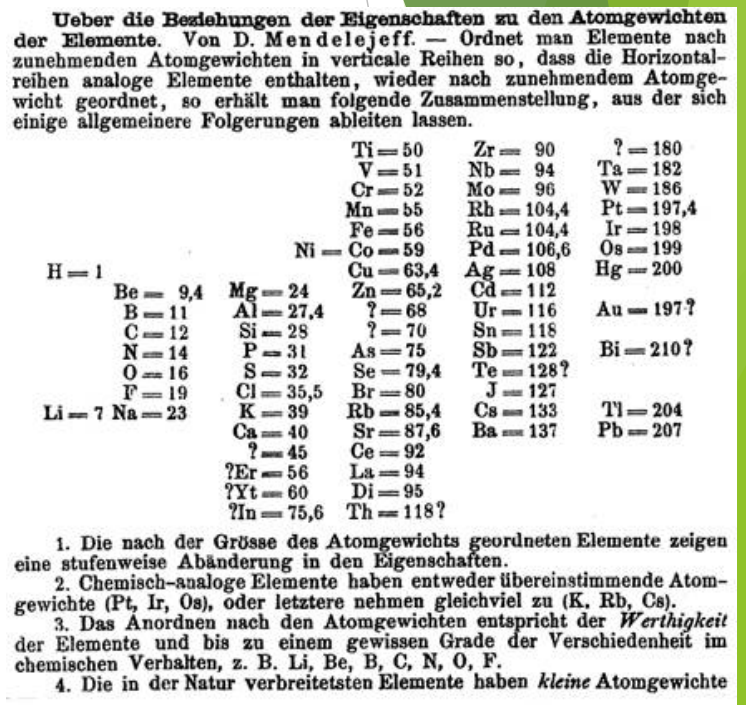
Periodic Trends

History of the Periodic Table

- Many scientists suspected a pattern in the order of the elements, but were not able to exactly figure it out.
- **Dmitri Mendeleev** was the first to create an accurate arrangement of the known elements based on atomic mass.



Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente. Von D. Mendelejeff. — Ordnet man Elemente nach zunehmenden Atomgewichten in verticale Reihen so, dass die Horizontalreihen analoge Elemente enthalten, wieder nach zunehmendem Atomgewicht geordnet, so erhält man folgende Zusammenstellung, aus der sich einige allgemeinere Folgerungen ableiten lassen.

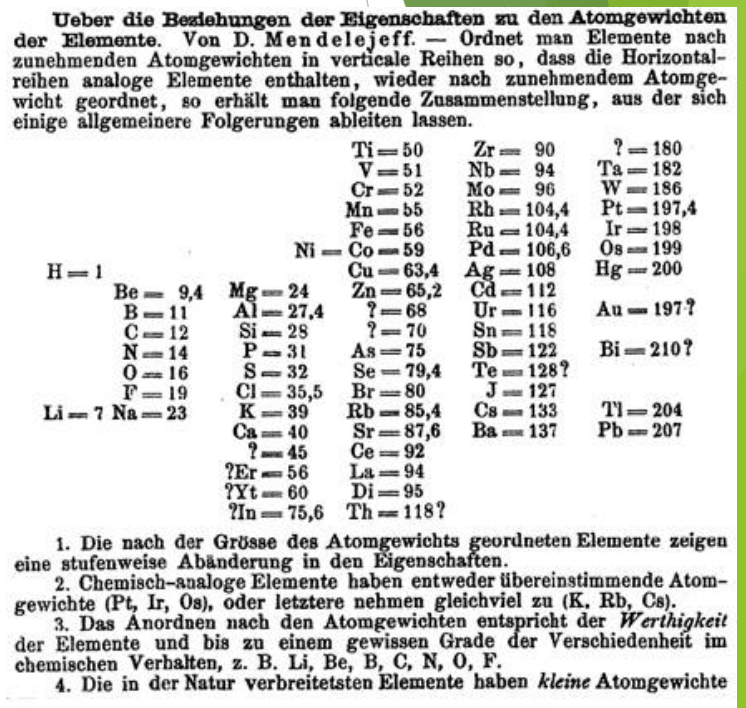
			Ti = 50	Zr = 90	? = 180	
			V = 51	Nb = 94	Ta = 182	
			Cr = 52	Mo = 96	W = 186	
			Mn = 55	Rh = 104,4	Pt = 197,4	
			Fe = 56	Ru = 104,4	Ir = 198	
		Ni =	Co = 59	Pd = 106,6	Os = 199	
H = 1			Cu = 63,4	Ag = 108	Hg = 200	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112		
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35,5	Br = 80	J = 127		
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204	
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207	
		? = 45	Ce = 92			
		?Er = 56	La = 94			
		?Yt = 60	Di = 95			
		?In = 75,6	Th = 118?			

