**Chemistry Data Booklet**

**National 5**

For use in National Qualification Courses

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**Relationships for National 5 Chemistry**

*Eh*  *cm T*

*n*  *CV*

|  |  |
| --- | --- |
| *n =* | m |
|  | *GFM* |

|  |  |  |
| --- | --- | --- |
| *C*1*V*1 | *=* | *C*2*V*2 |
| 1 |  | *n*2 |

|  |  |
| --- | --- |
| *rate*  | *quantity* |
|  | *t* |

|  |  |  |  |
| --- | --- | --- | --- |
| % *by mass* | *=* | m | X 100 |
|  |  | GFM |  |

**Specific Heat Capacity of Liquid Water**

*c* = 4·18 kJ kg−1 °C−1

**Periodic Table of the Elements**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Column | Column | Column | Column | Column | Column | Column | Column |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 |  | 2 |  |  |
| Hydrogen |  | **Key** |  |  |  | Helium |  |  |
|  |  |  |  |  |  |  |  | Atomic Number |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **H** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **He** |  |  |
|  |  |  |  |  |  |  |  |  |  |  | Name of Element |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | 4 |  |  |  |  |  |  |  |  |  |  |  | Symbol |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  | 6 |  |  |  | 7 |  |  | 8 |  | 9 | 10 |  |  |
| Lithium | Beryllium |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Boron |  | Carbon |  | Nitrogen |  | Oxygen | Fluorine | Neon |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Li** | **Be** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **B** |  |  | **C** |  |  | **N** |  |  | **O** | **F** | **Ne** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 11 | 12 |  | 13 | 14 | 15 | 16 | 17 | 18 |  |  |
| Sodium | Magnesium |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | TRANSITION METALS |  |  |  |  |  |  |  |  |  |  | Aluminium | Silicon |  | Phosphorus |  | Sulfur | Chlorine | Argon |  |  |
| **Na** | **Mg** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **Al** |  |  | **Si** |  |  | **P** |  |  | **S** | **Cl** | **Ar** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 19 | 20 |  | 21 |  |  |  |  |  | 22 |  | 23 |  | 24 |  |  |  | 25 |  |  |  | 26 |  |  | 27 |  |  | 28 |  |  | 29 |  |  | 30 |  |  | 31 |  |  | 32 |  |  | 33 |  |  | 34 |  | 35 | 36 |  |  |
| Potassium | Calcium |  |  | Scandium |  |  |  |  |  | Titanium |  | Vanadium |  | Chromium |  | Manganese |  | Iron |  | Cobalt |  | Nickel |  | Copper |  | Zinc |  | Gallium |  | Germanium | Arsenic |  | Selenium | Bromine | Krypton |  |  |
| **K** | **Ca** |  |  |  | **Sc** |  |  |  |  |  | **Ti** |  | **V** |  | **Cr** |  |  | **Mn** |  |  | **Fe** |  | **Co** |  | **Ni** |  | **Cu** |  | **Zn** |  | **Ga** |  | **Ge** |  |  | **As** |  |  | **Se** | **Br** | **Kr** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 37 | 38 |  | 39 |  |  |  |  |  | 40 |  | 41 |  | 42 |  |  |  | 43 |  |  |  | 44 |  |  | 45 |  |  | 46 |  |  | 47 |  |  | 48 |  |  | 49 |  |  | 50 |  |  | 51 |  |  | 52 |  | 53 | 54 |  |
