

ELECTRONIC STRUCTURE AND PERIODICITY

The periodic table is the most essential learning aid in chemistry. It is an organized summary of information about the elements and predicts most of their properties and chemical reactions. The initial draft of the periodic table of elements started with Dmitry I. Mendeleev in the mid-19th century. The order of elements arranged based on their atomic numbers as we know today was recognized only in the early 20th century. (Pauling & Lagowski, 2024)

The Periodic Table: Key Terms (Bauer et al., 2024)

Periodic Table of the Elements

1 H Hydrogen 1.01																	2 He Helium 4.00	
3 Li Lithium 6.94	4 Be Beryllium 9.01							5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18					
11 Na Sodium 22.99	12 Mg Magnesium 24.31							13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95					
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 83.80	
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.29	
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides		72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (209.98)	86 Rn Radon 222.02
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Actinides		104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)
<div> <div>57 La Lanthanum 138.91</div> <div>58 Ce Cerium 140.12</div> <div>59 Pr Praseodymium 140.91</div> <div>60 Nd Neodymium 144.24</div> <div>61 Pm Promethium 144.91</div> <div>62 Sm Samarium 150.36</div> <div>63 Eu Europium 151.96</div> <div>64 Gd Gadolinium 157.25</div> <div>65 Tb Terbium 158.93</div> <div>66 Dy Dysprosium 162.50</div> <div>67 Ho Holmium 164.93</div> <div>68 Er Erbium 167.26</div> <div>69 Tm Thulium 168.93</div> <div>70 Yb Ytterbium 173.06</div> <div>71 Lu Lutetium 174.97</div> </div>																		
<div> <div>89 Ac Actinium 227.03</div> <div>90 Th Thorium 232.04</div> <div>91 Pa Protactinium 231.04</div> <div>92 U Uranium 238.03</div> <div>93 Np Neptunium 237.05</div> <div>94 Pu Plutonium 244.06</div> <div>95 Am Americium 243.06</div> <div>96 Cm Curium 247.07</div> <div>97 Bk Berkelium 247.07</div> <div>98 Cf Californium 251.08</div> <div>99 Es Einsteinium (254)</div> <div>100 Fm Fermium 257.10</div> <div>101 Md Mendelevium 258.10</div> <div>102 No Nobelium 259.10</div> <div>103 Lr Lawrencium (262)</div> </div>																		

Alkali Metal

Alkaline Earth

Transition Metal

Basic Metal

Metalloid

Nonmetal

Halogen

Noble Gas

Lanthanide

Actinide

Figure 1. Free printable periodic tables (PDF and PNG) - science notes and projects. (2024, August 28). Science Notes and Projects. <https://sciencenotes.org/printable-periodic-table/>

The elements are arranged in seven horizontal rows, in order of increasing atomic number from left to right and top to bottom. The rows are called *periods*, and they are numbered from 1 to 7. The elements are stacked so that elements with similar chemical properties form vertical columns, called *groups*, numbered from 1 to 18. Groups 1, 2, and 13–18 are the main group elements. Groups 3–12 are in the middle of the periodic table and are the transition elements. The two rows of 14 elements at the bottom of the periodic table are the lanthanides and the actinides, whose positions in the periodic table are indicated in group 3.

Classification of Elements in the Periodic Table

- **Period** - The periodic table consists of seven (7) horizontal rows.

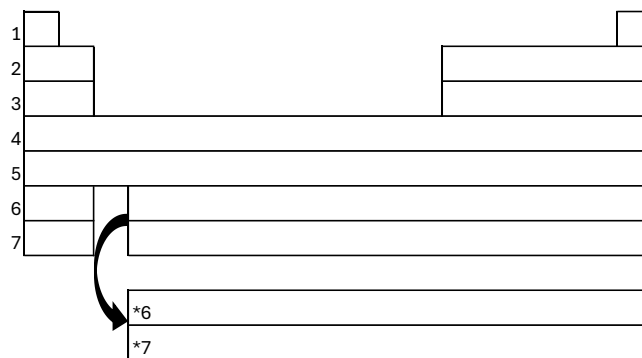


Figure 2. The row is labeled as periods.

- The first period contains two (2) elements, Hydrogen (H) and Helium (He)
- The second period includes eight (8) elements, from Lithium (Li) to Neon (Ne).
- The third period contains eight (8) elements, from Sodium (Na) to Argon (Ar).
- The fourth period contains eighteen (18) elements, from Potassium (K) to Krypton (Kr).
- The fifth period contains eighteen (18) elements, from Rubidium (Rb) to Xenon (Xe).
- The sixth and seventh period contains thirty-two (32) elements.
- The seventh period is incomplete. Although the elements from 105 are already named, the parenthesis in their atomic masses indicates that the elements are unstable.

