate²⁻ | 61.9 | 0.824 | Pivalate⁻ | 31.9 | 0.849 |
| 1/2Malonate²⁻ | 63.5 | 0.845 | Propionate⁻ | 35.8 | 0.953 |
| Methylsulfate⁻ | 48.8 | 1.299 | Propylsulfate⁻ | 37.1 | 0.988 |
| Naphthylacetate⁻ | 28.4 | 0.756 | Salicylate⁻ | 36 | 0.959 |
| 1/2Oxalate²⁻ | 74.11 | 0.987 | 1/2Suberate²⁻ | 36 | 0.479 |
| Octylsulfate⁻ | 29 | 0.772 | 1/2Succinate²⁻ | 58.8 | 0.783 |
| Phenylacetate⁻ | 30.6 | 0.815 | *p*-Sulfonate | 29.3 | 0.780 |
| 1/2*o*-Phthalate²⁻ | 52.3 | 0.696 | 1/2Tartarate²⁻ | 59.6 | 0.794 |
| 1/2*m*-Phthalate²⁻ | 54.7 | 0.728 | Trichloroacetate⁻ | 35 | 0.932 |