| Rubidium | Strontium |  |  | Yttrium |  |  |  |  |  | Zirconium |  | Niobium |  | Molybdenum |  | Technetium |  | Ruthenium | Rhodium | Palladium | Silver |  | Cadmium |  | Indium |  | Tin |  |  | Antimony |  | Tellurium | Iodine | Xenon |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Rb** | **Sr** |  |  |  | **Y** |  |  |  |  |  | **Zr** |  | **Nb** |  | **Mo** |  |  | **Tc** |  |  | **Ru** |  | **Rh** |  | **Pd** |  | **Ag** |  | **Cd** |  | **In** |  |  | **Sn** |  |  | **Sb** |  |  | **Te** | **I** | **Xe** |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 55 | 56 |  | 57 |  | 58-71 |  | 72 |  | 73 |  | 74 |  |  |  | 75 |  |  |  | 76 |  |  | 77 |  |  | 78 |  |  | 79 |  |  | 80 |  |  | 81 |  |  | 82 |  |  | 83 |  |  | 84 |  | 85 | 86 |  |  |
| Caesium | Barium |  |  | Lanthanum |  |  |  |  | Hafnium |  | Tantalum |  | Tungsten |  | Rhenium |  | Osmium |  | Iridium |  | Platinum | Gold |  | Mercury |  | Thallium |  | Lead |  |  | Bismuth |  | Polonium | Astatine | Radon |  |  |
| **Cs** | **Ba** |  |  |  | **La** |  |  |  |  |  | **Hf** |  | **Ta** |  | **W** |  |  | **Re** |  |  | **Os** |  | **Ir** |  | **Pt** |  | **Au** |  | **Hg** |  | **Tl** |  |  | **Pb** |  |  | **Bi** |  |  | **Po** | **At** | **Rn** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 87 | 88 |  | 89 |  | 90-103 |  | 104 |  | 105 |  | 106 |  |  | 107 |  |  | 108 |  | 109 |  |  | 110 |  |  | 111 |  |  | 112 |  |  |  |  |  |  | 114 |  |  |  |  |  | 116 |  |  |  |  |
| Francium | Radium |  |  | Actinium |  |  |  |  |  | Rutherfordium | Dubnium |  | Seaborgium |  | Bohrium |  | Hassium |  | Meitnerium | Darmstadtium | Roentgenium | Copernicium |  |  |  |  |  | Flerovium |  |  |  |  | Livermorium |  |  |  |  |
| **Fr** | **Ra** |  |  |  | **Ac** |  |  |  |  |  | **Rf** |  | **Db** |  | **Sg** |  |  | **Bh** |  |  | **Hs** |  | **Mt** |  | **Ds** |  | **Rg** |  | **Cn** |  |  |  |  |  | **Fl** |  |  |  |  |  | **Lv** |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 58 |  |  | 59 |  | 60 |  | 61 |  |  |  | 62 |  |  | 63 |  | 64 |  | 65 |  |  | 66 |  | 67 |  | 68 |  |  | 69 |  |  | 70 |  | 71 |  |  |  |  |  |
|  |  |  |  |  |  | Cerium |  | Praseodymium | Neodymium | Promethium |  | Samarium |  | Europium | Gadolinium |  | Terbium |  | Dysprosium |  | Holmium |  | Erbium |  | Thulium |  | Ytterbium | Lutetium |  |  |  |  |  |
|  |  |  |  |  |  |  | **Ce** |  |  | **Pr** |  | **Nd** |  | **Pm** |  |  | **Sm** |  |  |  | **Eu** |  |  | **Gd** |  |  | **Tb** |  |  | **Dy** |  |  | **Ho** |  | **Er** |  |  | **Tm** |  |  |  | **Yb** |  |  | **Lu** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 90 |  |  | 91 |  | 92 |  | 93 |  |  |  | 94 |  |  | 95 |  | 96 |  | 97 |  |  | 98 |  | 99 |  | 100 |  |  | 101 |  |  | 102 |  | 103 |  |  |  |  |  |
|  |  |  |  |  |  | Thorium |  | Protactinium | Uranium | Neptunium |  | Plutonium |  | Americium |  | Curium |  | Berkelium |  | Californium |  | Einsteinium | Fermium |  | Mendelevium |  | Nobelium | Lawrencium |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Th** |  |  | **Pa** |  |  | **U** |  | **Np** |  |  |  | **Pu** |  |  | **Am** |  |  | **Cm** |  |  | **Bk** |  |  | **Cf** |  |  | **Es** |  | **Fm** |  |  | **Md** |  |  | **No** |  |  | **Lr** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Elements below the dark line are metal

