



# Standard Specification for Methane Thermophysical Property Tables<sup>1</sup>

This standard is issued under the fixed designation D3956; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 The thermophysical property tables for methane are for use in the calculation of the pressure-volume-temperature (PVT), thermodynamic, and transport properties of methane for process design and operations. Tables are provided for gaseous and liquid methane at temperatures between 90 K and 600 K at pressures to 20 MPa. One table provides properties at the conditions of liquid-vapor equilibrium (saturation properties). The other table provides properties at selected  $T$ ,  $p$  points for the equilibrium phase at those conditions. The tables were developed by the National Institute of Standards and Technology from a Standard Reference Database product REFPROP, version 7.0.

## 2. Applicability

2.1 These tables apply directly only to pure gaseous methane. However, it is expected that they may find substantial use in mathematical models and tables for the thermophysical properties of mixtures containing methane.

## 3. Tables

3.1 *Thermophysical Properties of Coexisting Gaseous and Liquid Methane*, in SI units.

3.2 *Thermophysical Properties of Methane Along Isobars*, in SI units.

3.3 The tabulated properties are:

$\rho$  = molar density ( $\text{mol}\cdot\text{l}^{-1}$ )  
 $H$  = molar enthalpy ( $\text{J}\cdot\text{mol}^{-1}$ )  
 $S$  = molar entropy ( $\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$ )  
 $C_v$  = constant volume molar heat capacity ( $\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$ )  
 $C_p$  = constant pressure molar heat capacity ( $\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$ )  
 $c$  = speed of sound ( $\text{m}\cdot\text{s}^{-1}$ )  
 $\eta$  = viscosity ( $\mu\text{Pa}\cdot\text{s}$ )  
 $\lambda$  = thermal conductivity ( $\text{mW}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$ )

3.4 These tables were produced by equations from a computer package, “NIST Standard Reference Database 23; Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version 7.0.” A wide selection of units (SI units, engineering units, chemical units) and additional properties are available with this program.<sup>2</sup>

## 4. Additional Information

4.1 Reference state properties are required to calculate certain of the thermodynamic properties (enthalpy, entropy, etc.) from an equation of state formulation. The reference state properties used to generate the tables in this specification are: enthalpy,  $H$ , and entropy,  $S$ , at 298.15 K and 0.101325 MPa ( $H = 10018 \text{ J/mol}$  and  $S = 186.266 \text{ J/(mol K)}$ ). The molar mass of methane is 16.043 g/mol.

## 5. Keywords

5.1 methane gas tables; natural gas; thermodynamic properties of methane; transport properties of methane

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<sup>2</sup> Available from Standard Reference Data, National Institute of Standards and Technology (NIST), 100 Bureau Drive, Stop 3460, Gaithersburg, MD 20899.

**TABLE 1 Thermophysical Properties of Coexisting Gaseous and Liquid Methane**

| $T$<br>K | $p$<br>MPa | $\rho$<br>mol·l <sup>-1</sup> | $H$<br>J·mol <sup>-1</sup> | $S$<br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | $C_v$<br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | $C_p$<br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | $c$<br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|----------|------------|-------------------------------|----------------------------|---|---|---|--------------------------|-----------------|--|
| 90.70    | 0.011705   | 28.141                        | -15564                     | 9899.5                                      | 34.78   | 54.03   | 1538.5                   | 201.9           | 211.2  |
| 90.70    | 0.011705   | 0.015641                      | -6832.4                    | 9995.8                                      | 25.24   | 33.85   | 249.13                   | 3.609           | 8.792  |
| 92       | 0.013801   | 28.033                        | -15493                     | 9900.3                                      | 34.64   | 54.10   | 1526.7                   | 194.8           | 209.6  |
| 92       | 0.013801   | 0.018199                      | -6791.7                    | 9994.9                                      | 25.27   | 33.92   | 250.76                   | 3.658           | 8.949  |
| 94       | 0.017613   | 27.866                        | -15385                     | 9901.5                                      | 34.44   | 54.23   | 1508.4                   | 184.4           | 207.2  |
| 94       | 0.017613   | 0.02277                       | -6729.6                    | 9993.5                                      | 25.32   | 34.02   | 253.2                    | 3.732           | 9.192  |
| 96       | 0.022233   | 27.698                        | -15276                     | 9902.6                                      | 34.26   | 54.37   | 1489.8                   | 174.7           | 204.7  |
| 96       | 0.022233   | 0.028198                      | -6668.2                    | 9992.3                                      | 25.37   | 34.14   | 255.57                   | 3.808           | 9.438  |
| 98       | 0.027778   | 27.528                        | -15167                     | 9903.7                                      | 34.08   | 54.52   | 1471.0                   | 165.6           | 202.2  |
| 98       | 0.027778   | 0.034587                      | -6607.4                    | 9991.1                                      | 25.43   | 34.28   | 257.87                   | 3.883           | 9.687  |
| 100      | 0.034376   | 27.357                        | -15058                     | 9904.8                                      | 33.91   | 54.68   | 1452.0                   | 157.2           | 199.6  |
| 100      | 0.034376   | 0.042048                      | -6547.5                    | 9989.9                                      | 25.49   | 34.42   | 260.09                   | 3.960           | 9.939  |
| 102      | 0.042160   | 27.185                        | -14948                     | 9905.9                                      | 33.74   | 54.85   | 1432.9                   | 149.3           | 197.0  |
| 102      | 0.042160   | 0.050695                      | -6488.4                    | 9988.9                                      | 25.55   | 34.58   | 262.24                   | 4.036           | 10.19  |
| 104      | 0.051275   | 27.010                        | -14838                     | 9907.0                                      | 33.58   | 55.04   | 1413.6                   | 141.9           | 194.3  |
| 104      | 0.051275   | 0.060649                      | -6430.3                    | 9987.8                                      | 25.62   | 34.76   | 264.31                   | 4.114           | 10.46  |
| 106      | 0.061868   | 26.835                        | -14728                     | 9908.0                                      | 33.42   | 55.23   | 1394.1                   | 135.0           | 191.6  |
| 106      | 0.061868   | 0.072034                      | -6373.1                    | 9986.9                                      | 25.69   | 34.95   | 266.29                   | 4.192           | 10.72  |
| 108      | 0.074099   | 26.657                        | -14617                     | 9909.1                                      | 33.27   | 55.44   | 1374.5                   | 128.6           | 188.8  |
| 108      | 0.074099   | 0.08498                       | -6316.9                    | 9985.9                                      | 25.76   | 35.16   | 268.20                   | 4.270           | 10.99  |
| 110      | 0.08813    | 26.478                        | -14505                     | 9910.1                                      | 33.12   | 55.67   | 1354.7                   | 122.7           | 186.1  |
| 110      | 0.08813    | 0.099622                      | -6261.8                    | 9985.0                                      | 25.84   | 35.38   | 270.01                   | 4.349           | 11.26  |
| 112      | 0.10413    | 26.297                        | -14393                     | 9911.1                                      | 32.97   | 55.88   | 1334.8                   | 117.0           | 183.3  |
| 112      | 0.10413    | 0.1161                        | -6207.9                    | 9984.2                                      | 25.92   | 35.62   | 271.75                   | 4.429           | 11.54  |
| 114      | 0.12228    | 26.113                        | -14281                     | 9912.1                                      | 32.82   | 56.13   | 1314.7                   | 111.7           | 180.5  |
| 114      | 0.12228    | 0.13455                       | -6155.2                    | 9983.4                                      | 26.01   | 35.88   | 273.39                   | 4.510           | 11.82  |
| 116      | 0.14275    | 25.928                        | -14168                     | 9913.1                                      | 32.68   | 56.38   | 1294.4                   | 106.8           | 177.7  |
| 116      | 0.14275    | 0.15514                       | -6103.8                    | 9982.6                                      | 26.10   | 36.16   | 274.94                   | 4.591           | 12.11  |
| 118      | 0.16574    | 25.740                        | -14054                     | 9914.0                                      | 32.54   | 56.65   | 1274.0                   | 102.2           | 174.9  |
| 118      | 0.16574    | 0.17801                       | -6053.8                    | 9981.8                                      | 26.20   | 36.46   | 276.4                    | 4.674           | 12.41  |
| 120      | 0.19143    | 25.551                        | -13940                     | 9915.0                                      | 32.40   | 56.94   | 1253.5                   | 97.91           | 172.0  |
| 120      | 0.19143    | 0.20332                       | -6005.2                    | 9981.1                                      | 26.30   | 36.79   | 277.76                   | 4.757           | 12.71  |
| 122      | 0.22002    | 25.358                        | -13825                     | 9915.9                                      | 32.26   | 57.25   | 1232.7                   | 93.87           | 169.2  |
| 122      | 0.22002    | 0.23125                       | -5958.1                    | 9980.4                                      | 26.40   | 37.14   | 279.03                   | 4.841           | 13.02  |
| 124      | 0.2517     | 25.163                        | -13710                     | 9916.8                                      | 32.13   | 57.57   | 1211.9                   | 90.07           | 166.4  |
| 124      | 0.2517     | 0.26197                       | -5912.6                    | 9979.7                                      | 26.50   | 37.51   | 280.21                   | 4.926           | 13.33  |
| 126      | 0.28667    | 24.966                        | -13594                     | 9917.8                                      | 32.00   | 57.92   | 1190.8                   | 86.50           | 163.5  |
| 126      | 0.28667    | 0.29567                       | -5868.7                    | 9979.1                                      | 26.62   | 37.92   | 281.28                   | 5.012           | 13.66  |
| 128      | 0.32514    | 24.765                        | -13477                     | 9918.7                                      | 31.88   | 58.29   | 1169.5                   | 83.13           | 160.6  |
| 128      | 0.32514    | 0.33254                       | -5826.6                    | 9978.4                                      | 26.73   | 38.36   | 282.25                   | 5.100           | 13.99  |
| 130      | 0.36732    | 24.562                        | -13359                     | 9919.6                                      | 31.76   | 58.68   | 1148.1                   | 79.95           | 157.8  |
| 130      | 0.36732    | 0.37278                       | -5786.3                    | 9977.8                                      | 26.85   | 38.84   | 283.13                   | 5.188           | 14.33  |
| 132      | 0.41341    | 24.355                        | -13240                     | 9920.5                                      | 31.64   | 59.11   | 1126.4                   | 76.94           | 154.9  |
| 132      | 0.41341    | 0.41662                       | -5747.8                    | 9977.2                                      | 26.98   | 39.35   | 283.90                   | 5.278           | 14.69  |
| 134      | 0.46363    | 24.145                        | -13121                     | 9921.3                                      | 31.52   | 59.57   | 1104.6                   | 74.09           | 152.1  |
| 134      | 0.46363    | 0.46428                       | -5711.4                    | 9976.6                                      | 27.11   | 39.91   | 284.57                   | 5.370           | 15.05  |
| 136      | 0.51819    | 23.931                        | -13000                     | 9922.2                                      | 31.41   | 60.06   | 1082.5                   | 71.39           | 149.2  |

