Table 5. Recommended standard thermodynamic properties of REE minerals at temperature of 298.15 K and pressure of 1 bar, and selected heat capacity function, with *T* in Kelvin. Fonts in red represent predicted values.

| REEX | Crystal | $\Delta G^o_f$ | $\Delta H^o_f$ | $S^o$ | $V^o$ | $Cp = a + bT + c/T^2 + d/T^{0.5}$ | | | | Temperature range | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Structure | kJ mol$^{-1}$ | kJ mol$^{-1}$ | J K$^{-1}$ mol$^{-1}$ | cm$^3$ mol$^{-1}$ | *a* | *b*100* | *c* | *d* | *K* | References |
| $La_2O_3$ | A-Type | -1704.06 | -1791.60 | 127.32 | 49.63 | 120.6805 | 1.342414 | -1413668 | - | 298–1800 | K14 |
| $Ce_2O_3$ | A-Type | -1710.65 | -1799.80 | 148.10 | 47.84 | 113.736 | 2.84344 | -641205 | - | 298–2392 | K14 |
| $Pr_2O_3$ | A-Type | -1719.71 | -1809.90 | 152.70 | 46.68 | 121.6594 | 2.55611 | -989420 | - | 298–2310 | K14 |
| $Nd_2O_3$ | A-Type | -1719.30 | -1806.90 | 158.70 | 45.89 | 117.1079 | 2.813655 | -1258450 | - | 298–2379 | K14 |
| $Pm_2O_3$ | A-Type | - | - | - | 44.87 | 129.454 | 1.996 | - | - | 2013–2407 | K14 |
| $Pm_2O_3$ | B-Type | -1737.64 | -1824.61 | 158.00 | 45.70 | 122.9493 | 3.00141 | -1852170 | - | 298–2013 | K14 |
| $Sm_2O_3$ | B-Type | -1734.65 | -1823.00 | 150.60 | 45.08 | 129.7953 | 1.903114 | -1862270 | - | 298–2190 | K14 |
| $Eu_2O_3$ | B-Type | -1553.58 | -1650.40 | 138.60 | 44.25 | 133.3906 | 1.66443 | -1424350 | - | 298–2327 | K14 |
| $Gd_2O_3$ | B-Type | -1734.21 | -1819.70 | 157.10 | 43.40 | 114.6104 | 1.52344 | -1249170 | - | 298–2430 | K14 |
| $Cm_2O_3$ | B-Type | -1599.82 | -1684.00 | 167.00 | 45.98 | 123.532 | 0.1455 | -1348900 | - | 298–1888 | K14 |
| $Pm_2O_3$ | C-Type | -1759.73 | - | - | 49.96 | - | - | - | - | - | K14 |
| $Sm_2O_3$ | C-Type | -1763.14 | -1826.80 | 233.42 | 49.20 | 132.4358 | 1.87799 | -2408600 | - | 298–900 | K14 |
| $Eu_2O_3$ | C-Type | -1564.72 | -1662.50 | 135.40 | 48.33 | 136.2978 | 1.49877 | -1499300 | - | 298–1350 | K14 |
| $Gd_2O_3$ | C-Type | -1766.57 | -1854.00 | 150.60 | 47.57 | 114.8086 | 1.72911 | -1283970 | - | 298–2000 | K14 |
| $Cm_2O_3$ | C-Type | -1600.92 | - | - | 50.21 | - | - | - | - | - | K14 |
| $Tb_2O_3$ | C-Type | -1777.84 | -1865.20 | 159.20 | 46.47 | 120.6682 | 2.217194 | -1002610 | - | 298–1823 | K14 |
| $Dy_2O_3$ | C-Type | -1769.92 | -1863.40 | 149.80 | 45.65 | 121.2302 | 1.527609 | -845800 | - | 298–2223 | K14 |
| $Ho_2O_3$ | C-Type | -1793.34 | -1883.30 | 156.38 | 44.91 | 121.934 | 1.011623 | -886280 | - | 298–2538 | K14 |