- **Group/Families** – Vertical columns on the periodic table share similar chemical properties.

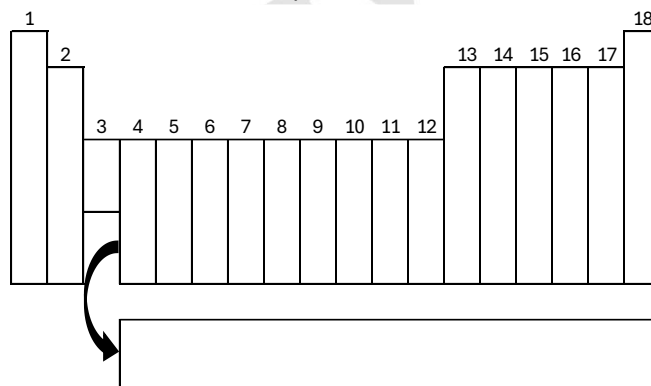


Figure 3. Columns as groups.

- Group 1 – Alkali Metals
- Group 2 – Alkaline Earth Metals
- Group 3 to 12 – Transition Metals
- Group 13 – Boron Group (triels)
- Group 14 – Carbon Group (tetrels)
- Group 15 – Pnictogens
- Group 16 – Chalcogens
- Group 17 – Halogens
- Group 18 – Noble gases

- **Metals** – Highly conductive elements to heat and electricity, usually solid, malleable, and ductile.

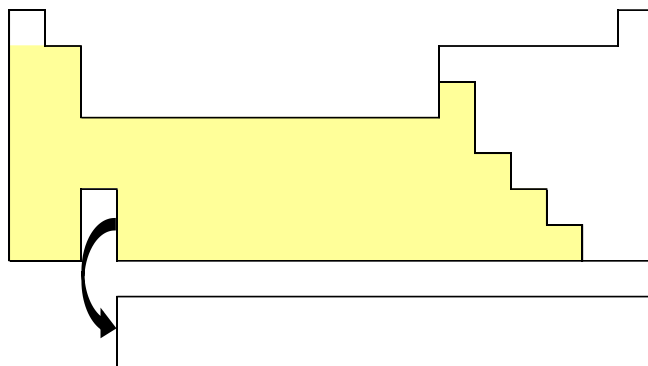


Figure 4. Elements that are metals in the periodic table.

- **Non-metals** – Elements that are poor in conduction of heat and electricity, very brittle, and cannot be rolled into wires or pounded into sheets. Some can exist as either solid or gas at room temperature.

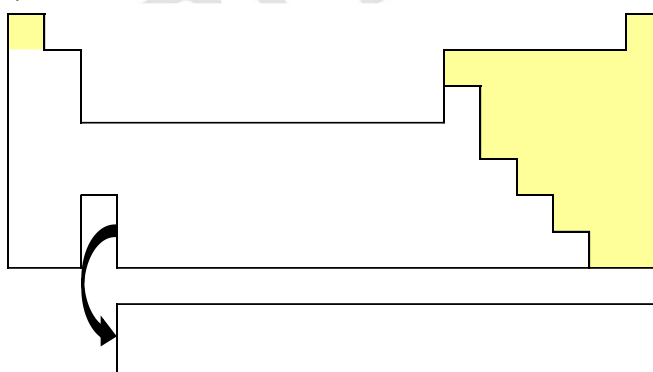


Figure 5. Elements that are non-metals in the periodic table.

- **Metalloids** – Elements found along the stair-step line that distinguish metals from non-metals and have properties of both metals and non-metals.

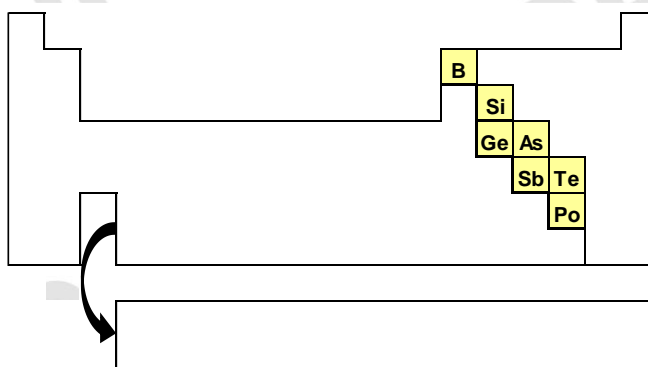


Figure 6. Elements that are metalloids in the periodic table.