**TABLE 1** *Continued*

| <i>T</i><br>K | <i>p</i><br>MPa | $\rho$<br>mol·l <sup>-1</sup> | <i>H</i><br>J·mol <sup>-1</sup> | <i>S</i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>v</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>p</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>c</i><br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|---------------|-----------------|-------------------------------|---------------------------------|--|--|--|-------------------------------|-----------------|--|
| 136           | 0.51819         | 0.51601                       | -5677.0                         | 9976.1   | 27.25  | 40.51  | 285.13                        | 5.464           | 15.42  |
| 138           | 0.57730         | 23.713                        | -12879                          | 9923.1   | 31.308   | 60.59  | 1060.2                        | 68.82           | 146.4  |
| 138           | 0.57730         | 0.57209                       | -5644.8                         | 9975.5   | 27.397   | 41.17  | 285.58                        | 5.559           | 15.81  |
| 140           | 0.64118         | 23.491                        | -12756                          | 9923.9   | 31.206   | 61.17  | 1037.7                        | 66.37           | 143.5  |
| 140           | 0.64118         | 0.63279                       | -5615.0                         | 9975.0   | 27.549   | 41.88  | 285.93                        | 5.656           | 16.21  |
| 142           | 0.71006         | 23.265                        | -12632                          | 9924.8   | 31.109   | 61.80  | 1014.9                        | 64.04           | 140.7  |
| 142           | 0.71006         | 0.69843                       | -5587.5                         | 9974.4   | 27.709   | 42.67  | 286.16                        | 5.756           | 16.62  |
| 144           | 0.78415         | 23.034                        | -12507                          | 9925.7   | 31.018   | 62.48  | 991.81                        | 61.81           | 137.8  |
| 144           | 0.78415         | 0.76935                       | -5562.6                         | 9973.9   | 27.877   | 43.52  | 286.29                        | 5.858           | 17.05  |
| 146           | 0.86368         | 22.798                        | -12381                          | 9926.5   | 30.932   | 63.22  | 968.46                        | 59.67           | 135.0  |
| 146           | 0.86368         | 0.84593                       | -5540.3                         | 9973.4   | 28.054   | 44.47  | 286.30                        | 5.962           | 17.50  |
| 148           | 0.94887         | 22.556                        | -12253                          | 9927.3   | 30.852   | 64.04  | 944.81                        | 57.62           | 132.1  |
| 148           | 0.94887         | 0.92857                       | -5520.9                         | 9972.8   | 28.241   | 45.51  | 286.19                        | 6.070           | 17.96  |
| 150           | 1.0400          | 22.309                        | -12123                          | 9928.2   | 30.78  | 64.93  | 920.85                        | 55.64           | 129.3  |
| 150           | 1.0400          | 1.0177                        | -5504.5                         | 9972.3   | 28.439   | 46.66  | 285.97                        | 6.181           | 18.45  |
| 152           | 1.1372          | 22.055                        | -11992                          | 9929.0   | 30.714   | 65.92  | 896.54                        | 53.74           | 126.4  |
| 152           | 1.1372          | 1.1140                        | -5491.3                         | 9971.8   | 28.649   | 47.94  | 285.63                        | 6.296           | 18.95  |
| 154           | 1.2408          | 21.794                        | -11859                          | 9929.9   | 30.656   | 67.02  | 871.87                        | 51.90           | 123.6  |
| 154           | 1.2408          | 1.2178                        | -5481.5                         | 9971.3   | 28.872   | 49.36  | 285.16                        | 6.415           | 19.49  |
| 156           | 1.3509          | 21.526                        | -11724                          | 9930.7   | 30.608   | 68.24  | 846.82                        | 50.12           | 120.8  |
| 156           | 1.3509          | 1.3299                        | -5475.3                         | 9970.8   | 29.110   | 50.97  | 284.57                        | 6.538           | 20.05  |
| 158           | 1.4680          | 21.249                        | -11587                          | 9931.5   | 30.569   | 69.61  | 821.35                        | 48.39           | 117.9  |
| 158           | 1.4680          | 1.4511                        | -5473.0                         | 9970.2   | 29.363   | 52.78  | 283.86                        | 6.667           | 20.65  |
| 160           | 1.5921          | 20.964                        | -11447                          | 9932.4   | 30.541   | 71.16  | 795.43                        | 46.71           | 115.0  |
| 160           | 1.5921          | 1.5821                        | -5475.0                         | 9969.7   | 29.636   | 54.85  | 283.01                        | 6.802           | 21.28  |
| 162           | 1.7235          | 20.668                        | -11305                          | 9933.2   | 30.526   | 72.91  | 769.03                        | 45.07           | 112.2  |
| 162           | 1.7235          | 1.7241                        | -5481.6                         | 9969.2   | 29.928   | 57.22  | 282.03                        | 6.943           | 21.96  |
| 164           | 1.8626          | 20.360                        | -11160                          | 9934.1   | 30.525   | 74.92  | 742.10                        | 43.46           | 109.3  |
| 164           | 1.8626          | 1.8782                        | -5493.1                         | 9968.6   | 30.244   | 59.96  | 280.91                        | 7.093           | 22.70  |
| 166           | 2.0096          | 20.040                        | -11011                          | 9934.9   | 30.541   | 77.25  | 714.59                        | 41.89           | 106.4  |
| 166           | 2.0096          | 2.0459                        | -5510.2                         | 9968.1   | 30.588   | 63.16  | 279.65                        | 7.252           | 23.49  |
| 168           | 2.1647          | 19.706                        | -10859                          | 9935.8   | 30.576   | 79.98  | 686.42                        | 40.33           | 103.5  |
| 168           | 2.1647          | 2.2289                        | -5533.5                         | 9967.5   | 30.962   | 66.96  | 278.23                        | 7.421           | 24.36  |
| 170           | 2.3283          | 19.355                        | -10702                          | 9936.7   | 30.634   | 83.22  | 657.52                        | 38.80           | 100.6  |
| 170           | 2.3283          | 2.4294                        | -5563.7                         | 9966.9   | 31.374   | 71.53  | 276.66                        | 7.604           | 25.34  |
| 172           | 2.5007          | 18.984                        | -10541                          | 9937.6   | 30.721   | 87.13  | 627.77                        | 37.27           | 97.63  |
| 172           | 2.5007          | 2.6500                        | -5601.7                         | 9966.3   | 31.829   | 77.11  | 274.93                        | 7.801           | 26.43  |
| 174           | 2.6822          | 18.591                        | -10374                          | 9938.5   | 30.843   | 91.95  | 597.05                        | 35.74           | 94.65  |
| 174           | 2.6822          | 2.8944                        | -5648.8                         | 9965.6   | 32.337   | 84.09  | 273.02                        | 8.018           | 27.69  |
| 176           | 2.8732          | 18.170                        | -10200                          | 9939.4   | 31.011   | 98.06  | 565.18                        | 34.20           | 91.65  |
| 176           | 2.8732          | 3.1671                        | -5706.6                         | 9964.9   | 32.912   | 93.05  | 270.92                        | 8.258           | 29.17  |
| 178           | 3.0740          | 17.716                        | -10017                          | 9940.4   | 31.24  | 106.0  | 531.94                        | 32.65           | 88.63  |
| 178           | 3.0740          | 3.4744                        | -5777.2                         | 9964.2   | 33.57  | 105.0  | 268.60                        | 8.528           | 30.97  |
| 180           | 3.2852          | 17.218                        | -9824.6                         | 9941.4   | 31.554   | 117.0  | 497.01                        | 31.05           | 85.60  |
| 180           | 3.2852          | 3.8257                        | -5863.9                         | 9963.4   | 34.338   | 121.5  | 266.04                        | 8.837           | 33.23  |
| 182           | 3.5071          | 16.664                        | -9618.3                         | 9942.5   | 31.996   | 132.9  | 459.94                        | 29.39           | 82.60  |
| 182           | 3.5071          | 4.2349                        | -5971.3                         | 9962.5   | 35.257   | 146.0  | 263.17                        | 9.201           | 36.23  |
| 184           | 3.7405          | 16.028                        | -9392.8                         | 9943.6   | 32.641   | 158.5  | 420.00                        | 27.62           | 79.73  |
| 184           | 3.7405          | 4.7255                        | -6107.3                         | 9961.5   | 36.397   | 186.0  | 259.89                        | 9.646           | 40.50  |

**TABLE 1** *Continued*

| <i>T</i><br>K | $\rho$<br>MPa | $\rho$<br>mol·l <sup>-1</sup> | <i>H</i><br>J·mol <sup>-1</sup> | <i>S</i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>V</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>P</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>c</i><br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|---------------|---------------|-------------------------------|---------------------------------|--|--|--|-------------------------------|-----------------|--|
| 186           | 3.9860        | 15.267                        | -9137.8                         | 9944.9   | 33.654   | 206.7  | 375.88                        | 25.66           | 77.32  |
| 186           | 3.9860        | 5.3422                        | -6286.8                         | 9960.2   | 37.893   | 262.0  | 255.97                        | 10.22           | 47.31  |
| 188           | 4.2448        | 14.270                        | -8828.0                         | 9946.5   | 35.503   | 332.7  | 324.57                        | 23.34           | 76.72  |
| 188           | 4.2448        | 6.1945                        | -6545.2                         | 9958.6   | 40.109   | 461.6  | 250.72                        | 11.06           | 60.74  |
| 190           | 4.5186        | 12.515                        | -8343.5                         | 9948.9   | 41.746   | 1508.  | 250.31                        | 19.78           | 95.22  |
| 190           | 4.5186        | 7.8027                        | -7047.8                         | 9955.7   | 45.796   | 2259.  | 238.55                        | 12.80           | 117.1  |