**Melting and Boiling Points of Selected Elements**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Group | Group | Group | Group | Group | Group | Group | Group |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 |  |  |
| Hydrogen |  |  |  | **Key** |  |  |  |  |  |  |  |  |  |  |  |  |  | Helium |  |  |
| **—259** |  |  |  | Atomic Number |  |  |  |  |  |  |  |  |  |  | **—272** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *—253* |  |  |  |  | Name of Element |  |  |  |  |  |  |  |  |  |  | *—269* |  |  |
|  |  |  |  |  | Melting Point/°C |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | 4 |  |  |  |  |  |  |  |  | 5 | 6 | 7 | 8 | 9 | 10 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lithium | Beryllium |  |  |  | *Boiling Point/°C* |  |  |  |  |  | Boron | Carbon | Nitrogen | Oxygen | Fluorine | Neon |  |  |
| **181** | **1287** |  |  |  |  |  |  |  |  |  |  |  | **2075** | **3825**† | **—210** | **—219** | **—220** | **—249** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| *1342* | *2471*\* |  |  |  |  |  |  |  |  |  |  |  | *4000* |  | *—196* | *—183* | *—188* | *—246* |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 11 | 12 |  |  |  |  |  |  |  |  |  |  |  | 13 | 14 | 15 | 16 | 17 | 18 |  |  |
| Sodium | Magnesium |  |  |  |  |  |  |  |  |  |  |  | Aluminium | Silicon | Phosphorus | Sulfur | Chlorine | Argon |  |  |
| **98** | **650** |  |  |  |  |  |  |  |  |  |  |  | **660** | **1414** | **44** | **115** | **—101** | **—189** |  |  |
| *883* | *1090* |  |  |  |  |  |  |  |  |  |  |  | *2519* | *3265* | *280* | *445* | *—34* | *—186* |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |  | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |  |
|  |  |  |
| Potassium | Calcium | Scandium | Titanium | Vanadium | Chromium | Manganese | Iron | Cobalt | Nickel | Copper | Zinc | Gallium | Germanium | Arsenic | Selenium | Bromine | Krypton |  |
| **63** | **842** | **1541** | **1668** | **1910** | **1907** | **1246** | **1538** |  | **1495** | **1455** | **1085** | **420** | **30** | **938** | **817**\* | **221** | **—7** | **—157** |  |
|  |  |  |
| *759* | *1484* | *2836* | *3287* | *3407* | *2672* | *2061* | *2861* |  | *2927* | *2913* | *2562* | *907* | *2204* | *2833* | *616*† | *685* | *59* | *—153* |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |  | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |  |  |
| Rubidium | Strontium | Yttrium | Zirconium | Niobium | Molybdenum | Technetium | Ruthenium | Rhodium | Palladium | Silver | Cadmium | Indium | Tin | Antimony | Tellurium | Iodine | Xenon |  |  |
| **39** | **777** | **1522** | **1855** | **2477** | **2623** | **2157** | **2333** |  | **1964** | **1555** | **962** | **321** | **157** | **232** | **631** | **449** | **114** | **—112** |  |  |
| *688* | *1382* | *3345* | *4409* | *4744* | *4639* | *4265* | *4150* |  | *3695* | *2963* | *2162* | *767* | *2072* | *2602* | *1587* | *988* | *184* | *—108* |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 55 | 56 | 57 | 72 | 73 | 74 | 75 | 76 |  | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 |  |  |
| Caesium | Barium | Lanthanum | Hafnium | Tantalum | Tungsten | Rhenium | Osmium | Iridium | Platinum | Gold | Mercury | Thallium | Lead | Bismuth | Polonium | Astatine | Radon |  |  |
| **28** | **727** | **920** | **2223** | **3017** | **3422** | **3185** | **3033** |  | **2446** | **1768** | **1064** | **—39** | **304** | **328** | **271** | **254** | **302** | **—71** |  |  |
| *671* | *1897* | *3464* | *4602* | *5458* | *5555* | *5596* | *5012* |  | *4428* | *3825* | *2856* | *357* | *1473* | *1749* | *1564* | *962* |  | *—62* |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

at\* 28 atmospheres

† sublimes

**Electron Arrangements of Main Group Elements**

|  |  |  |
| --- | --- | --- |
| Key |  |  |
| Atomic Number |  |
|  |  |
|  | Name of Element |  |
|  | Symbol |  |
|  | Electron arrangement |  |
|  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Group | Group | Group | Group | Group | Group | Group | Group |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 |  |  |  |  |  |  |  |  |  |  | 2 |  |  |  |
| Hydrogen |  |  |  |  |  |  |  |  |  |  | Helium |  |  |  |
| H |  |  |  |  |  |  |  |  |  |  | He |  |  |  |
| 1 |  |  |  |  |  |  |  |  |  |  | 2 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | 4 |  | 5 | 6 |  | 7 | 8 |  | 9 | 10 |  |  |  |
| Lithium | Beryllium |  | Boron | Carbon | Nitrogen | Oxygen |  | Fluorine | Neon |  |  |  |
| Li | Be |  | B | C | N | O |  | F | Ne |  |  |  |
| 2,1 | 2,2 |  | 2,3 | 2,4 |  | 2,5 | 2,6 |  | 2,7 | 2,8 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 11 | 12 |  | 13 | 14 |  | 15 | 16 |  | 17 | 18 |  |  |  |
| Sodium | Magnesium |  | Aluminium | Silicon | Phosphorus | Sulfur |  | Chlorine | Argon |  |  |  |
| Na | Mg |  | Al | Si | P | S |  | Cl | Ar |  |  |  |
| 2,8,1 | 2,8,2 |  | 2,8,3 | 2,8,4 |  | 2,8,5 | 2,8,6 |  | 2,8,7 | 2,8,8 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 19 | 20 |  | 31 | 32 |  | 33 | 34 |  | 35 | 36 |  |  |  |
| Potassium | Calcium |  | Gallium | Germanium | Arsenic | Selenium |  | Bromine | Krypton |  |  |  |
| K | Ca |  | Ga | Ge | As | Se |  | Br | Kr |  |  |  |
| 2,8,8,1 | 2,8,8,2 |  | 2,8,18,3 | 2,8,18,4 |  | 2,8,18,5 | 2,8,18,6 |  | 2,8,18,7 | 2,8,18,8 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 37 | 38 |  | 49 | 50 |  | 51 | 52 |  | 53 | 54 |  |  |  |
| Rubidium | Strontium |  | Indium | Tin | Antimony | Tellurium |  | Iodine | Xenon |  |  |  |
| Rb | Sr |  | In | Sn | Sb | Te |  | I | Xe |  |  |  |
| 2,8,18, | 2,8,18, |  | 2,8,18, | 2,8,18, |  | 2,8,18, | 2,8,18, |  | 2,8,18, | 2,8,18, |  |  |  |
| 8,1 | 8,2 |  | 18,3 | 18,4 |  | 18,5 | 18,6 |  | 18,7 | 18,8 |  |  |  |
| 55 | 56 |  | 81 | 82 |  | 83 | 84 |  | 85 | 86 |  |  |  |
| Caesium | Barium |  | Thallium | Lead | Bismuth | Polonium |  | Astatine | Radon |  |  |  |
| Cs | Ba |  | Tl | Pb | Bi | Po |  | At | Rn |  |  |  |
| 2,8,18, | 2,8,18, |  | 2,8,18, | 2,8,18, |  | 2,8,18, | 2,8,18, |  | 2,8,18, | 2,8,18, |  |  |  |
| 18,8,1 | 18,8,2 |  | 32,18,3 | 32,18,4 |  | 32,18,5 | 32,18,6 |  | 32,18,7 | 32,18,8 |  |  |  |
| 87 | 88 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Francium | Radium |  |  | The elements on this side | The elements on this side of the |  |
| Fr | Ra |  |  |  |
|  |  | of the dark line are metals. dark line are non-metals. |  |
| 2,8,18,32, | 2,8,18,32, |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| 18,8,1 | 18,8,2 |  |  |  |  |  |  |  |  |  |  |  |  |  |



