



Chapter Twelve: Atoms and the Periodic Table

- **12.1 The Structure of the Atom**
- **12.2 Electrons**
- **12.3 The Periodic Table of Elements**
- **12.4 Properties of the Elements**



Chapter 12.3 Learning Goals

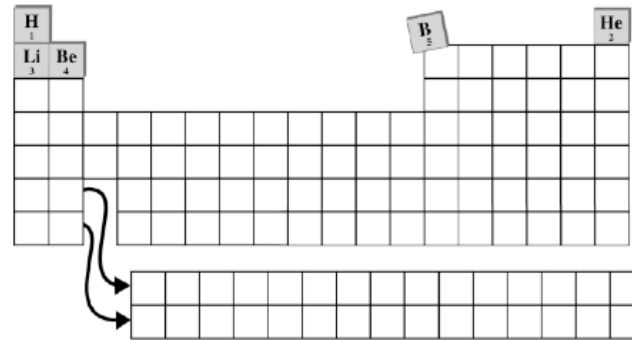
- Explain how the periodic table is organized.
- Use the periodic table to become familiar with groups of elements and their properties.
- Identify metals, semimetals, and nonmetals on the periodic table.



Investigation 12B The Periodic Table

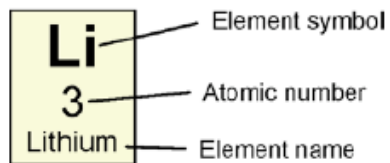
▪ Key Question:

How is the periodic table organized?





12.3 The Periodic Table



- **The periodic table organizes the elements according to how they combine with other elements (chemical properties).**
- **The periodic table is organized in order of increasing atomic number.**



12.3 The Periodic Table

| Alkali metals | | Group 2 metals | | Halogens | | Noble gases | |
|---------------|----------|----------------|----------|----------|----------|-------------|----------|
| Li 3 | Rb 37 | Be 4 | Sr 38 | F 9 | | He 2 | Kr 36 |
| Na 11 | Cs 55 | Mg 12 | Ba 56 | Cl 17 | I 53 | Ne 10 | Xe 54 |
| K 19 | Fr 87 | Ca 20 | Ra 88 | Br 35 | At 85 | Ar 18 | Rn 86 |

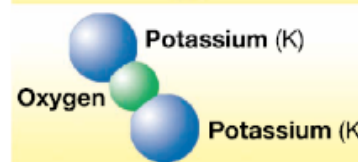
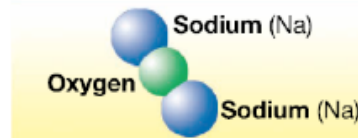
| Transition metals | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|----|----|----|----|
| Li | Be | | | | | | | | | | | | | | | He | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Na | Mg | | | | | | | | | | | | | | | Ne | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| K | Ca | Sc | Ti | V | Cr | Mn | Fe | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | Xe | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cs | Ba | | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fr | Ra | | Rf | Db | Sg | Bh | Hs | Mt | | | | | | | | Rn | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; text-align: center;"> <tr> <td>La</td><td>Ce</td><td>Pr</td><td>Nd</td><td>Pm</td><td>Sm</td><td>Eu</td><td>Gd</td><td>Tb</td><td>Dy</td><td>Ho</td><td>Er</td><td>Tm</td><td>Yb</td><td>Lu</td> </tr> <tr> <td>Ac</td><td>Th</td><td>Pa</td><td>U</td><td>Np</td><td>Pu</td><td>Am</td><td>Cm</td><td>Bk</td><td>Cf</td><td>Es</td><td>Fm</td><td>Md</td><td>No</td><td>Lr</td> </tr> </table> | | | | | | | | | | | | | | | | La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |
| La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- The periodic table is further divided into periods and groups.
- Each horizontal row is called a period.
- Each vertical column is called a group.