| $Er_2O_3$ | C-Type | -1788.61 | -1879.13 | 153.13 | 44.16 | 123.2921 | 0.862245 | -1544330 | - | 298–2538 | K14 |
| $Tm_2O_3$ | C-Type | -1795.52 | -1889.30 | 139.70 | 43.41 | 128.4322 | 0.523209 | -1178910 | - | 298–2588 | K14 |
| $Yb_2O_3$ | C-Type | -1726.73 | -1814.50 | 133.10 | 42.76 | 130.6438 | 0.334628 | -1448200 | - | 298–2687 | K14 |
| $Lu_2O_3$ | C-Type | -1792.65 | -1877.00 | 126.79 | 42.23 | 122.4593 | 0.729001 | -2034140 | - | 298–2762 | K14 |
| $Y_2O_3$ | C-Type | -1823.00 | -1911.74 | 98.96 | 44.80 | 122.91 | 0.743 | -1931300 | - | 298-2000 | MK05 |
| $CeO_2$ | Cubic | -1027.03 | -1090.40 | 62.29 | 23.85 | 74.4814 | 0.583682 | -1297100 | - | 298–3083 | K14 |
| $PrO_2$ | Cubic | -900.04 | -959.10 | 80.80 | 23.61 | 72.9881 | 1.6628 | -99900 | - | 298–663 | K14 |
| $TbO_2$ | Cubic | -915.41 | -972.20 | 86.90 | 21.41 | 73.259 | 1.32023 | 1042400 | - | 298–1400 | K14 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| $La(OH)_3$ | Cubic | -1284.20 | -1416.10 | 117.80 | 42.79 | 521.7845 | -40.255 | 709538.23 | -5081.56 | 200–350 | D98 |
| $Ce(OH)_3$ | Cubic | -1286.40 | -1418.60 | 129.40 | 41.47 | - | - | - | - | - | - |
| $Pr(OH)_3$ | Cubic | -1284.90 | -1404.00 | 131.70 | 40.64 | 520.9956 | -40.327 | 771992.59 | -5070.02 | 10–350 | D98 |
| $Nd(OH)_3$ | Cubic | -1283.00 | -1415.60 | 129.90 | 39.44 | 254.8777 | -2.25 | 366050.62 | -2324.81 | 10–350 | D98 |
| $Pm(OH)_3$ | Cubic | -1276.30 | | | 38.97 | - | - | - | - | - | - |
| $Sm(OH)_3$ | Cubic | -1273.30 | -1406.60 | 125.80 | 38.38 | - | - | - | - | - | - |
| $Eu(OH)_3$ | Cubic | -1180.60 | -1319.10 | 119.90 | 37.81 | 518.63 | -38.286 | 705759.72 | -5035.37 | 200–350 | D98 |
| $Gd(OH)_3$ | Cubic | -1276.20 | -1408.90 | 126.60 | 37.36 | 558.2502 | -44.302 | 871657.32 | -5615.29 | 200–350 | D98 |
| $Tb(OH)_3$ | Cubic | -1281.10 | -1414.80 | 128.40 | 36.49 | 558.8346 | -44.577 | 1041050 | -5623.85 | 10–350 | D98 |
| $Dy(OH)_3$ | Cubic | -1280.79 | -1414.45 | 130.30 | 37.98 | - | - | - | - | - | - |
| $Ho(OH)_3$ | Cubic | -1297.40 | -1431.10 | 130.00 | 35.84 | 568.9153 | -44.878 | 1049500 | -5771.39 | 10–350 | D98 |
| $Er(OH)_3$ | Cubic | -1288.14 | -1421.80 | 128.60 | 35.24 | - | - | - | - | - | - |
| $Tm(OH)_3$ | Cubic | -1286.60 | -1421.10 | 126.50 | 34.80 | - | - | - | - | - | - |
| $Yb(OH)_3$ | Cubic | -1262.90 | -1395.50 | 118.60 | 34.36 | - | - | - | - | - | - |
| $Lu(OH)_3$ | Cubic | -1288.54 | -1419.01 | 117.15 | 33.93 | - | - | - | - | - | - |
| $Y(OH)_3$ | Cubic | -1304.39 | -1438.26 | 99.20 | 35.96 | 575.1682 | -46.487 | 927559.26 | -5862.91 | 10–350 | D98 |