**TABLE 2 Thermophysical Properties of Methane Along Isobars**

| <i>T</i><br>K      | $\rho$<br>mol·l <sup>-1</sup> | <i>H</i><br>J·mol <sup>-1</sup> | <i>S</i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>V</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>P</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>c</i><br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|--------------------|-------------------------------|---------------------------------|--|--|--|-------------------------------|-----------------|--|
| Pressure = 0.1 MPa |                               |                                 |  |  |  |                               |                 |  |
| 92                 | 28.037                        | -5659.5                         | 68.57  | 34.64  | 54.09  | 1527.3                        | 209.7           | 194.9  |
| 100                | 27.360                        | -5224.6                         | 73.10  | 33.91  | 54.67  | 1452.6                        | 199.7           | 157.3  |
| 110                | 26.478                        | -4673.2                         | 78.36  | 33.12  | 55.65  | 1354.8                        | 186.1           | 122.6  |
| 111.51             | 26.341                        | -4589.1                         | 79.11  | 33.00  | 55.83  | 1339.7                        | 184.0           | 118.3  |
| 111.51             | 0.11186                       | 3610.7                          | 152.65   | 25.90  | 35.56  | 271.33                        | 11.47           | 4.410  |
| 120                | 0.10316                       | 3909.4                          | 155.23   | 25.57  | 34.88  | 282.84                        | 12.40           | 4.733  |
| 130                | 0.094632                      | 4255.8                          | 158.00   | 25.36  | 34.43  | 295.56                        | 13.55           | 5.116  |
| 140                | 0.087479                      | 4598.5                          | 160.54   | 25.25  | 34.15  | 307.59                        | 14.71           | 5.499  |
| 150                | 0.081375                      | 4939.1                          | 162.89   | 25.19  | 33.97  | 319.04                        | 15.89           | 5.881  |
| 160                | 0.076095                      | 5278.2                          | 165.08   | 25.15  | 33.86  | 330.01                        | 17.06           | 6.261  |
| 170                | 0.071476                      | 5616.4                          | 167.13   | 25.15  | 33.79  | 340.55                        | 18.24           | 6.639  |
| 180                | 0.067399                      | 5954.1                          | 169.06   | 25.16  | 33.76  | 350.71                        | 19.43           | 7.014  |
| 190                | 0.063770                      | 6291.6                          | 170.89   | 25.20  | 33.75  | 360.51                        | 20.63           | 7.385  |
| 200                | 0.060518                      | 6629.3                          | 172.62   | 25.26  | 33.78  | 369.98                        | 21.78           | 7.753  |
| 210                | 0.057586                      | 6967.4                          | 174.27   | 25.34  | 33.84  | 379.14                        | 22.95           | 8.116  |
| 220                | 0.054929                      | 7306.3                          | 175.85   | 25.46  | 33.94  | 388.01                        | 24.14           | 8.476  |
| 230                | 0.052508                      | 7646.2                          | 177.36   | 25.60  | 34.06  | 396.60                        | 25.34           | 8.831  |
| 240                | 0.050295                      | 7987.6                          | 178.81   | 25.78  | 34.22  | 404.91                        | 26.56           | 9.182  |
| 250                | 0.048261                      | 8330.8                          | 180.21   | 25.98  | 34.41  | 412.96                        | 27.80           | 9.528  |
| 260                | 0.046387                      | 8676.0                          | 181.57   | 26.22  | 34.64  | 420.77                        | 29.06           | 9.870  |
| 270                | 0.044655                      | 9023.7                          | 182.88   | 26.49  | 34.90  | 428.34                        | 30.35           | 10.21  |
| 280                | 0.043047                      | 9374.1                          | 184.15   | 26.79  | 35.19  | 435.68                        | 31.67           | 10.54  |
| 290                | 0.041552                      | 9727.6                          | 185.39   | 27.12  | 35.52  | 442.81                        | 33.02           | 10.87  |
| 300                | 0.040158                      | 10085                           | 186.60   | 27.48  | 35.87  | 449.74                        | 34.39           | 11.20  |
| 320                | 0.037635                      | 10810                           | 188.94   | 28.28  | 36.66  | 463.05                        | 37.25           | 11.84  |
| 340                | 0.035411                      | 11552                           | 191.19   | 29.18  | 37.55  | 475.7                         | 40.24           | 12.46  |
| 360                | 0.033436                      | 12312                           | 193.36   | 30.16  | 38.52  | 487.79                        | 43.36           | 13.07  |
| 380                | 0.031670                      | 13093                           | 195.47   | 31.20  | 39.56  | 499.38                        | 46.62           | 13.66  |
| 400                | 0.030082                      | 13895                           | 197.53   | 32.30  | 40.65  | 510.56                        | 50.00           | 14.24  |
| 420                | 0.028646                      | 14719                           | 199.54   | 33.44  | 41.79  | 521.38                        | 53.50           | 14.81  |
| 440                | 0.027341                      | 15566                           | 201.51   | 34.60  | 42.95  | 531.88                        | 57.11           | 15.36  |
| 460                | 0.026150                      | 16437                           | 203.45   | 35.79  | 44.13  | 542.11                        | 60.82           | 15.91  |
| 480                | 0.025059                      | 17332                           | 205.35   | 36.99  | 45.33  | 552.09                        | 64.62           | 16.44  |
| 500                | 0.024055                      | 18250                           | 207.23   | 38.20  | 46.53  | 561.86                        | 68.50           | 16.96  |
| 520                | 0.023129                      | 19193                           | 209.07   | 39.40  | 47.74  | 571.43                        | 72.46           | 17.48  |
| 540                | 0.022271                      | 20160                           | 210.90   | 40.61  | 48.94  | 580.82                        | 76.49           | 17.98  |
| 560                | 0.021475                      | 21151                           | 212.70   | 41.81  | 50.14  | 590.04                        | 80.58           | 18.47  |
| 580                | 0.020734                      | 22165                           | 214.48   | 43.00  | 51.33  | 599.11                        | 84.73           | 18.96  |
| 600                | 0.020042                      | 23204                           | 216.24   | 44.18  | 52.51  | 608.04                        | 88.93           | 19.44  |
| Pressure = 1 MPa   |                               |                                 |  |  |  |                               |                 |  |
| 92                 | 28.074                        | -5636.1                         | 68.47  | 34.682   | 54.010   | 1533.5                        | 210.52          | 196.8  |
| 100                | 27.403                        | -5202                           | 73.00  | 33.95  | 54.562   | 1459.6                        | 200.54          | 158.9  |
| 110                | 26.529                        | -4651.9                         | 78.24  | 33.156   | 55.497   | 1363.2                        | 187.09          | 123.9  |
| 120                | 25.606                        | -4091.1                         | 83.12  | 32.437   | 56.733   | 1262.4                        | 173.04          | 98.95  |
| 130                | 24.616                        | -3515.7                         | 87.72  | 31.786   | 58.434   | 1156.6                        | 158.68          | 80.68  |
| 140                | 23.532                        | -2919.7                         | 92.14  | 31.220   | 60.937   | 1043.7                        | 144.11          | 66.77  |
| 149.14             | 22.416                        | -2347.7                         | 96.10  | 30.810   | 64.535   | 931.21                        | 130.52          | 56.48  |
| 149.14             | 0.97852                       | 4320.6                          | 140.81   | 28.353   | 46.147   | 286.08                        | 18.237          | 6.132  |
| 150                | 0.96844                       | 4360                            | 141.07   | 28.165   | 45.565   | 287.76                        | 18.267          | 6.163  |
| 160                | 0.8705                        | 4792.5                          | 143.86   | 26.991   | 41.516   | 305.18                        | 18.873          | 6.5221   |
| 170                | 0.79596                       | 5196.6                          | 146.31   | 26.470   | 39.472   | 320.20                        | 19.747          | 6.8835   |
| 180                | 0.73599                       | 5584.4                          | 148.53   | 26.161   | 38.186   | 333.74                        | 20.758          | 7.2449   |
| 190                | 0.68611                       | 5961.7                          | 150.57   | 25.976   | 37.322   | 346.20                        | 21.909          | 7.6048   |