**Flame Colours**

|  |  |  |
| --- | --- | --- |
| **Element** | **Ion** | **Flame colour** |
|  |  |  |
| barium | Ba2+ | green |
| calcium | Ca2+ | orange-red |
| copper | Cu2+ | blue-green |
| lithium | Li+ | red |

|  |  |  |
| --- | --- | --- |
| **Element** | **Ion** | **Flame colour** |
|  |  |  |
| potassium | K+ | lilac |
| sodium | Na+ | yellow |
| strontium | Sr2+ | red |

**Names, Symbols, Relative Atomic Masses, Densities and Dates of Discovery**

(Relative atomic masses, also known as average atomic masses, have been rounded to the nearest 0·5)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Element** | **Symbol** | **Relative** | **Density** | **Date of** |  |  |  |  |
| **atomic** | **(g cm-3)** | **Discovery** |  |  |  |  |
|  |  | **mass** |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Actinium | Ac | 227 | 10·1 | 1899 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Aluminium | Al | 27 | 2·70 | 1825 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Americium | Am | 243 | 13·7 | 1944 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Antimony | Sb | 122 | 6·68 | Ancient |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Argon | Ar | 40 | 0·0018 | 1894 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Arsenic | As | 75 | 5·78 | ~1250 |  |  |  |  |
| Astatine | At | 210 | unknown | 1940 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Barium | Ba | 137·5 | 3·62 | 1808 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Berkelium | Bk | 247 | 14·8 | 1949 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Beryllium | Be | 9 | 1·85 | 1798 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Bismuth | Bi | 209 | 9·79 | 1753 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Boron | B | 11 | 2·47 | 1808 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Bromine | Br | 80 | 3·12 | 1826 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Cadmium | Cd | 112·5 | 8·69 | 1817 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Calcium | Ca | 40 | 1·54 | 1808 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Californium | Cf | 251 | unknown | 1950 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Carbon | C | 12 | \* | Prehistoric |  |  |  |  |
| Cerium | Ce | 140 | 6·77 | 1803 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Caesium | Cs | 133 | 1·93 | 1860 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Chlorine | Cl | 35·5 | 0·0032 | 1774 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Chromium | Cr | 52 | 7·15 | 1797 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Cobalt | Co | 59 | 8·86 | 1739 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Copper | Cu | 63·5 | 8·96 | Ancient |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Curium | Cm | 247 | 13·3 | 1944 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Dysprosium | Dy | 162·5 | 8·55 | 1886 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Einsteinium | Es | 252 | unknown | 1952 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Erbium | Er | 167·5 | 9·07 | 1843 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Europium | Eu | 152 | 5·24 | 1896 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Fluorine | F | 19 | 0·0017 | 1886 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Francium | Fr | 223 | unknown | 1939 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Gadolinium | Gd | 157 | 7·90 | 1880 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Gallium | Ga | 69·5 | 5·91 | 1875 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Germanium | Ge | 72·5 | 5·32 | 1886 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Gold | Au | 197 | 19·3 | Ancient |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Hafnium | Hf | 178·5 | 13·3 | 1923 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Helium | He | 4 | 0·0002 | 1868 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Holmium | Ho | 165 | 8·80 | 1879 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Hydrogen | H | 1 | 0·00009 | 1766 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Indium | In | 115 | 7·31 | 1863 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Iodine | I | 127 | 4·95 | 1811 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Iridium | Ir | 192 | 22·5 | 1803 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Iron | Fe | 56 | 7·87 | Ancient |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Krypton | Kr | 84 | 0·0037 | 1898 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Lanthanum | La | 139 | 6·15 | 1839 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Lead | Pb | 207 | 11·3 | Ancient |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Lithium | Li | 7 | 0·53 | 1817 |  |  |  |  |
| Lutetium | Lu | 175 | 9·84 | 1907 |  |  |  |  |
| Magnesium | Mg | 24·5 | 1·74 | 1808 |  |  |  |  |