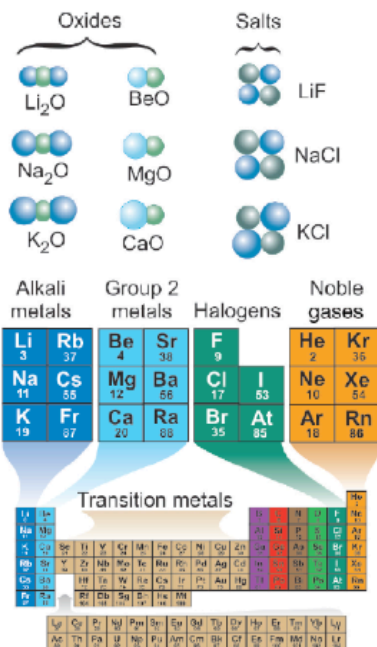


12.3 The Periodic Table

- All the elements in Group 1 of the periodic table form similar compounds.
- The metals lithium, sodium, and potassium all form compounds with a ratio of 2 atoms of the metal to 1 atom of oxygen.



Groups in the Periodic Table



Reading the Periodic Table

Periodic Table of the Elements

1
18

■ Main Group Elements

■ Non metals

■ Metalloids

■ Transition Elements

■ Metals

ROWS - PERIODS COLUMNS - GROUPS

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|------------------------------|---------------------------------|-----------------------------------|-------------------------------|--------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------------------|--------------------------------|-------------------------------|----------------------------------|----------------------------------|--------------------------------|------------------------------|-----------------------------|----------------------------|------------------------------|---------------------------|---------------------------------|------------------------------|-------------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|----------------------------|---------------------------|----------------------------|------------------------------|-----------------------------|-----------------------------|----------------------------|---------------------------------|---------------------------|------------------------------|------------------------------|------------------------------|---------------------------|------------------------------|--------------------------------|--------------------------------|-----------------------------|---------------------------------|------------------------------|--------------------------------|
| H 1 hydrogen | | | | | | | | | | | | | | | | | He 2 helium | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Li 3 lithium | Be 4 beryllium | | | | | | | | | | | B 5 boron | C 6 carbon | N 7 nitrogen | O 8 oxygen | F 9 fluorine | Ne 10 neon | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Na 11 sodium | Mg 12 magnesium | | | | | | | | | | | Al 13 aluminum | Si 14 silicon | P 15 phosphorus | S 16 sulfur | Cl 17 chlorine | Ar 18 argon | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| K 19 potassium | Ca 20 calcium | Sc 21 scandium | Ti 22 titanium | V 23 vanadium | Cr 24 chromium | Mn 25 manganese | Fe 26 iron | Co 27 cobalt | Ni 28 nickel | Cu 29 copper | Zn 30 zinc | Ga 31 gallium | Ge 32 germanium | As 33 arsenic | Se 34 selenium | Br 35 bromine | Kr 36 krypton | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rb 37 rubidium | Sr 38 strontium | Y 39 yttrium | Zr 40 zirconium | Nb 41 niobium | Mo 42 molybdenum | Tc 43 technetium | Ru 44 ruthenium | Rh 45 rhodium | Pd 46 palladium | Ag 47 silver | Cd 48 cadmium | In 49 indium | Sn 50 tin | Sb 51 antimony | Te 52 tellurium | I 53 iodine | Xe 54 xenon | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cs 55 cesium | Ba 56 barium | | Hf 72 hafnium | Ta 73 tantalum | W 74 tungsten | Re 75 rhenium | Os 76 osmium | Ir 77 iridium | Pt 78 platinum | Au 79 gold | Hg 80 mercury | Tl 81 thallium | Pb 82 lead | Bi 83 bismuth | Po 84 polonium | At 85 astatine | Rn 86 radon | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fr 87 francium | Ra 88 radium | | Rf 104 rutherfordium | Db 105 dubnium | Sg 106 seaborgium | Bh 107 bohrium | Hs 108 hassium | Mt 109 meitnerium | Uun 110 ununnium | Uuu 111 ununium | Uub 112 ununbium | Uuq 113 ununquadium | Uuq 114 ununquadium | 115 | 116 | 117 | 118 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td>La 57 lanthanum</td> <td>Ce 58 cerium</td> <td>Pr 59 praseodymium</td> <td>Nd 60 neodymium</td> <td>Pm 61 promethium</td> <td>Sm 62 samarium</td> <td>Eu 63 europium</td> <td>Gd 64 gadolinium</td> <td>Tb 65 terbium</td> <td>Dy 66 dysprosium</td> <td>Ho 67 holmium</td> <td>Er 68 erbium</td> <td>Tm 69 thulium</td> <td>Yb 70 ytterbium</td> <td>Lu 71 lutetium</td> </tr> <tr> <td>Ac 89 actinium</td> <td>Th 90 thorium</td> <td>Pa 91 protactinium</td> <td>U 92 uranium</td> <td>Np 93 neptunium</td> <td>Pu 94 plutonium</td> <td>Am 95 americium</td> <td>Cm 96 curium</td> <td>Bk 97 berkelium</td> <td>Cf 98 californium</td> <td>Es 99 einsteinium</td> <td>Fm 100 fermium</td> <td>Md 101 mendelevium</td> <td>No 102 nobelium</td> <td>Lr 103 lawrencium</td> </tr> </table> | | | | | | | | | | | | | | | | | | La 57 lanthanum | Ce 58 cerium | Pr 59 praseodymium | Nd 60 neodymium | Pm 61 promethium | Sm 62 samarium | Eu 63 europium | Gd 64 gadolinium | Tb 65 terbium | Dy 66 dysprosium | Ho 67 holmium | Er 68 erbium | Tm 69 thulium | Yb 70 ytterbium | Lu 71 lutetium | Ac 89 actinium | Th 90 thorium | Pa 91 protactinium | U 92 uranium | Np 93 neptunium | Pu 94 plutonium | Am 95 americium | Cm 96 curium | Bk 97 berkelium | Cf 98 californium | Es 99 einsteinium | Fm 100 fermium | Md 101 mendelevium | No 102 nobelium | Lr 103 lawrencium |
| La 57 lanthanum | Ce 58 cerium | Pr 59 praseodymium | Nd 60 neodymium | Pm 61 promethium | Sm 62 samarium | Eu 63 europium | Gd 64 gadolinium | Tb 65 terbium | Dy 66 dysprosium | Ho 67 holmium | Er 68 erbium | Tm 69 thulium | Yb 70 ytterbium | Lu 71 lutetium | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ac 89 actinium | Th 90 thorium | Pa 91 protactinium | U 92 uranium | Np 93 neptunium | Pu 94 plutonium | Am 95 americium | Cm 96 curium | Bk 97 berkelium | Cf 98 californium | Es 99 einsteinium | Fm 100 fermium | Md 101 mendelevium | No 102 nobelium | Lr 103 lawrencium | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |



12.3 Atomic Mass

- The mass of individual atoms is so small that the numbers are difficult to work with.
- To make calculations easier, scientists use the atomic mass unit (amu).
- The atomic mass of any element is the average mass (in amu) of an atom of each element.



12.3 Atomic Mass

- Atomic masses differ from mass numbers because most elements in nature contain more than one isotope.





12.3 Atomic Number

- Remember, the atomic number is the number of protons all atoms of that element have in their nuclei.

| | | | | | | | | | |
|---------------------------------|---|---------------------------------|-----------------------------------|---|-----------------------------------|---|-------------------------------------|---|---------------------------------|
| 1.008 1, 2 H 1 | | 6,941 6, 7 Li 3 | | | | | | | 4.003 3, 4 He 2 |
| 6,941 6, 7 Li 3 | 9,012 9 Be 4 | | 10,811 10, 11 B 5 | 12,011 12, 13 C 6 | 14,007 14, 15 N 7 | 15,999 16, 17, 18 O 8 | 18,998 19 F 9 | 20,180 20, 21, 22 Ne 10 | |
| 22,990 23 Na 11 | 24,305 24, 25, 26 Mg 12 | | 26,982 27 Al 13 | 28,086 28, 29, 30 Si 14 | 30,974 31 P 15 | 32,065 32,33,34,36 S 16 | 35,453 35, 37 Cl 17 | 39,948 36, 38, 40 Ar 18 | |