| $LaCl_3$ | $UCl_3$ | -995.89 | -1071.52 | 137.57 | 63.90 | 74.9288 | 5.1654 | 684520 | - | 1133 | KK03 |
| $CeCl_3$ | $UCl_3$ | -983.61 | -1059.02 | 151.42 | 62.52 | 90.9772 | 3.5812 | -271530 | - | 1090 | KK03 |
| $PrCl_3$ | $UCl_3$ | -982.72 | -1058.77 | 153.30 | 61.40 | 85.6511 | 3.9524 | 134650 | - | 1060 | KK03 |
| $NdCl_3$ | $UCl_3$ | -965.56 | -1041.18 | 153.43 | 60.47 | 87.2834 | 3.8586 | 40210 | - | 1032 | KK03 |
| $PmCl_3$ | $UCl_3$ | -955.47 | - | - | - | - | - | - | - | - | - |
| $SmCl_3$ | $UCl_3$ | -949.55 | -1025.32 | 150.12 | 59.12 | 95.3748 | 3.3444 | -516135 | - | 950 | KK03 |
| $EuCl_3$ | $UCl_3$ | -855.39 | -935.41 | 144.06 | 58.50 | 100.9736 | 3.0092 | -263620 | - | 894 | KK03 |
| $GdCl_3$ | $UCl_3$ | -943.28 | -1018.20 | 151.42 | 58.03 | 88.7959 | 3.1444 | -34750 | - | 875 | KK03 |
| $TbCl_3$ | $PuBr_3$ | -1010.60 | -1085.74 | 154.85 | - | 86.292 | 3.8598 | - | - | 783 | KK03 |
| $DyCl_3$ | $AlCl_3$ | -923.34 | -994.02 | 175.40 | 74.38 | -34.7111 | 8.714 | -1978460 | 2265.502 | 924 | KK03 |
| $HoCl_3$ | $AlCl_3$ | -928.29 | -997.68 | 177.10 | 74.80 | 100.382 | 0.5091 | - | - | 993 | KK03 |
| $ErCl_3$ | $AlCl_3$ | -925.02 | -994.81 | 175.10 | 75.21 | -28.255 | 8.272 | -2055060 | 2177.088 | 1049 | KK03 |
| $TmCl_3$ | $AlCl_3$ | -926.20 | -996.09 | 173.50 | 75.59 | -38.3601 | 8.67 | -2308450 | 2382.415 | 1095 | KK03 |
| $YbCl_3$ | $AlCl_3$ | -892.36 | -959.51 | 169.30 | 76.04 | -55.7145 | 9.322 | -2731060 | 2752.211 | 1138 | KK03 |
| $LuCl_3$ | $AlCl_3$ | -917.76 | -987.12 | 153.00 | 76.31 | -74.5384 | 10.439 | -3070270 | 3000.228 | 1198 | KK03 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| $YCl_3$ | $AlCl_3$ | -940.90 | -1013.13 | 136.82 | 74.83 | 101.7423 | 0.715464 | -1051439 | - | 298–994 | P84 |
| $LaF_3$ | $LaF_3$ | -1656.37 | -1732.05 | 106.98 | - | -329.312 | 16.191 | -15085500 | 9212.611 | 1766 | KK03 |
| $CeF_3$ | $LaF_3$ | -1641.37 | -1718.50 | 115.23 | - | -59.1137 | 8.063 | -4575500 | 3075.152 | 1703 | KK03 |
| $PrF_3$ | $LaF_3$ | -1641.37 | -1717.91 | 121.22 | - | 14.00406 | 3.548 | -5381370 | 2197.807 | 1670 | KK03 |
| $NdF_3$ | $LaF_3$ | -1634.37 | -1710.64 | 120.79 | - | 37.82125 | 4.02 | -2617590 | 1231.834 | 1649 | KK03 |
| $SmF_3$ | $YF_3$ | -1624.37 | -1701.09 | 116.50 | - | 169.0564 | -7.6809 | -4840760 | - | 743 | KK03 |
| $EuF_3$ | $YF_3$ | -1544.55 | -1625.63 | 110.07 | - | 117.4275 | - | -1735890 | - | 973 | KK03 |
| $GdF_3$ | $YF_3$ | -1621.37 | -1698.14 | 114.77 | - | 102.3403 | 0.60945 | -1401620 | - | 1347 | KK03 |