**TABLE 2** *Continued*

| <i>T</i><br>K    | $\rho$<br>mol·l <sup>-1</sup> | <i>H</i><br>J·mol <sup>-1</sup> | <i>S</i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>v</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>p</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>c</i><br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|------------------|-------------------------------|---------------------------------|--|--|--|-------------------------------|-----------------|--|
| 200              | 0.64363                       | 6331.7                          | 152.47   | 25.879   | 36.730   | 357.81                        | 22.869          | 7.9624   |
| 210              | 0.60682                       | 6696.9                          | 154.25   | 25.850   | 36.325   | 368.73                        | 23.941          | 8.3172   |
| 220              | 0.5745                        | 7058.7                          | 155.93   | 25.878   | 36.060   | 379.06                        | 25.053          | 8.6686   |
| 230              | 0.54581                       | 7418.4                          | 157.53   | 25.956   | 35.903   | 388.88                        | 26.194          | 9.0166   |
| 240              | 0.52011                       | 7777.1                          | 159.06   | 26.078   | 35.834   | 398.24                        | 27.362          | 9.3608   |
| 250              | 0.49693                       | 8135.4                          | 160.52   | 26.242   | 35.840   | 407.20                        | 28.558          | 9.7012   |
| 260              | 0.47587                       | 8494.1                          | 161.93   | 26.446   | 35.911   | 415.79                        | 29.782          | 10.038   |
| 270              | 0.45665                       | 8853.8                          | 163.29   | 26.688   | 36.040   | 424.04                        | 31.036          | 10.370   |
| 280              | 0.43902                       | 9215.1                          | 164.6  | 26.966   | 36.221   | 431.98                        | 32.322          | 10.699   |
| 290              | 0.42278                       | 9578.4                          | 165.88   | 27.277   | 36.450   | 439.64                        | 33.641          | 11.024   |
| 300              | 0.40776                       | 9944.2                          | 167.12   | 27.621   | 36.721   | 447.04                        | 34.994          | 11.345   |
| 320              | 0.38084                       | 10685                           | 169.51   | 28.397   | 37.376   | 461.13                        | 37.805          | 11.976   |
| 340              | 0.35738                       | 11440                           | 171.79   | 29.275   | 38.160   | 474.42                        | 40.757          | 12.592   |
| 360              | 0.33674                       | 12212                           | 174.00   | 30.239   | 39.048   | 487.02                        | 43.85           | 13.193   |
| 380              | 0.31842                       | 13003                           | 176.14   | 31.272   | 40.019   | 499.04                        | 47.078          | 13.781   |
| 400              | 0.30205                       | 13813                           | 178.22   | 32.360   | 41.056   | 510.57                        | 50.434          | 14.357   |
| 420              | 0.28731                       | 14645                           | 180.25   | 33.489   | 42.143   | 521.69                        | 53.91           | 14.919   |
| 440              | 0.27397                       | 15499                           | 182.23   | 34.650   | 43.268   | 532.44                        | 57.498          | 15.470   |
| 460              | 0.26184                       | 16376                           | 184.18   | 35.831   | 44.418   | 542.89                        | 61.187          | 16.010   |
| 480              | 0.25075                       | 17276                           | 186.1  | 37.025   | 45.587   | 553.06                        | 64.969          | 16.539   |
| 500              | 0.24058                       | 18200                           | 187.98   | 38.227   | 46.766   | 562.99                        | 68.837          | 17.058   |
| 520              | 0.23121                       | 19147                           | 189.84   | 39.431   | 47.950   | 572.7                         | 72.782          | 17.568   |
| 540              | 0.22255                       | 20118                           | 191.67   | 40.633   | 49.135   | 582.21                        | 76.799          | 18.068   |
| 560              | 0.21453                       | 21112                           | 193.48   | 41.830   | 50.316   | 591.55                        | 80.88           | 18.559   |
| 580              | 0.20707                       | 22130                           | 195.26   | 43.019   | 51.492   | 600.71                        | 85.019          | 19.043   |
| 600              | 0.20012                       | 23172                           | 197.03   | 44.198   | 52.659   | 609.73                        | 89.212          | 19.518   |
| Pressure = 2 MPa |                               |                                 |  |  |  |                               |                 |  |
| 92               | 28.115                        | -5610.1                         | 68.368   | 34.722   | 53.921   | 1540.4                        | 211.41          | 198.86   |
| 100              | 27.45                         | -5176.8                         | 72.884   | 33.992   | 54.445   | 1467.4                        | 201.51          | 160.67   |
| 110              | 26.585                        | -4628.1                         | 78.113   | 33.201   | 55.329   | 1372.3                        | 188.17          | 125.43   |
| 120              | 25.674                        | -4069.3                         | 82.975   | 32.483   | 56.489   | 1273.3                        | 174.25          | 100.24   |
| 130              | 24.701                        | -3497                           | 87.555   | 31.831   | 58.063   | 1169.7                        | 160.05          | 81.838   |
| 140              | 23.641                        | -2905.8                         | 91.935   | 31.258   | 60.331   | 1060.1                        | 145.69          | 67.873   |
| 150              | 22.453                        | -2286.2                         | 96.209   | 30.798   | 63.871   | 941.45                        | 131.13          | 56.73  |
| 160              | 21.055                        | -1619.4                         | 100.51   | 30.526   | 70.193   | 807.65                        | 116.04          | 47.234   |
| 165.87           | 20.061                        | -1188.9                         | 103.15   | 30.539   | 77.093   | 716.36                        | 106.6           | 41.986   |
| 165.87           | 2.0348                        | 4322.7                          | 136.38   | 30.565   | 62.944   | 279.73                        | 23.439          | 7.2413   |
| 170              | 1.9032                        | 4565.8                          | 137.83   | 29.192   | 55.613   | 290.52                        | 23.12           | 7.3450   |
| 180              | 1.6770                        | 5075.7                          | 140.74   | 27.775   | 47.612   | 311.34                        | 23.20           | 7.6356   |
| 190              | 1.5180                        | 5531.1                          | 143.21   | 27.121   | 43.836   | 328.4                         | 23.954          | 7.9508   |
| 200              | 1.3957                        | 5957.4                          | 145.39   | 26.741   | 41.587   | 343.3                         | 24.45           | 8.2763   |
| 210              | 1.2969                        | 6365.5                          | 147.39   | 26.521   | 40.122   | 356.7                         | 25.308          | 8.6065   |
| 220              | 1.2143                        | 6761.4                          | 149.23   | 26.415   | 39.129   | 368.98                        | 26.274          | 8.9382   |
| 230              | 1.1437                        | 7149.1                          | 150.95   | 26.394   | 38.447   | 380.37                        | 27.305          | 9.2697   |
| 240              | 1.0823                        | 7531.1                          | 152.58   | 26.443   | 37.986   | 391.03                        | 28.386          | 9.6000   |
| 250              | 1.0283                        | 7909.3                          | 154.12   | 26.552   | 37.689   | 401.07                        | 29.51           | 9.9284   |
| 260              | 0.98014                       | 8285.3                          | 155.60   | 26.712   | 37.521   | 410.57                        | 30.673          | 10.254   |
| 270              | 0.93689                       | 8660.1                          | 157.01   | 26.919   | 37.457   | 419.61                        | 31.875          | 10.578   |
| 280              | 0.89775                       | 9034.7                          | 158.37   | 27.168   | 37.48  | 428.22                        | 33.116          | 10.898   |
| 290              | 0.8621                        | 9409.9                          | 159.69   | 27.457   | 37.576   | 436.47                        | 34.395          | 11.215   |
| 300              | 0.82945                       | 9786.5                          | 160.97   | 27.781   | 37.736   | 444.38                        | 35.713          | 11.529   |
| 320              | 0.77164                       | 10546                           | 163.42   | 28.526   | 38.215   | 459.34                        | 38.463          | 12.147   |
| 340              | 0.72194                       | 11316                           | 165.75   | 29.382   | 38.865   | 473.3                         | 41.365          | 12.753   |
| 360              | 0.67864                       | 12101                           | 167.99   | 30.328   | 39.650   | 486.45                        | 44.415          | 13.345   |
| 380              | 0.64052                       | 12903                           | 170.16   | 31.348   | 40.540   | 498.91                        | 47.607          | 13.925   |
| 400              | 0.60667                       | 13723                           | 172.27   | 32.425   | 41.511   | 510.82                        | 50.931          | 14.493   |
| 420              | 0.57636                       | 14564                           | 174.32   | 33.546   | 42.544   | 522.24                        | 54.38           | 15.050   |
| 440              | 0.54905                       | 15425                           | 176.32   | 34.699   | 43.624   | 533.26                        | 57.942          | 15.595   |
| 460              | 0.52431                       | 16309                           | 178.28   | 35.874   | 44.736   | 543.93                        | 61.609          | 16.129   |
| 480              | 0.50176                       | 17215                           | 180.21   | 37.064   | 45.873   | 554.3                         | 65.371          | 16.654   |
| 500              | 0.48113                       | 18144                           | 182.11   | 38.261   | 47.024   | 564.39                        | 69.221          | 17.168   |
| 520              | 0.46218                       | 19096                           | 183.97   | 39.462   | 48.185   | 574.25                        | 73.150          | 17.673   |
| 540              | 0.4447                        | 20071                           | 185.81   | 40.660   | 49.349   | 583.89                        | 77.152          | 18.170   |
| 560              | 0.42852                       | 21070                           | 187.63   | 41.854   | 50.512   | 593.33                        | 81.219          | 18.658   |
| 580              | 0.4135                        | 22092                           | 189.42   | 43.041   | 51.672   | 602.59                        | 85.345          | 19.138   |
| 600              | 0.39951                       | 23137                           | 191.19   | 44.218   | 52.825   | 611.69                        | 89.526          | 19.610   |
| Pressure = 3 MPa |                               |                                 |  |  |  |                               |                 |  |
| 92               | 28.156                        | -5584.1                         | 68.265   | 34.762   | 53.835   | 1547.1                        | 212.29          | 200.94   |
| 100              | 27.496                        | -5151.6                         | 72.773   | 34.034   | 54.331   | 1475                          | 202.47          | 162.48   |
| 110              | 26.64                         | -4604.2                         | 77.989   | 33.245   | 55.169   | 1381.2                        | 189.24          | 126.93   |
| 120              | 25.74                         | -4047.3                         | 82.834   | 32.528   | 56.258   | 1283.8                        | 175.44          | 101.53   |