6,941 — Average atomic mass (amu)
6, 7 — Stable mass numbers
Li — Element symbol
3 — Atomic number



Alkali metals

| | |
|----------|----------|
| Li 3 | Rb 37 |
| Na 11 | Cs 55 |
| K 19 | Fr 87 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| Li 3 | Be 4 | | | | | | | | | | | | | | | | | B 5 | C 6 | N 7 | O 8 | F 9 | Ne 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Na 11 | Mg 12 | | | | | | | | | | | Al 13 | Si 14 | P 15 | S 16 | Cl 17 | Ar 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| K 19 | Ca 20 | Sc 21 | Ti 22 | V 23 | Cr 24 | Mn 25 | Fe 26 | Co 27 | Ni 28 | Cu 29 | Zn 30 | Ga 31 | Ge 32 | As 33 | Se 34 | Br 35 | Kr 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rb 37 | Sr 38 | Y 39 | Zr 40 | Nb 41 | Mo 42 | Tc 43 | Ru 44 | Rh 45 | Pd 46 | Ag 47 | Cd 48 | In 49 | Sn 50 | Sb 51 | Te 52 | I 53 | Xe 54 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cs 55 | Ba 56 | | | Hf 72 | Ta 73 | W 74 | Re 75 | Os 76 | Ir 77 | Pt 78 | Au 79 | Hg 80 | Tl 81 | Pb 82 | Bi 83 | Po 84 | At 85 | Rn 86 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fr 87 | Ra 88 | | | Rf 104 | Db 105 | Sg 106 | Bh 107 | Hs 108 | Mt 109 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <td>La 57</td> <td>Ce 58</td> <td>Pr 59</td> <td>Nd 60</td> <td>Pm 61</td> <td>Sm 62</td> <td>Eu 63</td> <td>Gd 64</td> <td>Tb 65</td> <td>Dy 66</td> <td>Ho 67</td> <td>Er 68</td> <td>Tm 69</td> <td>Yb 70</td> <td>Lu 71</td> </tr> <tr> <td>Ac 89</td> <td>Th 90</td> <td>Pa 91</td> <td>U 92</td> <td>Np 93</td> <td>Pu 94</td> <td>Am 95</td> <td>Cm 96</td> <td>Bk 97</td> <td>Cf 98</td> <td>Es 99</td> <td>Fm 100</td> <td>Md 101</td> <td>No 102</td> <td>Lr 103</td> </tr> </table> | | | | | | | | | | | | | | | | | | | La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 |
| La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Group 2 metals

| | |
|-----------------|-----------------|
| Be 4 | Sr 38 |
| Mg 12 | Ba 56 |
| Ca 20 | Ra 88 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| Li 3 | Be 4 | | | | | | | | | | | | | | | | | B 5 | C 6 | N 7 | O 8 | F 9 | Ne 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Na 11 | Mg 12 | | | | | | | | | | | | | | | | | Al 13 | Si 14 | P 15 | S 16 | Cl 17 | Ar 18 | | | | | | | | | | | | | | | | | | | | | | | | | |
| K 19 | Ca 20 | Sc 21 | Ti 22 | V 23 | Cr 24 | Mn 25 | Fe 26 | Co 27 | Ni 28 | Cu 29 | Zn 30 | Ga 31 | Ge 32 | As 33 | Se 34 | Br 35 | Kr 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rb 37 | Sr 38 | Y 39 | Zr 40 | Nb 41 | Mo 42 | Tc 43 | Ru 44 | Rh 45 | Pd 46 | Ag 47 | Cd 48 | In 49 | Sn 50 | Sb 51 | Te 52 | I 53 | Xe 54 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cs 55 | Ba 56 | | | Hf 72 | Ta 73 | W 74 | Re 75 | Os 76 | Ir 77 | Pt 78 | Au 79 | Hg 80 | Tl 81 | Pb 82 | Bi 83 | Po 84 | At 85 | Rn 86 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fr 87 | Ra 88 | | | Rf 104 | Db 105 | Sg 106 | Bh 107 | Hs 108 | Mt 109 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <td>La 57</td> <td>Ce 58</td> <td>Pr 59</td> <td>Nd 60</td> <td>Pm 61</td> <td>Sm 62</td> <td>Eu 63</td> <td>Gd 64</td> <td>Tb 65</td> <td>Dy 66</td> <td>Ho 67</td> <td>Er 68</td> <td>Tm 69</td> <td>Yb 70</td> <td>Lu 71</td> </tr> <tr> <td>Ac 89</td> <td>Th 90</td> <td>Pa 91</td> <td>U 92</td> <td>Np 93</td> <td>Pu 94</td> <td>Am 95</td> <td>Cm 96</td> <td>Bk 97</td> <td>Cf 98</td> <td>Es 99</td> <td>Fm 100</td> <td>Md 101</td> <td>No 102</td> <td>Lr 103</td> </tr> </table> | | | | | | | | | | | | | | | | | | | La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 |
| La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |



Halogens

| | |
|-----------------|-----------------|
| F 9 | |
| Cl 17 | I 53 |
| Br 35 | At 85 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|----------|-----------|----------|-----------|-----------|-----------|-----------|-----------|----------|----------|-----------|-----------|-----------|-----------|----------|----------|----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| Li 3 | Be 4 | | | | | | | | | | | B 5 | C 6 | N 7 | O 8 | F 9 | Ne 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Na 11 | Mg 12 | | | | | | | | | | | Al 13 | Si 14 | P 15 | S 16 | Cl 17 | Ar 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| K 19 | Ca 20 | Sc 21 | Ti 22 | V 23 | Cr 24 | Mn 25 | Fe 26 | Co 27 | Ni 28 | Cu 29 | Zn 30 | Ga 31 | Ge 32 | As 33 | Se 34 | Br 35 | Kr 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rb 37 | Sr 38 | Y 39 | Zr 40 | Nb 41 | Mo 42 | Tc 43 | Ru 44 | Rh 45 | Pd 46 | Ag 47 | Cd 48 | In 49 | Sn 50 | Sb 51 | Te 52 | I 53 | Xe 54 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cs 55 | Ba 56 | Hf 72 | | Ta 73 | W 74 | Re 75 | Os 76 | Ir 77 | Pt 78 | Au 79 | Hg 80 | Tl 81 | Pb 82 | Bi 83 | Po 84 | At 85 | Rn 86 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fr 87 | Ra 88 | Rf 104 | | Db 105 | Sg 106 | Bh 107 | Hs 108 | Mt 109 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <td>Lr 103</td> <td>Ce 58</td> <td>Pr 59</td> <td>Nd 60</td> <td>Pm 61</td> <td>Sm 62</td> <td>Eu 63</td> <td>Gd 64</td> <td>Tb 65</td> <td>Dy 66</td> <td>Ho 67</td> <td>Er 68</td> <td>Tm 69</td> <td>Yb 70</td> <td>Lu 71</td> </tr> <tr> <td>Ac 89</td> <td>Th 90</td> <td>Pa 91</td> <td>U 92</td> <td>Np 93</td> <td>Pu 94</td> <td>Am 95</td> <td>Cm 96</td> <td>Bk 97</td> <td>Cf 98</td> <td>Es 99</td> <td>Fm 100</td> <td>Md 101</td> <td>No 102</td> <td>Lr 103</td> </tr> </table> | | | | | | | | | | | | | | | | | | Lr 103 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 |
| Lr 103 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |



Noble gases

| | |
|----------|----------|
| He 2 | Kr 36 |
| Ne 10 | Xe 54 |
| Ar 18 | Rn 86 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| | | | | | | | | | | | | | | | | He 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Li 3 | Be 4 | | | | | | | | | | | B 5 | C 6 | N 7 | O 8 | F 9 | Ne 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Na 11 | Mg 12 | | | | | | | | | | | Al 13 | Si 14 | P 15 | S 16 | Cl 17 | Ar 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| K 19 | Ca 20 | Sc 21 | Ti 22 | V 23 | Cr 24 | Mn 25 | Fe 26 | Co 27 | Ni 28 | Cu 29 | Zn 30 | Ga 31 | Ge 32 | As 33 | Se 34 | Br 35 | Kr 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rb 37 | Sr 38 | Y 39 | Zr 40 | Nb 41 | Mo 42 | Tc 43 | Ru 44 | Rh 45 | Pd 46 | Ag 47 | Cd 48 | In 49 | Sn 50 | Sb 51 | Te 52 | I 53 | Xe 54 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cs 55 | Ba 56 | | Hf 72 | Ta 73 | W 74 | Re 75 | Os 76 | Ir 77 | Pt 78 | Au 79 | Hg 80 | Tl 81 | Pb 82 | Bi 83 | Po 84 | At 85 | Rn 86 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fr 87 | Ra 88 | | Rf 104 | Db 105 | Sg 106 | Bh 107 | Hs 108 | Mt 109 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <td>La 57</td> <td>Ce 58</td> <td>Pr 59</td> <td>Nd 60</td> <td>Pm 61</td> <td>Sm 62</td> <td>Eu 63</td> <td>Gd 64</td> <td>Tb 65</td> <td>Dy 66</td> <td>Ho 67</td> <td>Er 68</td> <td>Tm 69</td> <td>Yb 70</td> <td>Lu 71</td> </tr> <tr> <td>Ac 89</td> <td>Th 90</td> <td>Pa 91</td> <td>U 92</td> <td>Np 93</td> <td>Pu 94</td> <td>Am 95</td> <td>Cm 96</td> <td>Bk 97</td> <td>Cf 98</td> <td>Es 99</td> <td>Fm 100</td> <td>Md 101</td> <td>No 102</td> <td>Lr 103</td> </tr> </table> | | | | | | | | | | | | | | | | | | La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 |
| La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

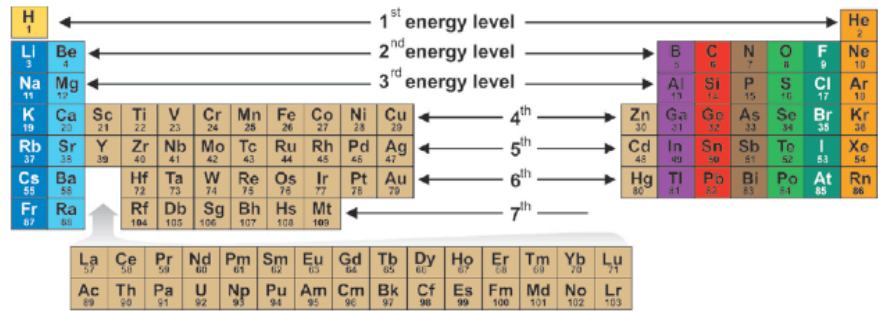


12.3 Transition metals

- In the middle of the periodic table are the transition metals, including titanium (Ti), iron (Fe), and copper (Cu).
- These elements are usually good conductors of heat and electricity.

| | | | | | | | | | | | | | | |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| Sc 21 | Ti 22 | V 23 | Cr 24 | Mn 25 | Fe 26 | Co 27 | Ni 28 | Cu 29 | Zn 30 | | | | | |
| Y 39 | Zr 40 | Nb 41 | Mo 42 | Tc 43 | Ru 44 | Rh 45 | Pd 46 | Ag 47 | Cd 48 | | | | | |
| | Hf 72 | Ta 73 | W 74 | Re 75 | Os 76 | Ir 77 | Pt 78 | Au 79 | Hg 80 | | | | | |
| | Rf 104 | Db 105 | Sg 106 | Bh 107 | Hs 108 | Mt 109 | | | | | | | | |
| La 57 | Ce 58 | Pr 59 | Nd 60 | Pm 61 | Sm 62 | Eu 63 | Gd 64 | Tb 65 | Dy 66 | Ho 67 | Er 68 | Tm 69 | Yb 70 | Lu 71 |
| Ac 89 | Th 90 | Pa 91 | U 92 | Np 93 | Pu 94 | Am 95 | Cm 96 | Bk 97 | Cf 98 | Es 99 | Fm 100 | Md 101 | No 102 | Lr 103 |

Energy Levels and the Periodic Table



| | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |

