



GCE AS

B410U10-1A



S25-B410U10-1A



**TUESDAY, 13 MAY 2025 – MORNING**

**CHEMISTRY – AS component 1**  
**Data Booklet**

Avogadro constant  
molar gas constant  
molar gas volume at 273 K and 1 atm  
molar gas volume at 298 K and 1 atm  
Planck constant  
speed of light  
density of water  
specific heat capacity of water  
ionic product of water at 298 K  
fundamental electronic charge

$$\begin{aligned}N_A &= 6.02 \times 10^{23} \text{ mol}^{-1} \\R &= 8.31 \text{ J mol}^{-1} \text{ K}^{-1} \\V_m &= 22.4 \text{ dm}^3 \text{ mol}^{-1} \\V_m &= 24.5 \text{ dm}^3 \text{ mol}^{-1} \\h &= 6.63 \times 10^{-34} \text{ J s} \\c &= 3.00 \times 10^8 \text{ m s}^{-1} \\d &= 1.00 \text{ g cm}^{-3} \\c &= 4.18 \text{ J g}^{-1} \text{ K}^{-1} \\K_w &= 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6} \\e &= 1.60 \times 10^{-19} \text{ C}\end{aligned}$$

temperature (K) = temperature (°C) + 273

$1 \text{ dm}^3 = 1000 \text{ cm}^3$   
 $1 \text{ m}^3 = 1000 \text{ dm}^3$   
 $1 \text{ tonne} = 1000 \text{ kg}$   
 $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$

| Multiple  | Prefix | Symbol |
|-----------|--------|--------|
| $10^{-9}$ | nano   | n      |
| $10^{-6}$ | micro  | $\mu$  |
| $10^{-3}$ | milli  | m      |

| Multiple | Prefix | Symbol |
|----------|--------|--------|
| $10^3$   | kilo   | k      |
| $10^6$   | mega   | M      |
| $10^9$   | giga   | G      |

## Infrared absorption values

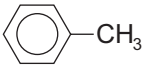
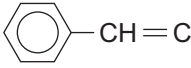
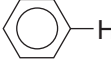
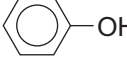
| Bond                     | Wavenumber / $\text{cm}^{-1}$ |
|--------------------------|-------------------------------|
| C — Br                   | 500 to 600                    |
| C — Cl                   | 650 to 800                    |
| C — O                    | 1000 to 1300                  |
| C = C                    | 1620 to 1670                  |
| C = O                    | 1650 to 1750                  |
| C $\equiv$ N             | 2100 to 2250                  |
| C — H                    | 2800 to 3100                  |
| O — H (carboxylic acid)  | 2500 to 3200 (very broad)     |
| O — H (alcohol / phenol) | 3200 to 3550 (broad)          |
| N — H                    | 3300 to 3500                  |

<sup>13</sup>C NMR chemical shifts relative to TMS = 0

| Type of carbon                                                                                         | Chemical shift, $\delta$ (ppm) |
|--------------------------------------------------------------------------------------------------------|--------------------------------|
| $\begin{array}{c}   \quad   \\ -\text{C}-\text{C}- \\   \quad   \end{array}$                           | 5 to 40                        |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{Cl or Br} \\   \end{array}$                             | 10 to 70                       |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{C}- \\    \quad   \\ \text{O} \end{array}$              | 20 to 50                       |
| $\begin{array}{c}   \\ \text{R}-\text{C}-\text{N} \diagup \diagdown \\   \end{array}$                  | 25 to 60                       |
| $\begin{array}{c}   \\ -\text{C}-\text{O}- \\   \end{array}$                                           | 50 to 90                       |
| $\begin{array}{c} \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \end{array}$ | 90 to 150                      |
| $\text{R}-\text{C} \equiv \text{N}$                                                                    | 110 to 125                     |
|                     | 110 to 160                     |
| $\begin{array}{c} \text{R}-\text{C}- \text{ (carboxylic acid / ester)} \\    \\ \text{O} \end{array}$  | 160 to 185                     |
| $\begin{array}{c} \text{R}-\text{C}- \text{ (aldehyde / ketone)} \\    \\ \text{O} \end{array}$        | 190 to 220                     |