**TABLE 2** *Continued*

| <i>T</i><br>K      | $\rho$<br>mol·l <sup>-1</sup> | <i>H</i><br>J·mol <sup>-1</sup> | <i>S</i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>v</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>p</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>c</i><br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|--------------------|-------------------------------|---------------------------------|--|--|--|-------------------------------|-----------------|--|
| 130                | 24.783                        | -3477.9                         | 87.391   | 31.876   | 57.717   | 1182.4                        | 161.39          | 82.990   |
| 140                | 23.746                        | -2891.0                         | 91.739   | 31.298   | 59.781   | 1075.8                        | 147.24          | 68.960   |
| 150                | 22.595                        | -2278.7                         | 95.962   | 30.823   | 62.908   | 961.61                        | 132.96          | 57.829   |
| 160                | 21.264                        | -1625.9                         | 100.17   | 30.505   | 68.179   | 835.51                        | 118.36          | 48.460   |
| 170                | 19.6                          | -897.08                         | 104.59   | 30.508   | 79.233   | 687.08                        | 102.8           | 39.876   |
| 177.27             | 17.885                        | -252.81                         | 108.3  | 31.148   | 102.88   | 544.18                        | 89.73           | 33.215   |
| 177.27             | 3.3584                        | 4081.8                          | 132.75   | 33.320   | 100.21   | 269.47                        | 30.274          | 8.4260   |
| 180                | 3.1212                        | 4324.3                          | 134.11   | 31.392   | 80.386   | 280.27                        | 28.92           | 8.3937   |
| 190                | 2.6146                        | 4985.2                          | 137.68   | 28.798   | 57.334   | 307.50                        | 27.623          | 8.5024   |
| 200                | 2.3157                        | 5515.5                          | 140.41   | 27.846   | 49.701   | 327.51                        | 26.805          | 8.7291   |
| 210                | 2.1029                        | 5990.8                          | 142.73   | 27.328   | 45.725   | 344.24                        | 27.167          | 8.9979   |
| 220                | 1.9386                        | 6435.0                          | 144.79   | 27.032   | 43.298   | 358.90                        | 27.841          | 9.2869   |
| 230                | 1.8054                        | 6859.5                          | 146.68   | 26.883   | 41.704   | 372.09                        | 28.674          | 9.5864   |
| 240                | 1.694                         | 7270.8                          | 148.43   | 26.840   | 40.619   | 384.17                        | 29.611          | 9.8916   |
| 250                | 1.5987                        | 7673.0                          | 150.07   | 26.881   | 39.875   | 395.36                        | 30.623          | 10.199   |
| 260                | 1.5157                        | 8069.1                          | 151.63   | 26.990   | 39.373   | 405.81                        | 31.697          | 10.508   |
| 270                | 1.4425                        | 8461.1                          | 153.11   | 27.157   | 39.051   | 415.63                        | 32.825          | 10.817   |
| 280                | 1.3772                        | 8850.6                          | 154.52   | 27.375   | 38.870   | 424.92                        | 34.004          | 11.125   |
| 290                | 1.3185                        | 9238.9                          | 155.89   | 27.638   | 38.802   | 433.75                        | 35.230          | 11.431   |
| 300                | 1.2653                        | 9627.0                          | 157.20   | 27.942   | 38.827   | 442.16                        | 36.501          | 11.735   |
| 320                | 1.1723                        | 10406                           | 159.71   | 28.655   | 39.098   | 457.93                        | 39.174          | 12.337   |
| 340                | 1.0934                        | 11192                           | 162.10   | 29.487   | 39.598   | 472.53                        | 42.015          | 12.928   |
| 360                | 1.0254                        | 11991                           | 164.38   | 30.417   | 40.269   | 486.19                        | 45.015          | 13.509   |
| 380                | 0.96602                       | 12804                           | 166.58   | 31.423   | 41.071   | 499.07                        | 48.164          | 14.079   |
| 400                | 0.9136                        | 13634                           | 168.71   | 32.490   | 41.972   | 511.32                        | 51.452          | 14.639   |
| 420                | 0.86692                       | 14483                           | 170.78   | 33.602   | 42.948   | 523.03                        | 54.869          | 15.187   |
| 440                | 0.82505                       | 15353                           | 172.80   | 34.748   | 43.980   | 534.29                        | 58.403          | 15.726   |
| 460                | 0.78723                       | 16243                           | 174.78   | 35.917   | 45.054   | 545.16                        | 62.046          | 16.254   |
| 480                | 0.75289                       | 17155                           | 176.72   | 37.102   | 46.158   | 555.7                         | 65.787          | 16.773   |
| 500                | 0.72154                       | 18089                           | 178.63   | 38.295   | 47.281   | 565.94                        | 69.617          | 17.283   |
| 520                | 0.69279                       | 19046                           | 180.50   | 39.492   | 48.417   | 575.93                        | 73.528          | 17.783   |
| 540                | 0.66633                       | 20026                           | 182.35   | 40.687   | 49.560   | 585.68                        | 77.513          | 18.276   |
| 560                | 0.64188                       | 21029                           | 184.17   | 41.879   | 50.706   | 595.22                        | 81.566          | 18.76  |
| 580                | 0.61921                       | 22054                           | 185.97   | 43.063   | 51.849   | 604.57                        | 85.679          | 19.236   |
| 600                | 0.59814                       | 23103                           | 187.75   | 44.238   | 52.988   | 613.74                        | 89.847          | 19.705   |
| Pressure = 5 MPa   |                               |                                 |  |  |  |                               |                 |  |
| 92                 | 28.236                        | -5531.9                         | 68.062   | 34.841   | 53.67  | 1560.4                        | 214.03          | 205.16   |
| 100                | 27.586                        | -5100.8                         | 72.554   | 34.116   | 54.117   | 1490.0                        | 204.37          | 166.12   |
| 110                | 26.746                        | -4556.1                         | 77.746   | 33.332   | 54.870   | 1398.6                        | 191.35          | 129.97   |
| 120                | 25.868                        | -4002.8                         | 82.559   | 32.618   | 55.832   | 1304.3                        | 177.78          | 104.11   |
| 130                | 24.940                        | -3438.4                         | 87.076   | 31.965   | 57.092   | 1206.8                        | 164.01          | 85.281   |
| 140                | 23.944                        | -2859.4                         | 91.366   | 31.381   | 58.818   | 1105.3                        | 150.21          | 71.097   |
| 150                | 22.856                        | -2259.6                         | 95.504   | 30.884   | 61.308   | 998.65                        | 136.42          | 59.948   |
| 160                | 21.632                        | -1628.8                         | 99.573   | 30.506   | 65.159   | 884.35                        | 122.58          | 50.734   |
| 170                | 20.190                        | -947.17                         | 103.70   | 30.318   | 71.859   | 758.12                        | 108.42          | 42.643   |
| 180                | 18.323                        | -165.97                         | 108.16   | 30.541   | 86.815   | 609.53                        | 93.389          | 34.852   |
| 190                | 15.003                        | 955.15                          | 114.21   | 32.915   | 171.85   | 393.44                        | 78.132          | 25.138   |
| 200                | 5.4706                        | 4153.5                          | 130.69   | 32.029   | 116.67   | 291.29                        | 40.398          | 10.906   |
| 210                | 4.3438                        | 5027.6                          | 134.96   | 29.525   | 70.783   | 319.48                        | 34.313          | 10.407   |
| 220                | 3.7699                        | 5661.4                          | 137.91   | 28.538   | 57.833   | 340.20                        | 32.894          | 10.384   |
| 230                | 3.3870                        | 6205.3                          | 140.33   | 28.006   | 51.563   | 357.45                        | 32.663          | 10.505   |
| 240                | 3.1023                        | 6701.1                          | 142.44   | 27.717   | 47.890   | 372.50                        | 32.947          | 10.691   |
| 250                | 2.8772                        | 7167.4                          | 144.35   | 27.587   | 45.528   | 385.97                        | 33.514          | 10.912   |
| 260                | 2.6924                        | 7614.2                          | 146.10   | 27.572   | 43.934   | 398.24                        | 34.263          | 11.155   |
| 270                | 2.5363                        | 8047.7                          | 147.73   | 27.648   | 42.833   | 409.56                        | 35.142          | 11.412   |
| 280                | 2.4018                        | 8472.0                          | 149.28   | 27.795   | 42.073   | 420.08                        | 36.122          | 11.676   |
| 290                | 2.2841                        | 8890.0                          | 150.74   | 28.003   | 41.56  | 429.95                        | 37.185          | 11.947   |
| 300                | 2.1799                        | 9303.8                          | 152.15   | 28.262   | 41.234   | 439.25                        | 38.321          | 12.22  |
| 320                | 2.0024                        | 10125                           | 154.80   | 28.908   | 40.991   | 456.47                        | 40.779          | 12.772   |
| 340                | 1.8559                        | 10946                           | 157.29   | 29.694   | 41.135   | 472.18                        | 43.456          | 13.325   |
| 360                | 1.7322                        | 11772                           | 159.65   | 30.589   | 41.548   | 486.71                        | 46.326          | 13.875   |
| 380                | 1.6259                        | 12609                           | 161.91   | 31.569   | 42.154   | 500.29                        | 49.369          | 14.419   |
| 400                | 1.5333                        | 13460                           | 164.09   | 32.614   | 42.903   | 513.11                        | 52.569          | 14.956   |
| 420                | 1.4516                        | 14326                           | 166.20   | 33.710   | 43.759   | 525.3                         | 55.911          | 15.485   |
| 440                | 1.3789                        | 15210                           | 168.26   | 34.842   | 44.693   | 536.96                        | 59.381          | 16.007   |
| 460                | 1.3137                        | 16114                           | 170.27   | 36.000   | 45.686   | 548.17                        | 62.967          | 16.521   |
| 480                | 1.2548                        | 17038                           | 172.24   | 37.176   | 46.722   | 559.00                        | 66.658          | 17.027   |
| 500                | 1.2013                        | 17983                           | 174.16   | 38.361   | 47.789   | 569.49                        | 70.443          | 17.525   |
| Pressure = 7.5 MPa |                               |                                 |  |  |  |                               |                 |  |
| 95                 | 28.096                        | -5305.7                         | 69.531   | 34.651   | 53.606   | 1551.2                        | 212.74          | 194.38   |
| 100                | 27.695                        | -5037.1                         | 72.287   | 34.217   | 53.869   | 1508.1                        | 206.71          | 170.74   |

