

| Substance and State                                | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |  | Substance and State                              | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |
|----------------------------------------------------|----------------------------|----------------------------|-------------------------|--|--------------------------------------------------|----------------------------|----------------------------|-------------------------|
| <b>Aluminum</b>                                    |                            |                            |                         |  | <b>Calcium<br/>(continued)</b>                   |                            |                            |                         |
| Al <sub>(s)</sub>                                  | 0                          | 0                          | 28                      |  | CaSO <sub>4(s)</sub>                             | -1433                      | -1320                      | 107                     |
| Al <sub>2</sub> O <sub>3(s)</sub>                  | -1676                      | -1582                      | 51                      |  | CaSiO <sub>3(s)</sub>                            | -1630                      | -1550                      | 84                      |
| Al(OH) <sub>3(s)</sub>                             | -1277                      |                            |                         |  | <b>Carbon</b>                                    |                            |                            |                         |
| AlCl <sub>3(s)</sub>                               | -704                       | -629                       | 111                     |  | C <sub>(s)</sub> (graphite)                      | 0                          | 0                          | 6                       |
| <b>Barium</b>                                      |                            |                            |                         |  | C <sub>(s)</sub> (diamond)                       | 2                          | 3                          | 2                       |
| Ba <sub>(s)</sub>                                  | 0                          | 0                          | 67                      |  | CO <sub>(g)</sub>                                | -110.5                     | -137                       | 198                     |
| BaCO <sub>3(s)</sub>                               | -1219                      | -1139                      | 112                     |  | CO <sub>2(g)</sub>                               | -393.5                     | -394                       | 214                     |
| BaO <sub>(s)</sub>                                 | -582                       | -552                       | 70                      |  | CH <sub>4(g)</sub>                               | -75                        | -51                        | 186                     |
| Ba(OH) <sub>2(s)</sub>                             | -946                       |                            |                         |  | CH <sub>3</sub> OH <sub>(g)</sub>                | -201                       | -163                       | 240                     |
| BaSO <sub>4(s)</sub>                               | -1465                      | -1353                      | 132                     |  | CH <sub>3</sub> OH <sub>(l)</sub>                | -239                       | -166                       | 127                     |
| <b>Beryllium</b>                                   |                            |                            |                         |  | H <sub>2</sub> CO <sub>(g)</sub>                 | -116                       | -110                       | 219                     |
| Be <sub>(s)</sub>                                  | 0                          | 0                          | 152                     |  | HCOOH <sub>(g)</sub>                             | -363                       | -351                       | 249                     |
| BeO <sub>(s)</sub>                                 | -599                       | -569                       | 14                      |  | HCN <sub>(g)</sub>                               | 135.1                      | 125                        | 202                     |
| Be(OH) <sub>2(s)</sub>                             | -904                       | -815                       | 47                      |  | C <sub>2</sub> H <sub>2(g)</sub>                 | 227                        | 209                        | 201                     |
| <b>Bromine</b>                                     |                            |                            |                         |  | C <sub>2</sub> H <sub>4(g)</sub>                 | 52                         | 68                         | 219                     |
| Br <sub>2(l)</sub>                                 | 0                          | 0                          | 152                     |  | CH <sub>3</sub> CHO <sub>(g)</sub>               | -166                       | -129                       | 250                     |
| Br <sub>2(g)</sub>                                 | 31                         | 3                          | 245                     |  | C <sub>2</sub> H <sub>5</sub> OH <sub>(l)</sub>  | -278                       | -175                       | 161                     |
| Br <sub>2(aq)</sub>                                | -3                         | 4                          | 130                     |  | C <sub>2</sub> H <sub>6(g)</sub>                 | -84.7                      | -32.9                      | 229.5                   |
| Br <sub>(aq)</sub> <sup>-</sup>                    | -121                       | -104                       | 82                      |  | C <sub>3</sub> H <sub>6(g)</sub>                 | 20.9                       | 62.7                       | 266.9                   |
| HBr <sub>(g)</sub>                                 | -36                        | -53                        | 199                     |  | C <sub>3</sub> H <sub>8(g)</sub>                 | -104                       | -24                        | 270                     |
