

## GCE Chemistry Data Sheet


**Table 1**  
Infrared absorption data

| Bond              | Wavenumber<br>/cm <sup>-1</sup> |
|-------------------|---------------------------------|
| N-H<br>(amines)   | 3300-3500                       |
| O-H<br>(alcohols) | 3230-3550                       |
| C-H               | 2850-3300                       |
| O-H<br>(acids)    | 2500-3000                       |
| C≡N               | 2220-2260                       |
| C=O               | 1680-1750                       |
| C=C               | 1620-1680                       |
| C-O               | 1000-1300                       |
| C-C               | 750-1100                        |

**Table 2**  
<sup>1</sup>H n.m.r. chemical shift data

| Type of proton  | δ/ppm     |
|---|-----------|
| ROH   | 0.5-5.0   |
| RCH <sub>3</sub>  | 0.7-1.2   |
| RNH <sub>2</sub>  | 1.0-4.5   |
| R <sub>2</sub> CH <sub>2</sub>  | 1.2-1.4   |
| R <sub>3</sub> CH   | 1.4-1.6   |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{C}- \\    \quad   \\ \text{O} \quad \text{H} \end{array}$              | 2.1-2.6   |
| $\begin{array}{c}   \\ \text{R}-\text{O}-\text{C}- \\   \\ \text{H} \end{array}$                                      | 3.1-3.9   |
| RCH <sub>2</sub> Cl or Br   | 3.1-4.2   |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{O}-\text{C}- \\    \quad   \\ \text{O} \quad \text{H} \end{array}$     | 3.7-4.1   |
| $\begin{array}{c} \text{R} \quad \text{H} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \end{array}$ | 4.5-6.0   |
| $\begin{array}{c} \text{O} \\ // \\ \text{R}-\text{C} \\ \diagdown \\ \text{H} \end{array}$                           | 9.0-10.0  |
| $\begin{array}{c} \text{O} \\ // \\ \text{R}-\text{C} \\ \diagdown \\ \text{O}-\text{H} \end{array}$                  | 10.0-12.0 |

**Table 3**  
<sup>13</sup>C n.m.r. chemical shift data

| Type of carbon   | δ/ppm   |
|--|---------|
| $\begin{array}{c}   \quad   \\ -\text{C}-\text{C}- \\   \quad   \end{array}$                                 | 5-40    |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{Cl or Br} \\   \end{array}$                                   | 10-70   |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{C}- \\    \quad   \\ \text{O} \quad   \end{array}$            | 20-50   |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{N} \\   \quad \diagdown \end{array}$                          | 25-60   |
| $\begin{array}{c}   \\ -\text{C}-\text{O}- \\   \end{array}$ alcohols,<br>ethers or<br>esters                | 50-90   |
| $\begin{array}{c} \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \end{array}$                   | 90-150  |
| R-C≡N  | 110-125 |
|                         | 110-160 |
| $\begin{array}{c} \text{O} \\ // \\ \text{R}-\text{C}- \\   \\ \text{O} \end{array}$ esters or<br>acids      | 160-185 |
| $\begin{array}{c} \text{O} \\ // \\ \text{R}-\text{C}- \\   \\ \text{O} \end{array}$ aldehydes<br>or ketones | 190-220 |