1. Die nach der Grösse des Atomgewichts geordneten Elemente zeigen eine stufenweise Abänderung in den Eigenschaften.
2. Chemisch-analoge Elemente haben entweder übereinstimmende Atomgewichte (Pt, Ir, Os), oder letztere nehmen gleichviel zu (K, Rb, Cs).
3. Das Anordnen nach den Atomgewichten entspricht der *Werthigkeit* der Elemente und bis zu einem gewissen Grade der Verschiedenheit im chemischen Verhalten, z. B. Li, Be, B, C, N, O, F.
4. Die in der Natur verbreitetsten Elemente haben *kleine* Atomgewichte

Mendeleev's Periodic Table, published in *Zeitschrift für Chemie*, 1869.

- Mendeleev was actually able to predict the existence of elements that didn't exist yet,
  based just on missing spaces in the patterns he saw on his periodic table.
  - Accurately predicted the actual properties of four of those undiscovered elements, including gallium, scandium, technetium, and germanium.

	Predicted Element	Actual Element
Name	Eka-Aluminum	Gallium
Density	6.0 g/cm^3	5.9 g/cm^3
Melting Point	Low	29.78C
Compound made with oxygen	Ea_2O_3	Ga_2O_3



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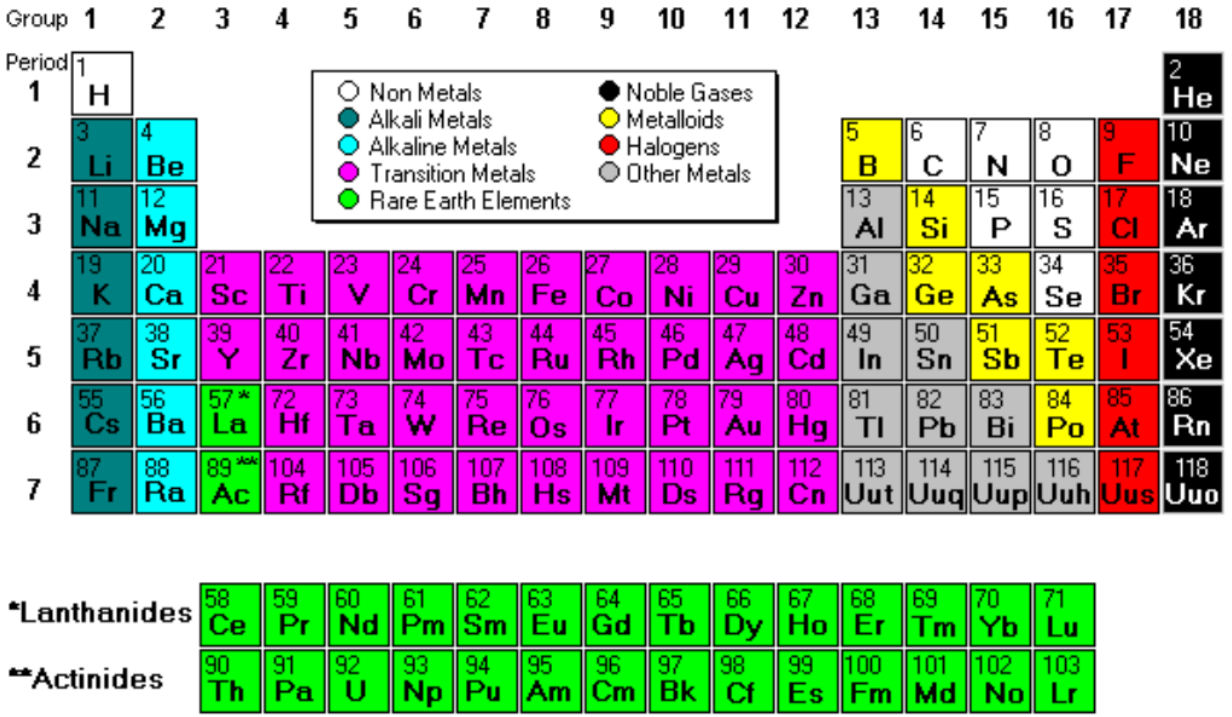
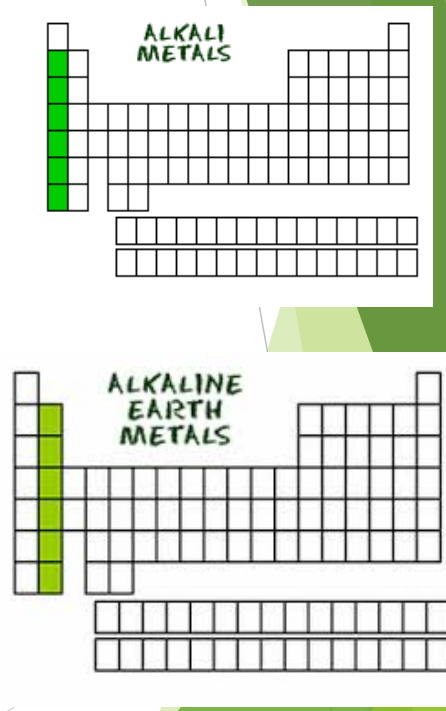
- Today, the periodic table is divided into a series of horizontal **periods** and vertical **groups** or families.
- Elements within a period or family will follow certain general trends, or have specific properties in common.