| <b>Cadmium</b>                                     |                            |                            |                         |  | C <sub>2</sub> H <sub>4</sub> O <sub>(g)</sub>   | -53                        | -13                        | 242                     |
| Cd <sub>(s)</sub>                                  | 0                          | 0                          | 52                      |  | CH <sub>2</sub> =CHCN <sub>(g)</sub>             | 185.0                      | 195.4                      | 274                     |
| CdO <sub>(s)</sub>                                 | -258                       | -228                       | 55                      |  | CH <sub>3</sub> COOH <sub>(l)</sub>              | -484                       | -389                       | 160                     |
| Cd(OH) <sub>2(s)</sub>                             | -561                       | -474                       | 96                      |  | C <sub>6</sub> H <sub>12</sub> O <sub>6(s)</sub> | -1275                      | -911                       | 212                     |
| CdS <sub>(s)</sub>                                 | -162                       | -156                       | 65                      |  | CCl <sub>4</sub>                                 | -135                       | -65                        | 216                     |
| CdSO <sub>4(s)</sub>                               | -935                       | -823                       | 123                     |  | <b>Chlorine</b>                                  |                            |                            |                         |
| <b>Calcium</b>                                     |                            |                            |                         |  | Cl <sub>2(g)</sub>                               | 0                          | 0                          | 223                     |
| Ca <sub>(s)</sub>                                  | 0                          | 0                          | 41                      |  | Cl <sub>2(aq)</sub>                              | -23                        | 7                          | 121                     |
| CaC <sub>2(s)</sub>                                | -63                        | -68                        | 70                      |  | Cl <sub>(aq)</sub> <sup>-</sup>                  | -167                       | -131                       | 57                      |
| CaCO <sub>3(s)</sub>                               | -1207                      | -1129                      | 93                      |  | HCl <sub>(g)</sub>                               | -92                        | -95                        | 187                     |
| CaO <sub>(s)</sub>                                 | -635                       | -604                       | 40                      |  | <b>Chromium</b>                                  |                            |                            |                         |
| Ca(OH) <sub>2(s)</sub>                             | -987                       | -899                       | 83                      |  | Cr <sub>(s)</sub>                                | 0                          | 0                          | 24                      |
| Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2(s)</sub> | -4126                      | -3890                      | 241                     |  | Cr <sub>2</sub> O <sub>3(s)</sub>                | -1128                      | -1047                      | 81                      |

| Substance and State                 | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |  | Substance and State                           | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |
|-------------------------------------|----------------------------|----------------------------|-------------------------|--|-----------------------------------------------|----------------------------|----------------------------|-------------------------|
| <b>Chromium (continued)</b>         |                            |                            |                         |  | <b>Iron (continued)</b>                       |                            |                            |                         |
| CrO <sub>3(s)</sub>                 | -579                       | -502                       | 72                      |  | FeSO <sub>4(s)</sub>                          | -929                       | -825                       | 121                     |
| <b>Copper</b>                       |                            |                            |                         |  | <b>Lead</b>                                   |                            |                            |                         |
| Cu <sub>(s)</sub>                   | 0                          | 0                          | 33                      |  | Pb <sub>(s)</sub>                             | 0                          | 0                          | 65                      |
| CuCO <sub>3(s)</sub>                | -595                       | -518                       | 88                      |  | PbO <sub>2(s)</sub>                           | -277                       | -217                       | 69                      |
| Cu <sub>2</sub> O <sub>(s)</sub>    | -170                       | -148                       | 93                      |  | PbS <sub>(s)</sub>                            | -100                       | -99                        | 91                      |
| CuO <sub>(s)</sub>                  | -156                       | -128                       | 43                      |  | PbSO <sub>4(s)</sub>                          | -920                       | -813                       | 149                     |
| Cu(OH) <sub>2(s)</sub>              | -450                       | -372                       | 108                     |  | <b>Magnesium</b>                              |                            |                            |                         |