# The Periodic Table of the Elements

| 1                                    | 2                                    |   |  |                                      |   |                                       |                                       |   |   |  |   | 3                                    | 4                                    | 5                                    | 6                                     | 7                                    | 0                                  |
|--------------------------------------|--------------------------------------|---|--|--------------------------------------|---|---------------------------------------|---------------------------------------|---|---|--|---|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|--------------------------------------|------------------------------------|
| (1)                                  | (2)                                  | <b>Key</b><br>relative atomic mass<br><b>symbol</b><br>name<br>atomic (proton) number |  |                                      |   |                                       |                                       |   |   |  |   | (13)                                 | (14)                                 | (15)                                 | (16)                                  | (17)                                 | (18)                               |
| 6.9<br><b>Li</b><br>lithium<br>3     | 9.0<br><b>Be</b><br>beryllium<br>4   |   |  |                                      |   |                                       |                                       |   |   |  |   | 10.8<br><b>B</b><br>boron<br>5       | 12.0<br><b>C</b><br>carbon<br>6      | 14.0<br><b>N</b><br>nitrogen<br>7    | 16.0<br><b>O</b><br>oxygen<br>8       | 19.0<br><b>F</b><br>fluorine<br>9    | 4.0<br><b>He</b><br>helium<br>2    |
| 23.0<br><b>Na</b><br>sodium<br>11    | 24.3<br><b>Mg</b><br>magnesium<br>12 | (3)   | (4)  | (5)                                  | (6)                                     | (7)                                   | (8)                                   | (9)                                     | (10)                                      | (11)                                     | (12)  | 27.0<br><b>Al</b><br>aluminium<br>13 | 28.1<br><b>Si</b><br>silicon<br>14   | 31.0<br><b>P</b><br>phosphorus<br>15 | 32.1<br><b>S</b><br>sulfur<br>16      | 35.5<br><b>Cl</b><br>chlorine<br>17  | 39.9<br><b>Ar</b><br>argon<br>18   |
| 39.1<br><b>K</b><br>potassium<br>19  | 40.1<br><b>Ca</b><br>calcium<br>20   | 45.0<br><b>Sc</b><br>scandium<br>21   | 47.9<br><b>Ti</b><br>titanium<br>22        | 50.9<br><b>V</b><br>vanadium<br>23   | 52.0<br><b>Cr</b><br>chromium<br>24     | 54.9<br><b>Mn</b><br>manganese<br>25  | 55.8<br><b>Fe</b><br>iron<br>26       | 58.9<br><b>Co</b><br>cobalt<br>27       | 58.7<br><b>Ni</b><br>nickel<br>28         | 63.5<br><b>Cu</b><br>copper<br>29        | 65.4<br><b>Zn</b><br>zinc<br>30   | 69.7<br><b>Ga</b><br>gallium<br>31   | 72.6<br><b>Ge</b><br>germanium<br>32 | 74.9<br><b>As</b><br>arsenic<br>33   | 79.0<br><b>Se</b><br>selenium<br>34   | 79.9<br><b>Br</b><br>bromine<br>35   | 83.8<br><b>Kr</b><br>krypton<br>36 |
| 85.5<br><b>Rb</b><br>rubidium<br>37  | 87.6<br><b>Sr</b><br>strontium<br>38 | 88.9<br><b>Y</b><br>yttrium<br>39   | 91.2<br><b>Zr</b><br>zirconium<br>40       | 92.9<br><b>Nb</b><br>niobium<br>41   | 96.0<br><b>Mo</b><br>molybdenum<br>42   | [98]<br><b>Tc</b><br>technetium<br>43 | 101.1<br><b>Ru</b><br>ruthenium<br>44 | 102.9<br><b>Rh</b><br>rhodium<br>45     | 106.4<br><b>Pd</b><br>palladium<br>46     | 107.9<br><b>Ag</b><br>silver<br>47       | 112.4<br><b>Cd</b><br>cadmium<br>48   | 114.8<br><b>In</b><br>indium<br>49   | 118.7<br><b>Sn</b><br>tin<br>50      | 121.8<br><b>Sb</b><br>antimony<br>51 | 127.6<br><b>Te</b><br>tellurium<br>52 | 126.9<br><b>I</b><br>iodine<br>53    | 131.3<br><b>Xe</b><br>xenon<br>54  |
| 132.9<br><b>Cs</b><br>caesium<br>55  | 137.3<br><b>Ba</b><br>barium<br>56   | 138.9<br><b>La</b> *<br>lanthanum<br>57   | 178.5<br><b>Hf</b><br>hafnium<br>72        | 180.9<br><b>Ta</b><br>tantalum<br>73 | 183.8<br><b>W</b><br>tungsten<br>74     | 186.2<br><b>Re</b><br>rhenium<br>75   | 190.2<br><b>Os</b><br>osmium<br>76    | 192.2<br><b>Ir</b><br>iridium<br>77     | 195.1<br><b>Pt</b><br>platinum<br>78      | 197.0<br><b>Au</b><br>gold<br>79         | 200.6<br><b>Hg</b><br>mercury<br>80   | 204.4<br><b>Tl</b><br>thallium<br>81 | 207.2<br><b>Pb</b><br>lead<br>82     | 209.0<br><b>Bi</b><br>bismuth<br>83  | [209]<br><b>Po</b><br>polonium<br>84  | [210]<br><b>At</b><br>astatine<br>85 | [222]<br><b>Rn</b><br>radon<br>86  |
| [223]<br><b>Fr</b><br>francium<br>87 | [226]<br><b>Ra</b><br>radium<br>88   | [227]<br><b>Ac</b> †<br>actinium<br>89  | [267]<br><b>Rf</b><br>rutherfordium<br>104 | [268]<br><b>Db</b><br>dubnium<br>105 | [271]<br><b>Sg</b><br>seaborgium<br>106 | [272]<br><b>Bh</b><br>bohrium<br>107  | [270]<br><b>Hs</b><br>hassium<br>108  | [276]<br><b>Mt</b><br>meitnerium<br>109 | [281]<br><b>Ds</b><br>darmstadtium<br>110 | [280]<br><b>Rg</b><br>roentgenium<br>111 | Elements with atomic numbers 112-116 have been reported but not fully authenticated |                                      |                                      |                                      |                                       |                                      |                                    |