**$^1\text{H}$  NMR chemical shifts relative to TMS = 0**

| Type of proton | Chemical shift, $\delta$ (ppm) |
|----------------|--------------------------------|
|----------------|--------------------------------|

|                                                                                     |            |
|-------------------------------------------------------------------------------------|------------|
| $-\text{CH}_3$                                                                      | 0.1 to 2.0 |
| $\text{R}-\text{CH}_3$                                                              | 0.9        |
| $\text{R}-\text{CH}_2-\text{R}$                                                     | 1.3        |
| $\text{CH}_3-\text{C}\equiv\text{N}$                                                | 2.0        |
| $\text{CH}_3-\text{C}(=\text{O})$                                                   | 2.0 to 2.5 |
| $-\text{CH}_2-\text{C}(=\text{O})$                                                  | 2.0 to 3.0 |
|    | 2.2 to 2.3 |
| $\text{HC}-\text{Cl}$ or $\text{HC}-\text{Br}$                                      | 3.1 to 4.3 |
| $\text{HC}-\text{O}$                                                                | 3.3 to 4.3 |
| $\text{R}-\text{OH}$                                                                | 4.5 *      |
| $-\text{C}=\text{CH}$                                                               | 4.5 to 6.3 |
| $-\text{C}=\text{CH}-\text{CO}$                                                     | 5.8 to 6.5 |
|  | 6.5 to 7.5 |
|  | 6.5 to 8.0 |
|  | 7.0 *      |
| $\text{R}-\text{C}(=\text{O})\text{H}$                                              | 9.8 *      |
| $\text{R}-\text{C}(=\text{O})\text{OH}$                                             | 11.0 *     |