**TABLE 2** *Continued*

| <i>T</i><br>K     | $\rho$<br>mol·l <sup>-1</sup> | <i>H</i><br>J·mol <sup>-1</sup> | <i>S</i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>v</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>C<sub>p</sub></i><br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | <i>c</i><br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|-------------------|-------------------------------|---------------------------------|--|--|--|-------------------------------|-----------------|--|
| 110               | 26.875                        | -4495.2                         | 77.451   | 33.438   | 54.529   | 1419.6                        | 193.92          | 133.81   |
| 120               | 26.021                        | -3945.9                         | 82.230   | 32.728   | 55.357   | 1328.7                        | 180.62          | 107.37   |
| 130               | 25.125                        | -3387.3                         | 86.701   | 32.075   | 56.414   | 1235.4                        | 167.16          | 88.135   |
| 140               | 24.174                        | -2816.5                         | 90.930   | 31.486   | 57.815   | 1139.5                        | 153.73          | 73.718   |
| 150               | 23.149                        | -2229.3                         | 94.981   | 30.972   | 59.742   | 1040.2                        | 140.44          | 62.484   |
| 160               | 22.025                        | -1618.9                         | 98.919   | 30.552   | 62.511   | 936.47                        | 127.3           | 53.345   |
| 170               | 20.756                        | -974.27                         | 102.83   | 30.257   | 66.735   | 826.79                        | 114.22          | 45.556   |
| 180               | 19.261                        | -274.88                         | 106.82   | 30.150   | 73.823   | 708.67                        | 101.11          | 38.550   |
| 190               | 17.361                        | 524.50                          | 111.14   | 30.387   | 87.903   | 578.15                        | 88.496          | 31.776   |
| 200               | 14.556                        | 1555.8                          | 116.42   | 31.379   | 124.95   | 434.03                        | 74.347          | 24.417   |
| 210               | 10.183                        | 3083.2                          | 123.87   | 32.226   | 160.40   | 334.78                        | 60.014          | 16.695   |
| 220               | 7.3716                        | 4365.5                          | 129.84   | 30.585   | 100.36   | 335.06                        | 47.217          | 13.541   |
| 230               | 6.0799                        | 5217.7                          | 133.63   | 29.498   | 73.999   | 350.92                        | 41.924          | 12.632   |
| 240               | 5.3123                        | 5891.3                          | 136.50   | 28.856   | 62.040   | 366.82                        | 39.766          | 12.326   |
| 250               | 4.7819                        | 6475.9                          | 138.89   | 28.486   | 55.452   | 381.48                        | 38.935          | 12.258   |
| 260               | 4.3831                        | 7008.5                          | 140.98   | 28.303   | 51.379   | 394.89                        | 38.786          | 12.308   |
| 270               | 4.0670                        | 7508.0                          | 142.87   | 28.254   | 48.685   | 407.23                        | 39.040          | 12.426   |
| 280               | 3.8071                        | 7985.0                          | 144.60   | 28.308   | 46.829   | 418.65                        | 39.560          | 12.586   |
| 290               | 3.5879                        | 8446.4                          | 146.22   | 28.444   | 45.525   | 429.30                        | 40.270          | 12.775   |
| 300               | 3.3992                        | 8896.8                          | 147.75   | 28.647   | 44.607   | 439.29                        | 41.125          | 12.982   |
| 320               | 3.0884                        | 9776.9                          | 150.59   | 29.211   | 43.543   | 457.63                        | 43.165          | 13.432   |
| 340               | 2.8404                        | 10643                           | 153.21   | 29.939   | 43.152   | 474.23                        | 45.543          | 13.911   |
| 360               | 2.6360                        | 11506                           | 155.68   | 30.792   | 43.193   | 489.47                        | 48.188          | 14.403   |
| 380               | 2.4635                        | 12373                           | 158.02   | 31.741   | 43.529   | 503.63                        | 51.054          | 14.901   |
| 400               | 2.3153                        | 13248                           | 160.27   | 32.763   | 44.072   | 516.93                        | 54.111          | 15.401   |
| 420               | 2.1862                        | 14137                           | 162.43   | 33.839   | 44.768   | 529.51                        | 57.335          | 15.899   |
| 440               | 2.0723                        | 15040                           | 164.54   | 34.955   | 45.575   | 541.50                        | 60.705          | 16.394   |
| 460               | 1.9710                        | 15960                           | 166.58   | 36.100   | 46.464   | 553.00                        | 64.206          | 16.885   |
| 480               | 1.8800                        | 16899                           | 168.58   | 37.264   | 47.414   | 564.07                        | 67.822          | 17.371   |
| 500               | 1.7978                        | 17857                           | 170.53   | 38.440   | 48.409   | 574.77                        | 71.543          | 17.851   |
| Pressure = 10 MPa |                               |                                 |  |  |  |                               |                 |  |
| 95                | 28.194                        | -5240.5                         | 69.283   | 34.745   | 53.412   | 1567.6                        | 214.92          | 199.56   |
| 100               | 27.802                        | -4972.9                         | 72.028   | 34.314   | 53.642   | 1525.7                        | 209.00          | 175.46   |
| 110               | 26.999                        | -4433.7                         | 77.167   | 33.54  | 54.22  | 1439.8                        | 196.44          | 137.71   |
| 120               | 26.167                        | -3888                           | 81.914   | 32.835   | 54.935   | 1351.9                        | 183.38          | 110.65   |
| 130               | 25.299                        | -3334.4                         | 86.345   | 32.184   | 55.827   | 1262.3                        | 170.19          | 90.99  |
| 140               | 24.386                        | -2770.6                         | 90.522   | 31.593   | 56.977   | 1171.0                        | 157.09          | 76.302   |
| 150               | 23.414                        | -2193.6                         | 94.503   | 31.069   | 58.504   | 1077.6                        | 144.2           | 64.934   |
| 160               | 22.365                        | -1598.7                         | 98.342   | 30.625   | 60.586   | 981.8                         | 131.57          | 55.787   |
| 170               | 21.214                        | -979.1                          | 102.10   | 30.277   | 63.513   | 882.98                        | 119.22          | 48.132   |
| 180               | 19.919                        | -323.98                         | 105.84   | 30.049   | 67.799   | 780.76                        | 107.15          | 41.468   |
| 190               | 18.415                        | 384.52                          | 109.67   | 29.981   | 74.405   | 675.09                        | 95.79           | 35.423   |
| 200               | 16.593                        | 1177.6                          | 113.74   | 30.129   | 85.085   | 567.92                        | 84.052          | 29.710   |
| 210               | 14.308                        | 2104.4                          | 118.25   | 30.45  | 100.72   | 469.31                        | 73.07           | 24.201   |
| 220               | 11.693                        | 3164.4                          | 123.18   | 30.536   | 107.7  | 404.38                        | 63.42           | 19.46  |
| 230               | 9.4897                        | 4183.7                          | 127.72   | 30.152   | 94.030   | 382.48                        | 55.367          | 16.495   |
| 240               | 8.0039                        | 5039.4                          | 131.36   | 29.627   | 77.860   | 383.61                        | 49.876          | 15.014   |
| 250               | 7.0079                        | 5758.9                          | 134.30   | 29.196   | 66.874   | 392.22                        | 46.708          | 14.296   |
| 260               | 6.2963                        | 6390                            | 136.78   | 28.918   | 59.841   | 402.84                        | 45.015          | 13.951   |
| 270               | 5.7571                        | 6963.6                          | 138.94   | 28.783   | 55.198   | 413.78                        | 44.217          | 13.807   |
| 280               | 5.3299                        | 7498.8                          | 140.89   | 28.764   | 52.016   | 424.47                        | 43.988          | 13.782   |
| 290               | 4.9800                        | 8007.1                          | 142.67   | 28.841   | 49.774   | 434.73                        | 44.142          | 13.832   |
| 300               | 4.6859                        | 8496.3                          | 144.33   | 28.995   | 48.165   | 444.53                        | 44.569          | 13.932   |
| 320               | 4.2146                        | 9437.5                          | 147.37   | 29.487   | 46.171   | 462.78                        | 45.997          | 14.228   |
| 340               | 3.8489                        | 10350                           | 150.13   | 30.165   | 45.193   | 479.45                        | 47.959          | 14.598   |
| 360               | 3.5536                        | 11249                           | 152.71   | 30.981   | 44.837   | 494.83                        | 50.302          | 15.011   |
| 380               | 3.3084                        | 12146                           | 155.13   | 31.902   | 44.888   | 509.14                        | 52.939          | 15.449   |
| 400               | 3.1002                        | 13047                           | 157.44   | 32.902   | 45.220   | 522.58                        | 55.815          | 15.900   |
| 420               | 2.9206                        | 13956                           | 159.66   | 33.960   | 45.753   | 535.3                         | 58.893          | 16.358   |
| 440               | 2.7634                        | 14878                           | 161.80   | 35.062   | 46.432   | 547.42                        | 62.142          | 16.820   |
| 460               | 2.6244                        | 15814                           | 163.88   | 36.195   | 47.218   | 559.03                        | 65.54           | 17.282   |
| 480               | 2.5003                        | 16767                           | 165.91   | 37.349   | 48.083   | 570.20                        | 69.07           | 17.743   |
| 500               | 2.3887                        | 17738                           | 167.89   | 38.516   | 49.007   | 580.99                        | 72.715          | 18.202   |
| Pressure = 20 MPa |                               |                                 |  |  |  |                               |                 |  |
| 100               | 28.198                        | -4713.1                         | 71.055   | 34.677   | 52.897   | 1591.1                        | 217.79          | 195.43   |
| 110               | 27.454                        | -4182.5                         | 76.112   | 33.925   | 53.234   | 1513.8                        | 206.00          | 154.15   |
| 120               | 26.694                        | -3648.2                         | 80.76  | 33.236   | 53.631   | 1435.7                        | 193.74          | 124.31   |
| 130               | 25.915                        | -3109.7                         | 85.071   | 32.596   | 54.094   | 1357.3                        | 181.4           | 102.63   |
| 140               | 25.113                        | -2566.1                         | 89.099   | 32.006   | 54.647   | 1279.2                        | 169.24          | 86.565   |
| 150               | 24.284                        | -2016.3                         | 92.892   | 31.471   | 55.322   | 1201.4                        | 157.41          | 74.326   |
| 160               | 23.424                        | -1459.1                         | 96.487   | 30.994   | 56.146   | 1124.3                        | 146.04          | 64.712   |