\* 58 – 71 Lanthanides

|                                     |  |                                       |  |                                       |                                       |  |                                       |   |   |                                      |  |                                       |   |
|-------------------------------------|--|---------------------------------------|--|---------------------------------------|---------------------------------------|--|---------------------------------------|---|---|--------------------------------------|--|---------------------------------------|---|
| 140.1<br><b>Ce</b><br>cerium<br>58  | 140.9<br><b>Pr</b><br>praseodymium<br>59 | 144.2<br><b>Nd</b><br>neodymium<br>60 | [145]<br><b>Pm</b><br>promethium<br>61 | 150.4<br><b>Sm</b><br>samarium<br>62  | 152.0<br><b>Eu</b><br>europium<br>63  | 157.3<br><b>Gd</b><br>gadolinium<br>64 | 158.9<br><b>Tb</b><br>terbium<br>65   | 162.5<br><b>Dy</b><br>dysprosium<br>66  | 164.9<br><b>Ho</b><br>holmium<br>67     | 167.3<br><b>Er</b><br>erbium<br>68   | 168.9<br><b>Tm</b><br>thulium<br>69      | 173.1<br><b>Yb</b><br>ytterbium<br>70 | 175.0<br><b>Lu</b><br>lutetium<br>71    |
| 232.0<br><b>Th</b><br>thorium<br>90 | 231.0<br><b>Pa</b><br>protactinium<br>91 | 238.0<br><b>U</b><br>uranium<br>92    | [237]<br><b>Np</b><br>neptunium<br>93  | [244]<br><b>Pu</b><br>plutonium<br>94 | [243]<br><b>Am</b><br>americium<br>95 | [247]<br><b>Cm</b><br>curium<br>96     | [247]<br><b>Bk</b><br>berkelium<br>97 | [251]<br><b>Cf</b><br>californium<br>98 | [252]<br><b>Es</b><br>einsteinium<br>99 | [257]<br><b>Fm</b><br>fermium<br>100 | [258]<br><b>Md</b><br>mendelevium<br>101 | [259]<br><b>No</b><br>nobelium<br>102 | [262]<br><b>Lr</b><br>lawrencium<br>103 |

† 90 – 103 Actinides