\*variable figure dependent on concentration and solvent

# THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0**

Group

|                               |                               |                               |                               |                               |                               |                               |                               |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| s block                       |                               | p block                       |                               |                               |                               |                               |                               |
| 1                             | 2                             | 3                             | 4                             | 5                             | 6                             | 7                             | 0                             |
| 1.01<br>H<br>Hydrogen<br>1    | 6.94<br>Li<br>Lithium<br>3    | 23.0<br>Na<br>Sodium<br>11    | 39.1<br>K<br>Potassium<br>19  | 85.5<br>Rb<br>Rubidium<br>37  | 133<br>Cs<br>Caesium<br>55    | (223)<br>Fr<br>Francium<br>87 | 4.00<br>He<br>Helium<br>2     |
| 9.01<br>Be<br>Beryllium<br>4  | 24.3<br>Mg<br>Magnesium<br>12 | 40.1<br>Ca<br>Calcium<br>20   | 40.1<br>Ca<br>Calcium<br>20   | 87.6<br>Sr<br>Strontium<br>38 | 137<br>Ba<br>Barium<br>56     | (226)<br>Ra<br>Radium<br>88   | 20.2<br>Ne<br>Neon<br>10      |
| 45.0<br>Sc<br>Scandium<br>21  | 45.0<br>Sc<br>Scandium<br>21  | 45.0<br>Sc<br>Scandium<br>21  | 45.0<br>Sc<br>Scandium<br>21  | 45.0<br>Sc<br>Scandium<br>21  | 45.0<br>Sc<br>Scandium<br>21  | 45.0<br>Sc<br>Scandium<br>21  | 40.0<br>Ar<br>Argon<br>18     |
| 47.9<br>Ti<br>Titanium<br>22  | 47.9<br>Ti<br>Titanium<br>22  | 47.9<br>Ti<br>Titanium<br>22  | 47.9<br>Ti<br>Titanium<br>22  | 47.9<br>Ti<br>Titanium<br>22  | 47.9<br>Ti<br>Titanium<br>22  | 47.9<br>Ti<br>Titanium<br>22  | 35.5<br>Cl<br>Chlorine<br>17  |
| 50.9<br>V<br>Vanadium<br>23   | 50.9<br>V<br>Vanadium<br>23   | 50.9<br>V<br>Vanadium<br>23   | 50.9<br>V<br>Vanadium<br>23   | 50.9<br>V<br>Vanadium<br>23   | 50.9<br>V<br>Vanadium<br>23   | 50.9<br>V<br>Vanadium<br>23   | 32.1<br>S<br>Sulfur<br>16     |
| 54.9<br>Mn<br>Manganese<br>25 | 54.9<br>Mn<br>Manganese<br>25 | 54.9<br>Mn<br>Manganese<br>25 | 54.9<br>Mn<br>Manganese<br>25 | 54.9<br>Mn<br>Manganese<br>25 | 54.9<br>Mn<br>Manganese<br>25 | 54.9<br>Mn<br>Manganese<br>25 | 31.0<br>P<br>Phosphorus<br>15 |
| 55.8<br>Fe<br>Iron<br>26      | 55.8<br>Fe<br>Iron<br>26      | 55.8<br>Fe<br>Iron<br>26      | 55.8<br>Fe<br>Iron<br>26      | 55.8<br>Fe<br>Iron<br>26      | 55.8<br>Fe<br>Iron<br>26      | 55.8<br>Fe<br>Iron<br>26      | 28.1<br>Si<br>Silicon<br>14   |
| 58.9<br>Co<br>Cobalt<br>27    | 58.9<br>Co<br>Cobalt<br>27    | 58.9<br>Co<br>Cobalt<br>27    | 58.9<br>Co<br>Cobalt<br>27    | 58.9<br>Co<br>Cobalt<br>27    | 58.9<br>Co<br>Cobalt<br>27    | 58.9<br>Co<br>Cobalt<br>27    | 27.0<br>Al<br>Aluminium<br>13 |
| 58.7<br>Ni<br>Nickel<br>28    | 58.7<br>Ni<br>Nickel<br>28    | 58.7<br>Ni<br>Nickel<br>28    | 58.7<br>Ni<br>Nickel<br>28    | 58.7<br>Ni<br>Nickel<br>28    | 58.7<br>Ni<br>Nickel<br>28    | 58.7<br>Ni<br>Nickel<br>28    | 74.9<br>As<br>Arsenic<br>33   |
| 63.5<br>Cu<br>Copper<br>29    | 63.5<br>Cu<br>Copper<br>29    | 63.5<br>Cu<br>Copper<br>29    | 63.5<br>Cu<br>Copper<br>29    | 63.5<br>Cu<br>Copper<br>29    | 63.5<br>Cu<br>Copper<br>29    | 63.5<br>Cu<br>Copper<br>29    | 72.6<br>Ge<br>Germanium<br>32 |
| 65.4<br>Zn<br>Zinc<br>30      | 65.4<br>Zn<br>Zinc<br>30      | 65.4<br>Zn<br>Zinc<br>30      | 65.4<br>Zn<br>Zinc<br>30      | 65.4<br>Zn<br>Zinc<br>30      | 65.4<br>Zn<br>Zinc<br>30      | 65.4<br>Zn<br>Zinc<br>30      | 79.9<br>Br<br>Bromine<br>35   |
| 106<br>Pd<br>Palladium<br>46  | 106<br>Pd<br>Palladium<br>46  | 106<br>Pd<br>Palladium<br>46  | 106<br>Pd<br>Palladium<br>46  | 106<br>Pd<br>Palladium<br>46  | 106<br>Pd<br>Palladium<br>46  | 106<br>Pd<br>Palladium<br>46  | 127<br>I<br>Iodine<br>53      |
| 108<br>Ag<br>Silver<br>47     | 108<br>Ag<br>Silver<br>47     | 108<br>Ag<br>Silver<br>47     | 108<br>Ag<br>Silver<br>47     | 108<br>Ag<br>Silver<br>47     | 108<br>Ag<br>Silver<br>47     | 108<br>Ag<br>Silver<br>47     | 128<br>Te<br>Tellurium<br>52  |
| 112<br>Cd<br>Cadmium<br>48    | 112<br>Cd<br>Cadmium<br>48    | 112<br>Cd<br>Cadmium<br>48    | 112<br>Cd<br>Cadmium<br>48    | 112<br>Cd<br>Cadmium<br>48    | 112<br>Cd<br>Cadmium<br>48    | 112<br>Cd<br>Cadmium<br>48    | 131<br>Xe<br>Xenon<br>54      |
| 190<br>Os<br>Osmium<br>76     | 190<br>Os<br>Osmium<br>76     | 190<br>Os<br>Osmium<br>76     | 190<br>Os<br>Osmium<br>76     | 190<br>Os<br>Osmium<br>76     | 190<br>Os<br>Osmium<br>76     | 190<br>Os<br>Osmium<br>76     | (222)<br>Rn<br>Radon<br>86    |
| 186<br>Re<br>Rhenium<br>75    | 186<br>Re<br>Rhenium<br>75    | 186<br>Re<br>Rhenium<br>75    | 186<br>Re<br>Rhenium<br>75    | 186<br>Re<br>Rhenium<br>75    | 186<br>Re<br>Rhenium<br>75    | 186<br>Re<br>Rhenium<br>75    | (210)<br>Po<br>Polonium<br>84 |
| 184<br>W<br>Tungsten<br>74    | 184<br>W<br>Tungsten<br>74    | 184<br>W<br>Tungsten<br>74    | 184<br>W<br>Tungsten<br>74    | 184<br>W<br>Tungsten<br>74    | 184<br>W<br>Tungsten<br>74    | 184<br>W<br>Tungsten<br>74    | (210)<br>Po<br>Polonium<br>84 |
| 181<br>Ta<br>Tantalum<br>73   | 181<br>Ta<br>Tantalum<br>73   | 181<br>Ta<br>Tantalum<br>73   | 181<br>Ta<br>Tantalum<br>73   | 181<br>Ta<br>Tantalum<br>73   | 181<br>Ta<br>Tantalum<br>73   | 181<br>Ta<br>Tantalum<br>73   | (209)<br>Bi<br>Bismuth<br>83  |
| 179<br>Hf<br>Hafnium<br>72    | 179<br>Hf<br>Hafnium<br>72    | 179<br>Hf<br>Hafnium<br>72    | 179<br>Hf<br>Hafnium<br>72    | 179<br>Hf<br>Hafnium<br>72    | 179<br>Hf<br>Hafnium<br>72    | 179<br>Hf<br>Hafnium<br>72    | (207)<br>Pb<br>Lead<br>82     |
| 139<br>La<br>Lanthanum<br>57  | 139<br>La<br>Lanthanum<br>57  | 139<br>La<br>Lanthanum<br>57  | 139<br>La<br>Lanthanum<br>57  | 139<br>La<br>Lanthanum<br>57  | 139<br>La<br>Lanthanum<br>57  | 139<br>La<br>Lanthanum<br>57  | (204)<br>Ti<br>Thallium<br>81 |
| (227)<br>Ac<br>Actinium<br>89 | (227)<br>Ac<br>Actinium<br>89 | (227)<br>Ac<br>Actinium<br>89 | (227)<br>Ac<br>Actinium<br>89 | (227)<br>Ac<br>Actinium<br>89 | (227)<br>Ac<br>Actinium<br>89 | (227)<br>Ac<br>Actinium<br>89 | (204)<br>Ti<br>Thallium<br>81 |