- **Main-Group Elements** – Includes the active metals in the two (2) columns on the extreme left of the periodic table and the metals, semimetals, and nonmetals in the six (6) columns on the far right.

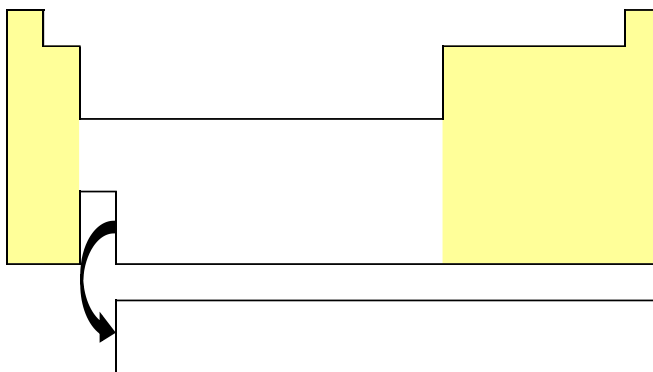


Figure 7. Location of main group elements in the periodic table.

- **Transition Metals** are more electronegative than the main group metals and, therefore, more likely to form covalent compounds.

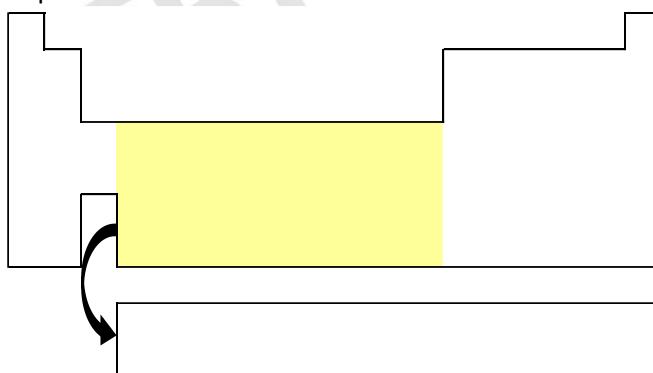


Figure 8. Location of transition metals in the periodic table.

- **Actinides and Lanthanides** – Located at the bottom of the table, they are sometimes known as the inner transition metals because they have atomic numbers that fall between the first and second elements in the last two (2) rows of the transition metals.

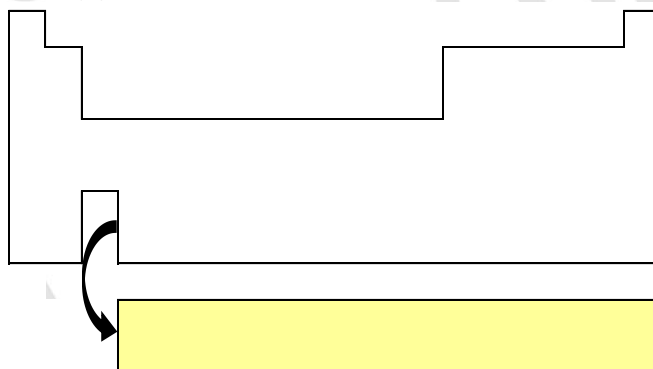


Figure 9. Location of actinides and lanthanides in the periodic table.

- **Chalcogens** – "ore formers"- are members of this group that show increasing metal character as the atomic number increases.

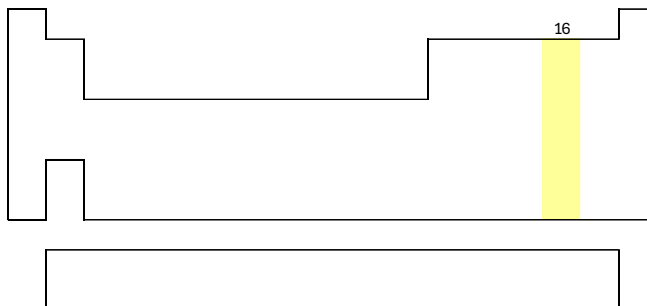


Figure 10. Location of chalcogens in the periodic table.

- **Halogens** – “salt formers”- exist as diatomic molecules in elemental states that are highly reactive and readily combine with most elements.