\*The density of carbon as graphite is 2·27 g cm−3 The density of carbon as diamond is 3·51 g cm−3 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Relative** | **Density** | **Date of** |  |
| **Element** | **Symbol** | **atomic** |  |
| **(g cm-3)** | **Discovery** |  |
|  |  | **mass** |  |
|  |  |  |  |  |
| Manganese | Mn | 55 | 7·47 | 1774 |  |
| Mercury | Hg | 200·5 | 13·5 | Ancient |  |
| Molybdenum | Mo | 96 | 10·2 | 1778 |  |
| Neodymium | Nd | 144 | 7·01 | 1885 |  |
| Neon | Ne | 20 | 0·0009 | 1898 |  |
| Neptunium | Np | 237 | 20·2 | 1940 |  |
| Nickel | Ni | 58·5 | 8·90 | 1751 |  |
| Niobium | Nb | 93 | 8·57 | 1801 |  |
| Nitrogen | N | 14 | 0.0013 | 1772 |  |
| Osmium | Os | 190 | 22·6 | 1803 |  |
| Oxygen | O | 16 | 0·0014 | 1774 |  |
| Palladium | Pd | 106·5 | 12·0 | 1803 |  |
| Phosphorus | P | 31 | 1·82 | 1669 |  |
| Platinum | Pt | 195 | 21·5 | 1735 |  |
| Plutonium | Pu | 244 | 19·7 | 1941 |  |
| Polonium | Po | 209 | 9·20 | 1898 |  |
| Potassium | K | 39 | 0·89 | 1807 |  |
| Praseodymium | Pr | 141 | 6·77 | 1885 |  |
| Promethium | Pm | 145 | 7·26 | 1944 |  |
| Protactinium | Pa | 231 | 15·4 | 1913 |  |
| Radium | Ra | 226 | 5·00 | 1898 |  |
| Radon | Rn | 222 | 0·0097 | 1900 |  |
| Rhenium | Re | 186 | 20·8 | 1925 |  |
| Rhodium | Rh | 103 | 12·4 | 1803 |  |
| Rubidium | Rb | 85·5 | 1·53 | 1861 |  |
| Ruthenium | Ru | 101 | 12·1 | 1844 |  |
| Samarium | Sm | 150·5 | 7·52 | 1853 |  |
| Scandium | Sc | 45 | 2·99 | 1879 |  |
| Selenium | Se | 79 | 4·81 | 1817 |  |
| Silicon | Si | 28 | 2·33 | 1824 |  |
| Silver | Ag | 108 | 10·5 | Ancient |  |
| Sodium | Na | 23 | 0·97 | 1807 |  |
| Strontium | Sr | 87·5 | 2·64 | 1790 |  |
| Sulfur | S | 32 | 2·09 | Ancient |  |
| Tantalum | Ta | 181 | 16·4 | 1802 |  |
| Technetium | Tc | 98 | 11 | 1937 |  |
| Tellurium | Te | 127·5 | 6·25 | 1782 |  |
| Terbium | Tb | 159 | 8·23 | 1843 |  |
| Thallium | Tl | 204·5 | 11·8 | 1861 |  |
| Thorium | Th | 232 | 11·7 | 1828 |  |
| Thulium | Tm | 169 | 9·32 | 1879 |  |
| Tin | Sn | 118·5 | 7·26 | Ancient |  |
| Titanium | Ti | 48 | 4·51 | 1791 |  |
| Tungsten | W | 184 | 19·3 | 1783 |  |
| Uranium | U | 238 | 19·1 | 1789 |  |
| Vanadium | V | 51 | 6·00 | 1801 |  |
| Xenon | Xe | 131·5 | 0·0059 | 1898 |  |
| Ytterbium | Yb | 173 | 6·90 | 1878 |  |
| Yttrium | Y | 89 | 4·47 | 1789 |  |
| Zinc | Zn | 65·5 | 7·14 | Ancient |  |
| Zirconium | Zr | 91 | 6·52 | 1789 |  |

 |

**Formulae of Selected Ions containing more than one kind of Atom**

|  |  |  |  |
| --- | --- | --- | --- |
| **one positive** | **one negative** | **two negative** | **three negative** |
| **Ion** | **Formula** | **Ion** | **Formula** | **Ion** | **Formula** | **Ion** | **Formula** |
| ammonium | NH4**+** | ethanoate | CH3COO**−** | carbonate | CO32**−** | phosphate | PO43**−** |
|  |  | hydrogencarbonate | HCO3**−** | chromate | CrO42**−** |  |  |
|  |  | hydrogensulfate | HSO **−** | dichromate | Cr2 O7 | **2-** |  |  |
|  |  | hydrogensulfite | HSO3**−** | sulfate | SO42**−** |  |  |
|  |  | hydroxide | OH**−** | sulfite | SO32**−** |  |  |
|  |  | nitrate | NO3**−** | thiosulfate | S2O32**−** |  |  |
|  |  | permanganate | MnO4**−** |  |  |  |  |