| CuS <sub>(s)</sub>                  | -49                        | -49                        | 67                      |  | Mg <sub>(s)</sub>                             | 0                          | 0                          | 33                      |
| <b>Fluorine</b>                     |                            |                            |                         |  | MgCO <sub>3(s)</sub>                          | -1113                      | -1029                      | 66                      |
| F <sub>2(g)</sub>                   | 0                          | 0                          | 203                     |  | MgO <sub>(s)</sub>                            | -602                       | -569                       | 27                      |
| F <sup>-</sup> <sub>(aq)</sub>      | -333                       | -279                       | -14                     |  | Mg(OH) <sub>2(s)</sub>                        | -925                       | -813                       | 149                     |
| HF <sub>(g)</sub>                   | -271                       | -273                       | 174                     |  | <b>Manganese</b>                              |                            |                            |                         |
| <b>Hydrogen</b>                     |                            |                            |                         |  | Mn <sub>(s)</sub>                             | 0                          | 0                          | 33                      |
| H <sub>2(g)</sub>                   | 0                          | 0                          | 131                     |  | MnO <sub>(s)</sub>                            | -385                       | -363                       | 60                      |
| H <sub>(g)</sub>                    | 217                        | 203                        | 115                     |  | Mn <sub>3</sub> O <sub>4(s)</sub>             | -1387                      | -1280                      | 149                     |
| H <sup>+</sup> <sub>(aq)</sub>      | 0                          | 0                          | 0                       |  | Mn <sub>2</sub> O <sub>3(s)</sub>             | -971                       | -893                       | 110                     |
| OH <sup>-</sup> <sub>(aq)</sub>     | -230                       | -157                       | -11                     |  | MnO <sub>2(s)</sub>                           | -521                       | -466                       | 53                      |
| H <sub>2</sub> O <sub>(l)</sub>     | -286                       | -237                       | 70                      |  | MnO <sub>4</sub> <sup>-</sup> <sub>(aq)</sub> | -543                       | -449                       | 190                     |
| H <sub>2</sub> O <sub>(g)</sub>     | -242                       | -229                       | 189                     |  | <b>Mercury</b>                                |                            |                            |                         |
| <b>Iodine</b>                       |                            |                            |                         |  | Hg <sub>(l)</sub>                             | 0                          | 0                          | 76                      |
| I <sub>2(s)</sub>                   | 0                          | 0                          | 116                     |  | Hg <sub>2</sub> Cl <sub>2(s)</sub>            | -265                       | -211                       | 196                     |
| I <sub>2(g)</sub>                   | 62                         | 19                         | 261                     |  | HgCl <sub>2(s)</sub>                          | -230                       | -184                       | 144                     |
| I <sub>2(aq)</sub>                  | 23                         | 16                         | 137                     |  | HgO <sub>(s)</sub>                            | -90                        | -59                        | 70                      |
| I <sup>-</sup> <sub>(aq)</sub>      | -55                        | -52                        | 106                     |  | HgS <sub>(s)</sub>                            | -58                        | -49                        | 78                      |
| <b>Iron</b>                         |                            |                            |                         |  | <b>Nickel</b>                                 |                            |                            |                         |
| Fe <sub>(s)</sub>                   | 0                          | 0                          | 27                      |  | Ni <sub>(s)</sub>                             | 0                          | 0                          | 30                      |
| Fe <sub>3</sub> C <sub>(s)</sub>    | 21                         | 15                         | 108                     |  | NiCl <sub>2(s)</sub>                          | -316                       | -272                       | 107                     |
| Fe <sub>0.95</sub> O <sub>(s)</sub> | -264                       | -240                       | 59                      |  | NiO <sub>(s)</sub>                            | -241                       | -213                       | 38                      |
| FeO                                 | -272                       | -255                       | 61                      |  | Ni(OH) <sub>2(s)</sub>                        | -538                       | -453                       | 79                      |
| Fe <sub>3</sub> O <sub>4(s)</sub>   | -1117                      | -1013                      | 146                     |  | NiS <sub>(s)</sub>                            | -93                        | -90                        | 53                      |
| Fe <sub>2</sub> O <sub>3(s)</sub>   | -826                       | -740                       | 90                      |  | <b>Nitrogen</b>                               |                            |                            |                         |