**TABLE 2** *Continued*

| $T$<br>K | $\rho$<br>mol·l <sup>-1</sup> | $H$<br>J·mol <sup>-1</sup> | $S$<br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | $C_v$<br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | $C_p$<br>J·mol <sup>-1</sup> ·K <sup>-1</sup> | $c$<br>m·s <sup>-1</sup> | $\eta$<br>μPa·s | $\lambda$<br>mW·m <sup>-1</sup> ·K <sup>-1</sup> |
|----------|-------------------------------|----------------------------|---|---|---|--------------------------|-----------------|--|
| 170      | 22.527                        | -892.82                    | 99.920                                      | 30.579  | 57.148  | 1048.2                   | 135.19          | 56.936   |
| 180      | 21.588                        | -315.50                    | 103.22                                      | 30.229  | 58.349  | 973.55                   | 124.94          | 50.482   |
| 190      | 20.603                        | 274.86                     | 106.41                                      | 29.945  | 59.758  | 901.01                   | 115.43          | 45.008   |
| 200      | 19.567                        | 880.27                     | 109.52                                      | 29.727  | 61.350  | 831.58                   | 106.41          | 40.293   |
| 210      | 18.481                        | 1502.2                     | 112.55                                      | 29.573  | 63.046  | 766.53                   | 98.170          | 36.191   |
| 220      | 17.351                        | 2141.0                     | 115.52                                      | 29.476  | 64.676  | 707.42                   | 90.750          | 32.615   |
| 230      | 16.194                        | 2794.6                     | 118.43                                      | 29.425  | 65.967  | 655.86                   | 84.229          | 29.522   |
| 240      | 15.036                        | 3458.0                     | 121.25                                      | 29.408  | 66.572  | 613.27                   | 78.651          | 26.894   |
| 250      | 13.915                        | 4122.9                     | 123.96                                      | 29.417  | 66.246  | 580.44                   | 74.001          | 24.719   |
| 260      | 12.866                        | 4780.0                     | 126.54                                      | 29.443  | 65.032  | 556.92                   | 70.205          | 22.975   |
| 270      | 11.914                        | 5421.5                     | 128.96                                      | 29.488  | 63.201  | 541.27                   | 67.157          | 21.615   |
| 280      | 11.069                        | 6043.0                     | 131.22                                      | 29.557  | 61.074  | 531.72                   | 64.759          | 20.579   |
| 290      | 10.327                        | 6642.9                     | 133.33                                      | 29.661  | 58.919  | 526.67                   | 62.926          | 19.803   |
| 300      | 9.6789                        | 7221.9                     | 135.29                                      | 29.805  | 56.917  | 524.86                   | 61.588          | 19.232   |
| 320      | 8.6166                        | 8326.0                     | 138.86                                      | 30.230  | 53.674  | 527.32                   | 60.134          | 18.527   |
| 340      | 7.7904                        | 9375.9                     | 142.04                                      | 30.826  | 51.471  | 534.23                   | 59.937          | 18.206   |
| 360      | 7.1314                        | 10390                      | 144.94                                      | 31.566  | 50.104  | 543.24                   | 60.651          | 18.119   |
| 380      | 6.5925                        | 11384                      | 147.63                                      | 32.419  | 49.355  | 553.19                   | 62.035          | 18.181   |
| 400      | 6.1425                        | 12368                      | 150.15                                      | 33.361  | 49.054  | 563.52                   | 63.927          | 18.341   |
| 420      | 5.7598                        | 13348                      | 152.54                                      | 34.371  | 49.081  | 573.95                   | 66.215          | 18.567   |
| 440      | 5.4295                        | 14332                      | 154.83                                      | 35.431  | 49.351  | 584.33                   | 68.817          | 18.839   |
| 460      | 5.1408                        | 15324                      | 157.03                                      | 36.528  | 49.801  | 594.60                   | 71.678          | 19.144   |
| 480      | 4.8857                        | 16325                      | 159.16                                      | 37.650  | 50.387  | 604.70                   | 74.753          | 19.472   |
| 500      | 4.6583                        | 17340                      | 161.23                                      | 38.790  | 51.076  | 614.64                   | 78.009          | 19.816   |

**Symbols:**
 $T$  = temperature (K)

 $\rho$  = molar density (mol·l<sup>-1</sup>)

 $H$  = molar enthalpy (J·mol<sup>-1</sup>)

 $S$  = molar entropy (J·K<sup>-1</sup>·mol<sup>-1</sup>)

 $C_v$  = constant volume molar heat capacity (J·K<sup>-1</sup>·mol<sup>-1</sup>)

 $C_p$  = constant pressure molar heat capacity (J·K<sup>-1</sup>·mol<sup>-1</sup>)

 $c$  = speed of sound (m·s<sup>-1</sup>)

 $\eta$  = viscosity (μPa·s)

 $\lambda$  = thermal conductivity (mW·m<sup>-1</sup>·K<sup>-1</sup>)

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