**Solubilities of Selected Compounds in Water**

The table shows how some compounds behave in cold water

|  |  |  |
| --- | --- | --- |
| vs | means very soluble | (a solubility greater than 10 g l−1) |
| s | means soluble | (a solubility of between 1 and 10 g l−1) |
| i | means insoluble | (a solubility of less than 1 g l−1) |

* no data

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **bromide** | **carbonate** | **chloride** | **iodide** | **nitrate** | **phosphate** | **sulfate** | **oxide** | **hydroxide** |
| **aluminium** | vs | − | vs | vs | vs | i | vs | i | i |
| **ammonium** | vs | vs | vs | vs | vs | vs | vs | − | − |
| **barium** | vs | i | vs | vs | vs | i | i | vs | vs |
| **calcium** | vs | i | vs | vs | vs | i | s | s | s |
| **copper(II)** | vs | i | vs | − | vs | i | vs | i | i |
| **iron(II)** | vs | i | vs | vs | vs | i | vs | i | i |
| **iron(III)** | vs | − | vs | − | vs | i | vs | i | i |
| **lead(II)** | s | i | s | i | vs | i | i | i | i |
| **lithium** | vs | vs | vs | vs | vs | i | vs | vs | vs |
| **magnesium** | vs | i | vs | vs | vs | i | vs | i | i |
| **nickel** | vs | i | vs | vs | vs | i | vs | i | i |
| **potassium** | vs | vs | vs | vs | vs | vs | vs | vs | vs |
| **silver** | i | i | i | i | vs | i | s | i | − |
| **sodium** | vs | vs | vs | vs | vs | vs | vs | vs | vs |
| **tin(II)** | vs | i | vs | s | − | i | vs | i | i |
| **zinc** | vs | i | vs | vs | vs | i | vs | i | i |

Note: Some of the compounds in the table hydrolyse significantly in water.

**Melting and Boiling Points of Selected Inorganic Compounds**

**COVALENT**

|  |  |  |
| --- | --- | --- |
| **Name of compound** | **mp/**°**C** | **bp/**°**C** |
|  |  |  |
| ammonia | —78 | —33 |
|  |  |  |
| carbon dioxide | —57 | —78 |
|  |  |  |
| carbon monoxide | —205 | —192 |
|  |  |  |
| nitrogen dioxide | —9 | 21 |
|  |  |  |
| silicon dioxide | 1713 | 2950 |
|  |  |  |
| sulfur dioxide | —75 | —10 |
|  |  |  |
| water | 0 | 100 |
|  |  |  |

**IONIC**

|  |  |  |
| --- | --- | --- |
| **Name of compound** | **mp/**°**C** | **bp/**°**C** |
|  |  |  |
| barium chloride | 961 | 1560 |
|  |  |  |
| calcium oxide | 2614 | 2850 |
|  |  |  |
| lithium bromide | 550 | 1265 |
|  |  |  |
| magnesium chloride | 714 | 1412 |
|  |  |  |
| potassium iodide | 681 | 1323 |
|  |  |  |
| sodium chloride | 801 | 1465 |
|  |  |  |

Under normal conditions, carbon dioxide does not melt but sublimes instead. The melting point and boiling point were measured under different conditions.