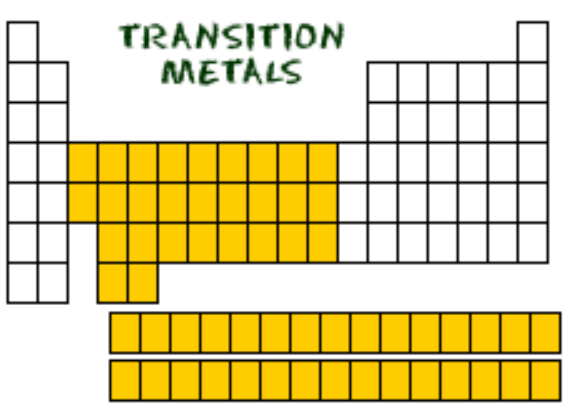


Periodic Table Groups

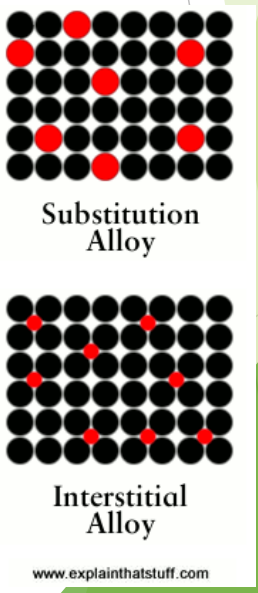
- **Alkali metals** occupy group 1.
  - One valence electron.
  - Highly reactive.
  - Rarely found in nature as pure elements.
- **Alkaline earth metals** occupy group 2.
  - Two valence electrons.
  - Reactive, but not as much as the alkali metals.
  - All are found in nature.



- **Transition metals** occupy groups 3-12.
  - Also referred to as the “d-block” because their electrons fill in the d sublevels.
  - Can form more than one ion due to the high number of d-sublevel electrons.
  - Able to form a wide variety of different colored compounds.
  - The bottom two rows, removed from the periodic table, are also called **rare earth metals**.

