Unit 3.2: The Periodic Table and Periodic Trends Notes

The Organization of the Periodic Table

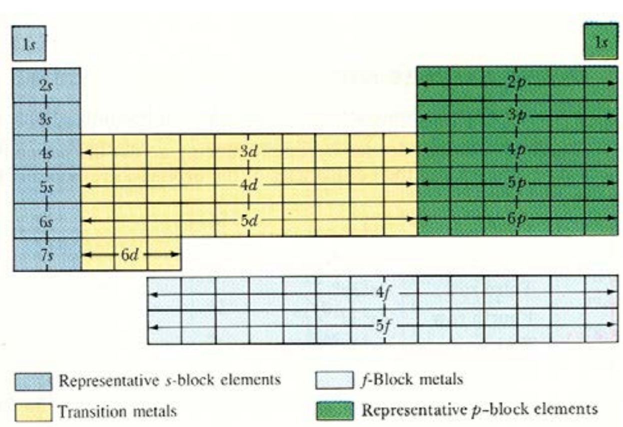
Dmitri Mendeleev was the first to organize the elements by their periodic properties. In 1871 he arranged the elements in vertical columns by their atomic mass and found he could get horizontal groups of 3 or 4 that had similar properties. Mendeleev discovered a repeating pattern or periodic trend in the elements that were known at the time. He was able to predict properties of elements that were not yet discovered.
In some cases Mendeleev's table had some irregularities. Putting elements in order of increasing atomic mass put elements in column where they didn't seem to fit (Te and I). Mendeleev thought the masses must be wrong, but he was wrong!


ПЕРИОДИЧЕСКАЯ СИСТЕМА ЭЛЕМЕНТОВ

ГРУППЫ ЭЛЕМЕНТОВ

	I	II	III	IV	V	VI	VII	VIII
I	H 1							
II	Li 7	Be 9,4	B 11	C 12	N 14	O 16	F 19	
III	Na 23	Mg 24	Al 27,4	Si 28	P 31	S 32	Cl 35,5	
IV	K 39	Ca 40	? 45	Ti 50	V 51	Cr 52	Mn 55	Fe 56 Co 59 Ni 59
V	Cu 63,4	Zn 65,2	? 68	? 70	As 75	Se 79,4	Br 80	
VI	Rb 85,4	Sr 87,6	Yt ? 88	Zr 90	Nb 94	Mo 96	? 100	Ru 104,4 Rh 104,4 Pd 106,6
VII	Ag 108	Cd 112	In 113	Sn 118	Sb 122	Te 128?	J 127	
VIII	Cs 133	Ba 137	Di ? 138	Ce ? 140				
IX								
X			Er ? 178	La ? 180	Ta 182	W 186		Pt 197,4 Ir 198 Os 199
XI	Au 197?	Hg 200	Tl 204	Pb 207	Bi 210			
XII				Th 231		U 240		

[Mendeleev's Periodic Table]



[Electron Configuration Periodic Table]

Henry Moseley later discovered that each element has a unique nuclear charge. The nuclear charge is the total charge of all the protons in the nucleus, which has the same value as the atomic number. When he arranged in order of atomic number instead of atomic mass the irregularities Mendeleev found disappeared.

THE PERIODIC LAW: Physical and chemical properties of the elements are periodic properties of their atomic number.

The elements are arranged in the table by their electron configurations. Elements in the same *vertical* column are called families or groups. Groups have similar properties and the same arrangements of valence electrons in their outer electron shell. Elements in the same *horizontal* row are called periods. Periods have the same major energy level.