**Melting and Boiling Points of Selected Organic Compounds**

|  |  |  |
| --- | --- | --- |
| **Name of compound** | **mp/**°**C** | **bp/**°**C** |
|  |  |  |
| methane | —182·5 | —162 |
|  |  |  |
| ethane | —183 | —89 |
|  |  |  |
| propane | —188 | —42 |
|  |  |  |
| butane | —138 | —1 |
|  |  |  |
| pentane | —130 | 36 |
|  |  |  |
| hexane | —95 | 69 |
|  |  |  |
| heptane | —91 | 98 |
|  |  |  |
| octane | —57 | 126 |
|  |  |  |
|  |  |  |
| cyclobutane | —91 | 13 |
|  |  |  |
| cyclopentane | —93 | 49 |
|  |  |  |
| cyclohexane | 7 | 81 |
|  |  |  |
|  |  |  |
| 2-methylpropane | —159 | —12 |
|  |  |  |
| 2-methylbutane | —160 | 28 |
|  |  |  |
| 2-methylpentane | —154 | 60 |
|  |  |  |
| 2-methylhexane | —118 | 90 |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **Name of compound** | **mp/**°**C** | **bp/**°**C** |
|  |  |  |
| ethene | —169 | —104 |
|  |  |  |
| propene | —185 | —48 |
|  |  |  |
| but-1-ene | —185 | —6 |
|  |  |  |
| pent-1-ene | —165 | 30 |
|  |  |  |
| hex-1-ene | —140 | 63 |
|  |  |  |
|  |  |  |
| 2-methylpropene | —141 | —7 |
|  |  |  |
| 2-methylbut-1-ene | —138 | 31 |
|  |  |  |
| 2-methylpent-1-ene | —136 | 62 |
|  |  |  |
| 2-methylhex-1-ene | —103 | 92 |
|  |  |  |
|  |  |  |
| methanol | —97·5 | 65 |
|  |  |  |
| ethanol | —114 | 78 |
|  |  |  |
| propan-1-ol | —124 | 97 |
|  |  |  |
| propan-2-ol | —88 | 82 |
|  |  |  |
| butan-1-ol | —89 | 118 |
|  |  |  |
| butan-2-ol | —89 | 100 |
|  |  |  |
|  |  |  |
| methanoic acid | 8 | 101 |
|  |  |  |
| ethanoic acid | 17 | 118 |
|  |  |  |
| propanoic acid | —21 | 141 |
|  |  |  |
| butanoic acid | —5 | 164 |
|  |  |  |

**Electrochemical Series (Reduction Reactions)**



|  |  |
| --- | --- |
| **Metal**  | **Reaction** |
| lithium | Li+(aq) + e− |  | Li(s) |
| potassium | K+(aq) + e− |  | K(s) |
| calcium | Ca2+(aq) + 2e− |  | Ca(s) |
| sodium | Na+(aq) + e− |  | Na(s) |
| magnesium | Mg2+(aq) + 2e− |  | Mg(s) |
| aluminium | Al3+(aq) + 3e− |  | Al(s) |
| zinc | Zn2+(aq) + 2e− |  | Zn(s) |
| iron | Fe2+(aq) + 2e− |  | Fe(s) |
| nickel | Ni2+(aq) + 2e− |  | Ni(s) |
| tin | Sn2+(aq) + 2e− |  | Sn(s) |
| lead | Pb2+(aq) + 2e− |  | Pb(s) |
|  | Fe3+(aq) + 3e− |  | Fe(s) |
| **hydrogen** | 2H+(aq) + 2e− |  | H2(g) |
|  | S4O62- (aq) + 2e− |  | 2S2O32−(aq) |
|  | SO4 2−(aq) + 2H+(aq) + 2e− |  | SO32−(aq) + H2O(l) |
|  |  |  |  |
| copper | Cu2+(aq) + 2e− |  | Cu(s) |
|  | 2H2O( ) + O2(g) + 4e− |  | 4OH−(aq) |
|  | I2(s) + 2e− |  | 2I−(aq) |
|  | Fe3+(aq) + e− |  | Fe2+(aq) |
| silver | Ag+(aq) + e− |  | Ag(s) |
| mercury | Hg2+(aq) + 2e− |  | Hg(l ) |
|  | Br2(l) + 2e− |  | 2Br−(aq) |
|  | Cl2(g) + 2e− |  | 2Cl−(aq) |
| gold | Au+(aq) + e− |  | Au(s) |
|  | H2O2(aq) + 2H+(aq) + 2e− |  | 2H2O (l) |