| $TbF_3$ | $YF_3$ | -1618.37 | -1695.14 | 118.97 | - | 97.5769 | 1.98845 | -1156100 | - | 1446 | KK03 |
| $DyF_3$ | $YF_3$ | -1616.87 | -1695.57 | 118.07 | - | 107.776 | 1.763 | -586828.7 | -299.813 | 1426 | KK03 |
| $HoF_3$ | $YF_3$ | -1624.37 | -1701.61 | 120.34 | - | -98.1651 | 8.272 | -7160320 | 4159.99 | 1416 | KK03 |
| $ErF_3$ | $YF_3$ | -1614.37 | -1692.45 | 116.86 | - | 6.16555 | 4.455 | -4469530 | 2073.427 | 1388 | KK03 |
| $TmF_3$ | $YF_3$ | -1614.37 | -1692.63 | 114.98 | - | 53.9644 | 2.401 | -3044090 | 1097.046 | 1325 | KK03 |
| $YbF_3$ | $YF_3$ | -1587.37 | -1662.58 | 111.84 | - | 103.7012 | 0.92366 | -1516080 | - | 1267 | KK03 |
| $LuF_3$ | $YF_3$ | -1610.37 | -1688.00 | 94.83 | - | 89.0368 | 1.92857 | -685980 | - | 1230 | KK03 |
| $YF_3$ | $YF_3$ | -1632.86 | -1710.36 | 88.70 | - | 106.8418 | 0.16485 | -434000 | - | 298–1350 | P84 |
| $LaFeO_3$ | Perovskite | -1277.80 | -1351.2 | 118.00 | - | - | - | - | - | - | - |
| $CeFeO_3$ | Perovskite | -1274.59 | - | - | - | - | - | - | - | - | - |
| $PrFeO_3$ | Perovskite | -1282.00 | -1364.6 | 102.70 | 57.48 | - | - | - | - | - | - |
| $NdFeO_3$ | Perovskite | -1277.40 | -1359.9 | 116.00 | 57.26 | - | - | - | - | - | - |
| $SmFeO_3$ | Perovskite | -1284.10 | -1367 | 161.50 | | - | - | - | - | - | - |
| $EuFeO_3$ | Perovskite | -1194.50 | -1280.6 | 188.00 | - | - | - | - | - | - | - |
| $GdFeO_3$ | Perovskite | -1269.80 | -1365.3 | 129.00 | - | - | - | - | - | - | - |
| $TbFeO_3$ | Perovskite | -1282.19 | -1383.9 | 65.91 | - | - | - | - | - | - | - |
| $DyFeO_3$ | Perovskite | -1285.30 | -1378.8 | 126.80 | - | - | - | - | - | - | - |
| $HoFeO_3$ | Perovskite | -1289.10 | -1388.7 | 131.00 | - | - | - | - | - | - | - |
| $ErFeO_3$ | Perovskite | -1287.80 | -1397.1 | 137.10 | - | - | - | - | - | - | - |
| $TmFeO_3$ | Perovskite | -1286.96 | - | 86.00 | - | - | - | - | - | - | - |
| $YbFeO_3$ | Perovskite | -1261.20 | -1354.3 | 82.44 | - | - | - | - | - | - | - |
| $LuFeO_3$ | Perovskite | - | -1385.6 | - | - | - | - | - | - | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $YFeO_3$ | Perovskite | -1296.40 | - | - | - | - | - | - | - | - | - |
| $La_2(CO_3)_3$ | - | -3141.77 | -3378.05 | 261.08 | - | - | - | - | - | - | - |
| $Ce_2(CO_3)_3$ | - | -3120.57 | -3357.69 | 284.51 | - | - | - | - | - | - | - |
| $Pr_2(CO_3)_3$ | - | -3130.57 | -3369.34 | 287.02 | - | - | - | - | - | - | - |
| $Nd_2(CO_3)_3$ | - | -3113.40 | -3349.75 | 292.46 | - | - | - | - | - | - | - |