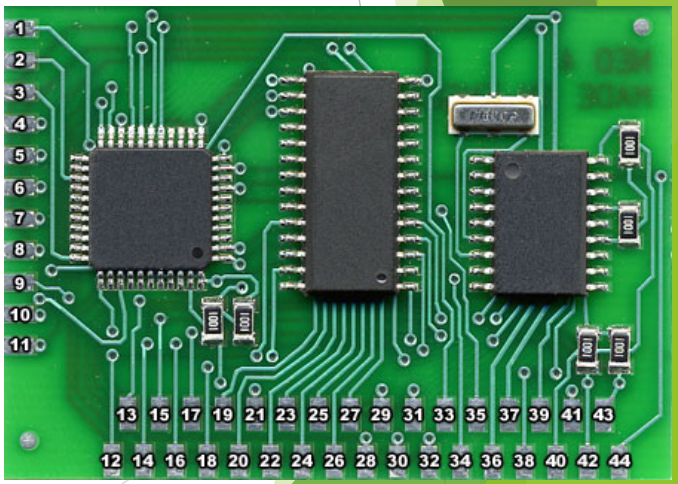


- Each of these groups contain **metals**, which all have a common set of properties:
  - Usually solid, with a high melting and boiling point.
    - Exceptions: Mercury (Hg) and Gallium (Ga) are liquids.
  - **Malleable**, meaning they can be hammered into thin sheets.
  - **Ductile**, meaning they can be drawn or twisted into wires.
  - **Conductive**, meaning they can transport electrons and heat.
- Some metals can be combined with other elements to produce **alloys**.
  - Alloys are technically mixtures, but may have better properties (stronger, resistant to corrosion) than their parent metal.

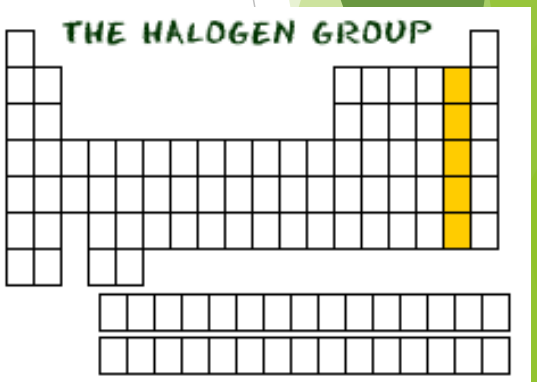


- Common alloys include:
  - Amalgam: Mercury + silver, tin, copper, and zinc.
  - Brass: Copper + zinc.
  - Bronze: Copper + tin.
  - Stainless Steel: Iron + chromium and carbon.
  - Sterling silver: Silver + copper
  - White gold: Gold + palladium, silver, and copper.

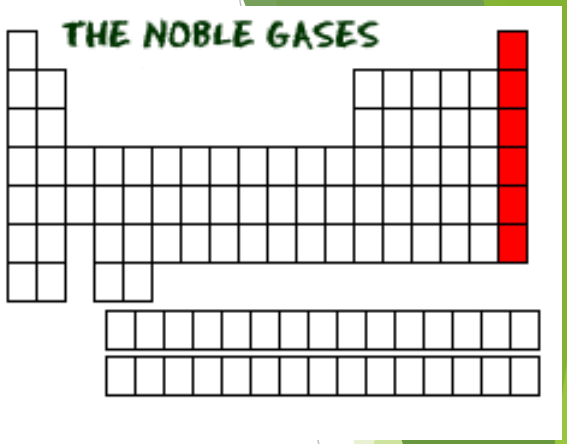
- The next four groups are named after the element at the top.
  - Group 13 is the boron family
  - Group 14 is the carbon family.
  - Group 15 is the nitrogen family.
  - Group 16 is the oxygen family.
- The boron family has the first metalloid on the periodic table.
- **Metalloids** have properties in between those of metals and nonmetals.
  - Example: They are electrical **semiconductors**, meaning they conduct electricity under some conditions, but not others.



- The last two groups of the periodic table only contain **nonmetals**, which also have a common set of properties.
  - They can be solids, liquids, or gases at room temperature.
  - Boiling and melting points are lower than metals.
  - They do not conduct electricity or heat well.
  - Solid nonmetals are usually brittle, and do not have a luster.
- The **halogens** occupy group 17.
  - Seven valence electrons.
  - Reactive.
  - Also called “salt-formers”, because they combine with various metals to produce salts.