f block

|                            |                                   |                              |                                 |                                |                                |                               |                                |                                  |                                  |                               |                                   |                                |                                  |
|----------------------------|-----------------------------------|------------------------------|---------------------------------|--------------------------------|--------------------------------|-------------------------------|--------------------------------|----------------------------------|----------------------------------|-------------------------------|-----------------------------------|--------------------------------|----------------------------------|
| f block                    |                                   |                              |                                 |                                |                                |                               |                                |                                  |                                  |                               |                                   |                                |                                  |
| Lanthanoid elements        |                                   |                              |                                 |                                |                                |                               |                                |                                  |                                  |                               |                                   |                                |                                  |
| 140<br>Ce<br>Cerium<br>58  | 141<br>Pr<br>Praseodymium<br>59   | 144<br>Nd<br>Neodymium<br>60 | (147)<br>Pm<br>Promethium<br>61 | 150<br>Sm<br>Samarium<br>62    | (153)<br>Eu<br>Europium<br>63  | 157<br>Gd<br>Gadolinium<br>64 | 159<br>Tb<br>Terbium<br>65     | 163<br>Dy<br>Dysprosium<br>66    | 165<br>Ho<br>Holmium<br>67       | 167<br>Er<br>Erbium<br>68     | 169<br>Tm<br>Thulium<br>69        | 173<br>Yb<br>Ytterbium<br>70   | 175<br>Lu<br>Lutetium<br>71      |
| Actinoid elements          |                                   |                              |                                 |                                |                                |                               |                                |                                  |                                  |                               |                                   |                                |                                  |
| 232<br>Th<br>Thorium<br>90 | (231)<br>Pa<br>Protactinium<br>91 | 238<br>U<br>Uranium<br>92    | (237)<br>Np<br>Neptunium<br>93  | (242)<br>Pu<br>Plutonium<br>94 | (243)<br>Am<br>Americium<br>95 | (247)<br>Cm<br>Curium<br>96   | (245)<br>Bk<br>Berkelium<br>97 | (251)<br>Cf<br>Californium<br>98 | (254)<br>Es<br>Einsteinium<br>99 | (253)<br>Fm<br>Fermium<br>100 | (256)<br>Md<br>Mendelevium<br>101 | (254)<br>No<br>Nobelium<br>102 | (257)<br>Lr<br>Lawrencium<br>103 |