| $Pm_2(CO_3)_3$ | - | -3100.89 | - | - | - | - | - | - | - | - | - |
| $Sm_2(CO_3)_3$ | - | -3102.02 | -3338.95 | 284.93 | - | - | - | - | - | - | - |
| $Eu_2(CO_3)_3$ | - | -2910.50 | -3153.69 | 280.33 | - | - | - | - | - | - | - |
| $Gd_2(CO_3)_3$ | - | -3097.75 | -3333.89 | 284.51 | - | - | - | - | - | - | - |
| $Tb_2(CO_3)_3$ | - | -3106.07 | -3343.95 | 287.02 | - | - | - | - | - | - | - |
| $Dy_2(CO_3)_3$ | - | -3093.23 | -3335.43 | 283.68 | - | - | - | - | - | - | - |
| $Ho_2(CO_3)_3$ | - | -3123.16 | -3361.30 | 292.04 | - | - | - | - | - | - | - |
| $Er_2(CO_3)_3$ | - | -3110.11 | -3348.97 | 288.28 | - | - | - | - | - | - | - |
| $Tm_2(CO_3)_3$ | - | -3110.16 | -3352.64 | 273.63 | - | - | - | - | - | - | - |
| $Yb_2(CO_3)_3$ | - | -3050.55 | -3287.05 | 266.94 | - | - | - | - | - | - | - |
| $Lu_2(CO_3)_3$ | - | -3105.73 | -3343.78 | 243.93 | - | - | - | - | - | - | - |
| $Y_2(CO3)_3$ | - | -3148.04 | -3385.43 | 233.05 | - | - | - | - | - | - | - |
| $La_2(CO_3)_3{\cdot}8H_2O$ | - | -4958.88 | -5688.65 | 471.96 | - | - | - | - | - | - | - |
| $Ce_2(CO_3)_3{\cdot}8H_2O$ | - | -4958.04 | -5670.43 | 556.47 | - | - | - | - | - | - | - |
| $Pr_2(CO_3)_3{\cdot}8H_2O$ | - | -4947.16 | -5699.38 | 430.95 | - | - | - | - | - | - | - |
| $Nd_2(CO_3)_3{\cdot}8H_2O$ | - | -4931.26 | - | - | - | - | - | - | - | - | - |
| $Sm_2(CO_3)_3{\cdot}3H_2O$ | - | -3739.24 | -4521.43 | 322.17 | - | - | - | - | - | - | - |
| $Eu_2(CO_3)_3.3H_2O$ | - | -3553.89 | -4356.07 | 271.54 | - | - | - | - | - | - | - |
| $Gd_2(CO_3)_3{\cdot}3H_2O$ | - | -3728.78 | -4510.92 | 319.24 | - | - | - | - | - | - | - |
| $Tb_2(CO_3)_3{\cdot}3H_2O$ | - | -3736.78 | -4528.28 | 296.23 | - | - | - | - | - | - | - |
| $Dy_2(CO_3)_3{\cdot}3H_2O$ | - | -3732.13 | -4509.73 | 353.97 | - | - | - | - | - | - | - |
| $Ho_2(CO_3)_3{\cdot}3H_2O$ | - | -3748.03 | -4522.57 | 358.99 | - | - | - | - | - | - | - |
| $Er_2(CO_3)_3{\cdot}3H_2O$ | - | -3736.31 | -4510.58 | 358.57 | - | - | - | - | - | - | - |
| $Tm_2(CO_3)_3{\cdot}3H_2O$ | - | -3719.58 | -4483.86 | 389.53 | - | - | - | - | - | - | - |
| $Yb_2(CO_3)_3{\cdot}6H_2O$ | - | -4389.02 | - | - | - | - | - | - | - | - | - |
| $Lu_2(CO_3)_3{\cdot}6H_2O$ | - | -4356.38 | - | - | - | - | - | - | - | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $Y_2(CO_3)_3 \cdot 3H_2O$ | - | -3766.87 | -4539.03 | 305.43 | - | - | - | - | - | - | - |

Abbreviations: K14: Konings et al. (2014); MK05: Morss and Konings (2004); D98: Diakonov et al. (1998); KK03: Konings and Kovács (2003); P84: Pankratz (1984).