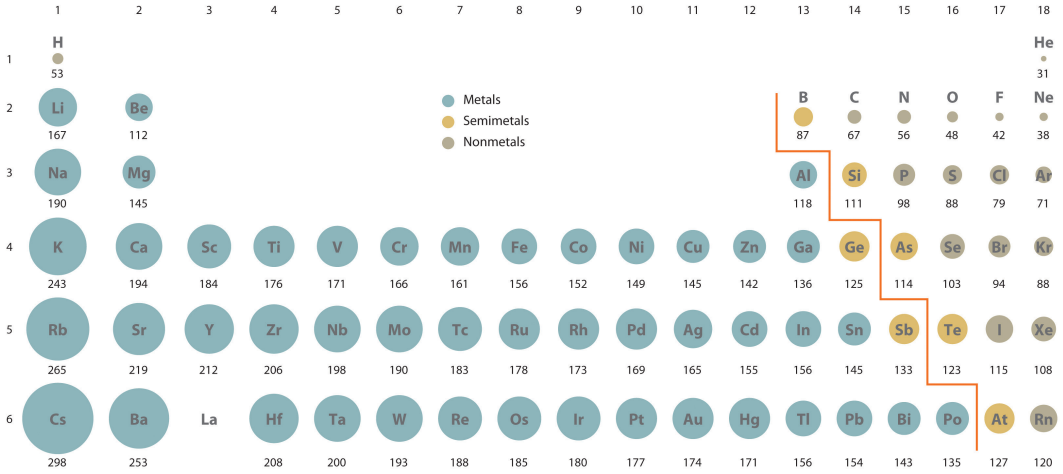


- Group 18 is the **noble gases**.
  - All are gases at room temperature.
  - Each has a full outer shell of valence electrons (2 for helium, 8 for the rest).
  - Very stable and non-reactive.

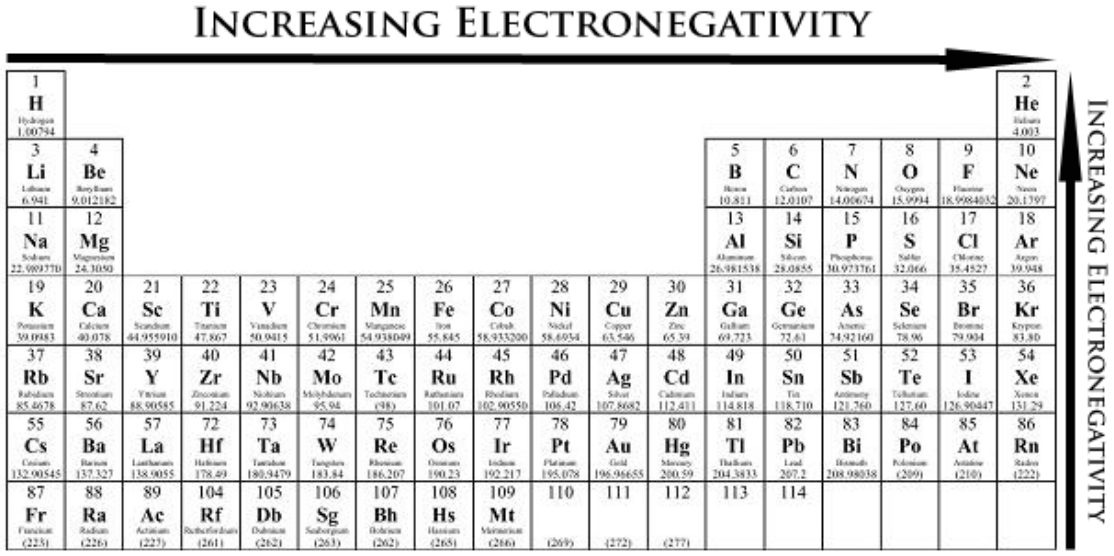


Periodic Trends

- Other properties will change in predictable ways as you move across or down the periodic table.
- **Atomic radius** is a measurement of how big an atom is.
  - Increases as you move down a group.
  - Decreases as you move across a period.



- **Electronegativity** and **electron affinity** measure the ability of an atom to attract and bond to other electrons.
  - Increases across a period.
  - Decreases down a period.



- **Ionization energy** is the amount of energy needed to remove an electron from a neutral atom.
  - Increases from left to right.
  - Decreases from top to bottom.
- As you move down a period, the valence electrons become more **shielded** from the nucleus, making them easier to remove.