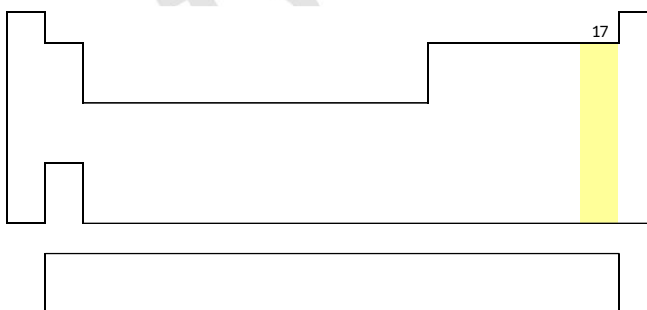


Figure 11. Location of halogens in the periodic table.

- **Noble gasses** – Inert gasses, which have an oxidation state of 0, contain a maximum number of electrons in their outer shell, making them stable.

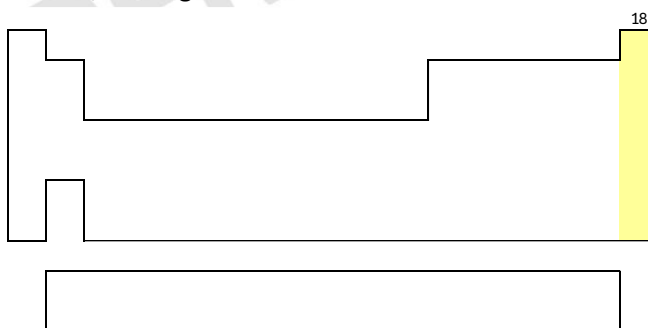


Figure 12. Location of noble gases in the periodic table.

Properties of Main Group Elements (Pauling & Lagowski, 2024)

The main group elements are the most abundant in the universe and are often called representative elements. These elements are located in the s- and p- blocks of the periodic table, meaning their electron configurations end in the s or p orbitals. Group 1 elements have one (1) valence electron, Group 2 elements have two (2), Group 13 elements have three (3), and this pattern continues up to Group 18, which has eight valence electrons.

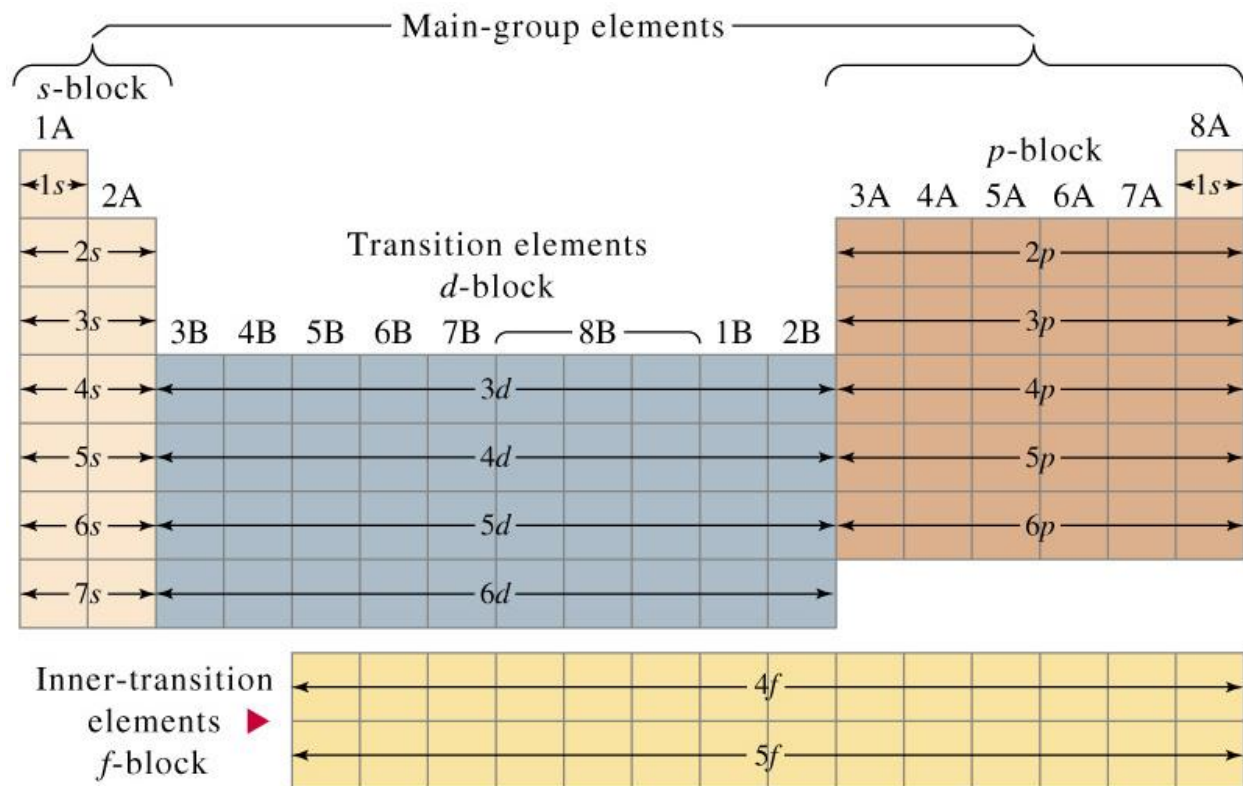


Figure 13. The summary of different periodic trends.