| FeS <sub>(s)</sub>                  | -95                        | -97                        | 67                      |  | N <sub>2(g)</sub>                             | 0                          | 0                          | 192                     |
| FeS <sub>2(s)</sub>                 | -178                       | -166                       | 53                      |  | NH <sub>3(g)</sub>                            | -46                        | -17                        | 193                     |

| Substance and State                              | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |  | Substance and State                 | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |
|--------------------------------------------------|----------------------------|----------------------------|-------------------------|--|-------------------------------------|----------------------------|----------------------------|-------------------------|
| <b>Nitrogen<br/>(continued)</b>                  |                            |                            |                         |  | <b>Potassium<br/>(continued)</b>    |                            |                            |                         |
| NH <sub>3(aq)</sub>                              | -80                        | -27                        | 111                     |  | KClO <sub>4(s)</sub>                | -433                       | -304                       | 151                     |
| NH <sub>4<sup>+</sup>(aq)</sub>                  | -132                       | -79                        | 113                     |  | K <sub>2</sub> O <sub>(s)</sub>     | -361                       | -322                       | 98                      |
| NO <sub>(g)</sub>                                | 90                         | 87                         | 211                     |  | K <sub>2</sub> O <sub>2(s)</sub>    | -496                       | -430                       | 113                     |
| NO <sub>2(g)</sub>                               | 34                         | 52                         | 240                     |  | KO <sub>2(s)</sub>                  | -283                       | -238                       | 117                     |
| N <sub>2</sub> O <sub>(g)</sub>                  | 82                         | 104                        | 220                     |  | KOH <sub>(s)</sub>                  | -425                       | -379                       | 79                      |
| N <sub>2</sub> O <sub>4(g)</sub>                 | 10                         | 98                         | 304                     |  | KOH <sub>(aq)</sub>                 | -481                       | -440                       | 9.20                    |
| N <sub>2</sub> O <sub>4(l)</sub>                 | -20                        | 97                         | 209                     |  | <b>Silicon</b>                      |                            |                            |                         |
| N <sub>2</sub> O <sub>5(s)</sub>                 | -42                        | 134                        | 178                     |  | SiO <sub>2(s)</sub>                 | -199                       | -856                       | 42                      |
| N <sub>2</sub> H <sub>4(l)</sub>                 | 51                         | 149                        | 121                     |  | SiCl <sub>4(l)</sub>                | -687                       | -620                       | 240                     |
| N <sub>2</sub> H <sub>3</sub> CH <sub>3(l)</sub> | 54                         | 180                        | 166                     |  | <b>Silver</b>                       |                            |                            |                         |
| HNO <sub>3(aq)</sub>                             | -207                       | -111                       | 146                     |  | Ag <sub>(s)</sub>                   | 0                          | 0                          | 43                      |
| HNO <sub>3(l)</sub>                              | -174                       | -81                        | 156                     |  | Ag <sup>+</sup> <sub>(aq)</sub>     | 105                        | 77                         | 73                      |
| NH <sub>4</sub> ClO <sub>4(s)</sub>              | -295                       | -89                        | 186                     |  | AgBr <sub>(s)</sub>                 | -100                       | -97                        | 107                     |
| NH <sub>4</sub> Cl <sub>(s)</sub>                | -314                       | -203                       | 96                      |  | AgCN <sub>(s)</sub>                 | 146                        | 164                        | 84                      |
| <b>Oxygen</b>                                    |                            |                            |                         |  | AgCl <sub>(s)</sub>                 | -127                       | -110                       | 96                      |
| O <sub>2(g)</sub>                                | 0                          | 0                          | 205                     |  | Ag <sub>2</sub> CrO <sub>4(s)</sub> | -712                       | -622                       | 217                     |
| O <sub>(g)</sub>                                 | 249                        | 232                        | 161                     |  | AgI <sub>(s)</sub>                  | -62                        | -66                        | 115                     |
| O <sub>3(g)</sub>                                | 143                        | 163                        | 239                     |  | Ag <sub>2</sub> O <sub>(s)</sub>    | -31                        | -11                        | 122                     |
| <b>Phosphorus</b>                                |                            |                            |                         |  | Ag <sub>2</sub> S <sub>(s)</sub>    | -32                        | -40                        | 146                     |
| P <sub>(s)</sub> (white)                         | 0                          | 0                          | 41                      |  | <b>Sodium</b>                       |                            |                            |                         |
| P <sub>(s)</sub> (red)                           | -18                        | -12                        | 23                      |  | Na <sub>(s)</sub>                   | 0                          | 0                          | 51                      |
| P <sub>(s)</sub> (black)                         | -39                        | -33                        | 23                      |  | Na <sup>+</sup> <sub>(aq)</sub>     | -240                       | -262                       | 59                      |
| P <sub>4(g)</sub>                                | 59                         | 24                         | 280                     |  | NaBr <sub>(s)</sub>                 | -360                       | -347                       | 84                      |
| PF <sub>5(g)</sub>                               | -1578                      | -1509                      | 296                     |  | Na <sub>2</sub> CO <sub>3(s)</sub>  | -1131                      | -1048                      | 136                     |
| PH <sub>3(g)</sub>                               | 5                          | 13                         | 210                     |  | NaHCO <sub>3(s)</sub>               | -948                       | -852                       | 102                     |
| H <sub>3</sub> PO <sub>4(s)</sub>                | -1279                      | -1119                      | 110                     |  | NaCl <sub>(s)</sub>                 | -411                       | -384                       | 72                      |
| H <sub>3</sub> PO <sub>4(l)</sub>                | -1267                      | ---                        | ---                     |  | NaH <sub>(s)</sub>                  | -56                        | -33                        | 40                      |
| H <sub>3</sub> PO <sub>4(g)</sub>                | -1288                      | -1143                      | 158                     |  | NaI <sub>(s)</sub>                  | -288                       | -282                       | 91                      |
| P <sub>4</sub> O <sub>10(s)</sub>                | -2984                      | -2698                      | 229                     |  | NaNO <sub>2(s)</sub>                | -359                       |                            |                         |
| <b>Potassium</b>                                 |                            |                            |                         |  | NaNO <sub>3(s)</sub>                | -467                       | -366                       | 116                     |
| K <sub>(s)</sub>                                 | 0                          | 0                          | 64                      |  | Na <sub>2</sub> O <sub>(s)</sub>    | -416                       | -377                       | 73                      |
| KCl <sub>(s)</sub>                               | -436                       | -408                       | 83                      |  | NaOH <sub>(s)</sub>                 | -427                       | -381                       | 64                      |
| KClO <sub>3(s)</sub>                             | -391                       | -290                       | 143                     |  | NaOH <sub>(aq)</sub>                | -470                       | -419                       | 50                      |

| Substance and State                           | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |  | Substance and State       | $\Delta H_f^0$<br>(kJ/mol) | $\Delta G_f^0$<br>(kJ/mol) | $\Delta S$<br>(J/K·mol) |
|-----------------------------------------------|----------------------------|----------------------------|-------------------------|--|---------------------------|----------------------------|----------------------------|-------------------------|
| <b>Sulfur</b>                                 |                            |                            |                         |  | <b>Zinc</b>               |                            |                            |                         |
| S <sub>(s)</sub> rhombic                      | 0                          | 0                          | 32                      |  | Zn <sub>(s)</sub>         | 0                          | 0                          | 402                     |
| S <sub>(s)</sub> clinic                       | 0.3                        | 0.1                        | 33                      |  | ZnO <sub>(s)</sub>        | -348                       | -318                       | 44                      |
| S <sup>2-</sup> <sub>(aq)</sub>               | 33                         | 86                         | -15                     |  | Zn(OH) <sub>2(s)</sub>    | -642                       |                            |                         |
| S <sub>8(g)</sub>                             | 102                        | 50                         | 431                     |  | ZnS <sub>(s)</sub> wurtz  | -193                       |                            |                         |
| SF <sub>6(g)</sub>                            | -1209                      | -1105                      | 292                     |  | ZnS <sub>(s)</sub> blende | -206                       | -201                       | 58                      |
| H <sub>2</sub> S <sub>(g)</sub>               | -21                        | -34                        | 206                     |  | ZnSO <sub>4(s)</sub>      | -983                       | -874                       | 120                     |
| SO <sub>2(g)</sub>                            | -297                       | -300                       | 248                     |  |                           |                            |                            |                         |
| SO <sub>3(g)</sub>                            | -396                       | -371                       | 257                     |  |                           |                            |                            |                         |
| SO <sub>4</sub> <sup>2-</sup> <sub>(aq)</sub> | -909                       | -745                       | 20                      |  |                           |                            |                            |                         |
| H <sub>2</sub> SO <sub>4(l)</sub>             | -814                       | -690                       | 157                     |  |                           |                            |                            |                         |
| H <sub>2</sub> SO <sub>4(aq)</sub>            | -909                       | -745                       | 20                      |  |                           |                            |                            |                         |
| <b>Tin</b>                                    |                            |                            |                         |  |                           |                            |                            |                         |
| Sn <sub>(s)</sub> (white)                     | 0                          | 0                          | 52                      |  |                           |                            |                            |                         |
| Sn <sub>(s)</sub> (gray)                      | -2                         | 0.1                        | 44                      |  |                           |                            |                            |                         |
| SnO <sub>(s)</sub>                            | -285                       | -257                       | 56                      |  |                           |                            |                            |                         |
| SnO <sub>2(s)</sub>                           | -581                       | -520                       | 52                      |  |                           |                            |                            |                         |
| Sn(OH) <sub>2(s)</sub>                        | -561                       | -492                       | 155                     |  |                           |                            |                            |                         |
| <b>Titanium</b>                               |                            |                            |                         |  |                           |                            |                            |                         |
| TiCl <sub>4(g)</sub>                          | -763                       | -727                       | 355                     |  |                           |                            |                            |                         |
| TiO <sub>2(s)</sub>                           | -945                       | -890                       | 50                      |  |                           |                            |                            |                         |
| <b>Uranium</b>                                |                            |                            |                         |  |                           |                            |                            |                         |
| U <sub>(s)</sub>                              | 0                          | 0                          | 50                      |  |                           |                            |                            |                         |
| UF <sub>6(s)</sub>                            | -2137                      | -2008                      | 228                     |  |                           |                            |                            |                         |
| UF <sub>6(g)</sub>                            | -2113                      | -2029                      | 380                     |  |                           |                            |                            |                         |
| UO <sub>2(s)</sub>                            | -1083                      | -1029                      | 78                      |  |                           |                            |                            |                         |
| U <sub>3</sub> O <sub>8(s)</sub>              | -3575                      | -3393                      | 282                     |  |                           |                            |                            |                         |
| UO <sub>3(s)</sub>                            | -1230                      | -1150                      | 99                      |  |                           |                            |                            |                         |
| <b>Xenon</b>                                  |                            |                            |                         |  |                           |                            |                            |                         |
| Xe <sub>(g)</sub>                             | 0                          | 0                          | 170                     |  |                           |                            |                            |                         |
| XeF <sub>2(g)</sub>                           | -108                       | -48                        | 254                     |  |                           |                            |                            |                         |
| XeF <sub>4(s)</sub>                           | -251                       | -121                       | 146                     |  |                           |                            |                            |                         |
| XeF <sub>6(g)</sub>                           | -294                       |                            |                         |  |                           |                            |                            |                         |
| XeO <sub>3(s)</sub>                           | 402                        |                            |                         |  |                           |                            |                            |                         |