Properties of s-block elements

1. The oxidation state of Group 1 elements, the alkali metals, is +1. The Group 2 elements, alkaline earth metals' oxidation number is +2.
2. These elements are very reactive except Helium.
3. The s-block metals are soft and have low melting and boiling points.
4. The metals in the s-block react to form basic oxides, hydrides, and hydroxides.

Properties of p-block elements

Group 13 – Icosagens
 Group 14 – Crytsallogens
 Group 15 – Pnictogens
 Group 16 – Chalcogens
 Group 17 – Halogens
 Group 18 – Noble gases

1. The oxidation states of p-block metals vary but are generally dependent on the electrons in the p-orbital. The noble gases of Group 18 have oxidation states equal to zero (0) because they are stable.
2. The p-block elements comprise non-metals, metalloids, and metals; thus, their properties vary.
3. The non-metals F, Cl, Br, and I form ionic compounds in the p-block.

Elemental Properties and Periodic Trends (Pauling & Lagowski, 2024b)

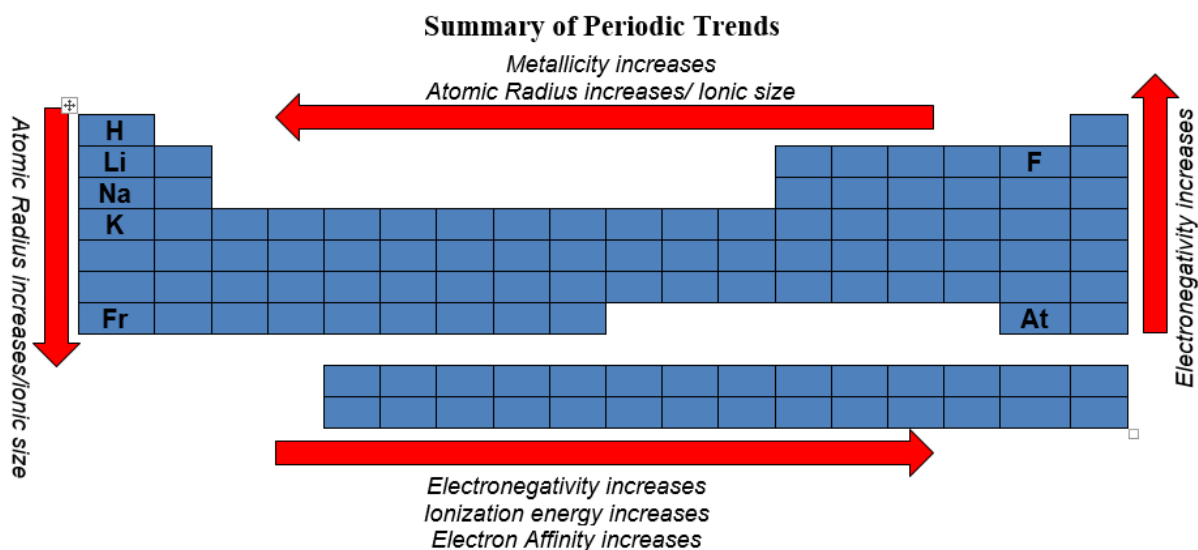


Figure 14. The summary of different periodic trends.

*The arrow indicated the increase of the different parameters among elements.

1. Electronegativity

- Tendency of an electron to bond
- Increases from left to right along a period
- Decreases from top to bottom along a column or group

2. Ionization Energy

- The energy needed to remove an electron from an atom
- Increases from left to right along a period
- Decreases from top to bottom along a column or group

3. Electron Affinity

- The energy released when an electron is added to an atom
- Positive when energy is released, negative when absorbed
- Generally, increases from left to right along a period
- Decreases from top to bottom along a column or group

4. Atomic Size/Radius

- The farthest extent of the presence of electrons
- Decreases from left to right along a period
- Increases from top to bottom along a column or group

5. Metallic Property

- Defined as how readily an atom can lose an electron
- The metallic character increases from right to left
- Increases from top to bottom.

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