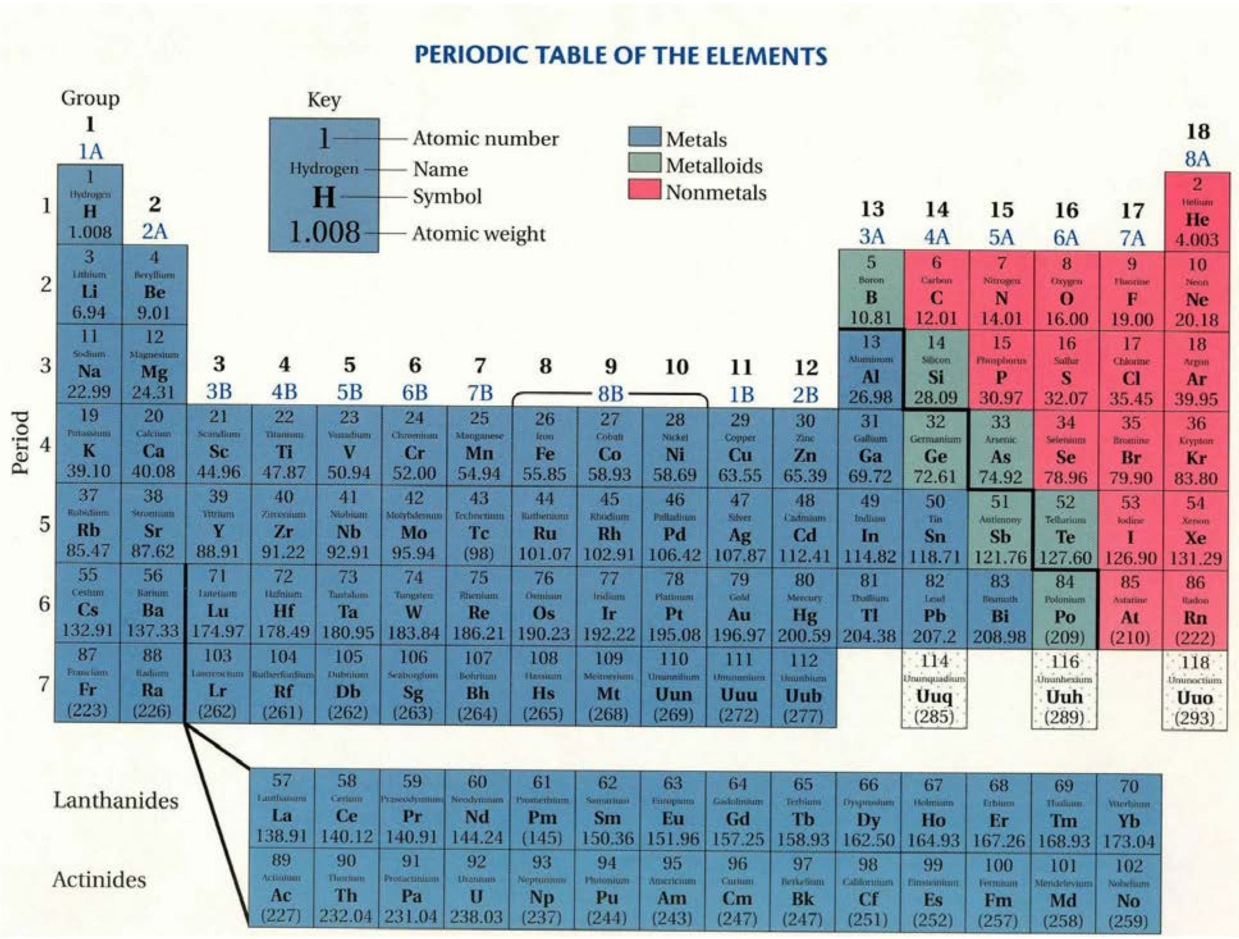
The periodic table provides a map for all the elements:

<u>Metals</u> – solids except for Hg mercury; good conductors, shiny, malleable

<u>Nonmetals</u> – gases or brittle solids

<u>Metalloids</u> – along the "stairstep"

<u>Noble gases</u> – nonreactive gases, monoatomic, almost inert group VIIIA (or sometimes 18)



<u>The Groups of the Periodic Table</u>

<u>ALKALI METALS</u>

Group 1 is the alkali metals. These are <u>soft</u> metals whose outer electron shell has an s^1 configuration. These are the most active metals. They tend to react <u>quickly</u> with air or water, producing a basic solution in water. They lose the s^1 electron and become <u>ions</u> with a +1 positive charge. Notice that if this happens they have the electron configuration of a <u>noble gas</u>.

<u>ALKALINE EARTH METALS</u>

Group 2 is the alkaline earth metals. Their outer electron shell has an s^2 configuration. They are harder & less <u>reactive</u> than the Group 1 metals. They lose the s^2 electron and become ions with a +2 positive <u>charge</u>. Notice that if this happens they have the electron configuration of a <u>noble gas</u>.

TRANSITION METALS
Groups 3 through 12 contain transition elements. The transition metals are harder & less reactive than Group 1 & 2 metals. Because the outer shells of these elements are filling the d-orbital, they are sometimes called d-block elements.

LANTHANIDES
The lanthanide (4f) series have atomic numbers 57-71. These metals are shiny & reactive. Some are used as phosphors that glow when electrons hit them.

ACTINIDES
The actinide (5f) series have atomic numbers 89-103. These metals are all radioactive. Many are man-made. Uranium is important in nuclear energy reactions.

MAIN BLOCK ELEMENTS
Groups 3 through 8 are called the main block elements. The metals in this group are aluminum, gallium, indium, tin, thallium, lead, bismuth, & polonium. The metalloids in this group are boron, silicon, germanium, arsenic, antimony & tellurium. The nonmetals in this group are hydrogen, oxygen, nitrogen, carbon, phosphorus, sulfur, selenium, fluorine, chlorine, bromine, iodine, and the noble gases.

HALOGENS
Group 7 is called the halogens. They form salts with the Group 1 metals. They are the most reactive nonmetals. Their outer electron shell is p^5 if they gain one electron they can have the electron configuration of a noble gas. If they do this they are ions with –1 charge.

CHALCOGENS
Group 6 is called the chalcogens. They have an outer electron configuration of s^2p^4 so they try to gain 2 electrons so they can have the electron configuration of a noble gas. If they do this they become ions with a –2 charge. Oxygen is the most reactive element of this group.

NOBLE GASES
Group 8 is the noble gases. They have filled s and p sublevels in their highest energy level. Having these electron shells filled makes them very stable. They are not willing to gain, lose or share electrons, so they will not react with other elements.

HYDROGEN
Hydrogen is in a group all by itself. With its electron configuration of $1s^1$ it can either give an electron away or gain an electron. In this respect, hydrogen can act as a metal or a nonmetal. It usually shares its electron. It reacts quickly with other molecules or forms H_2. It's the only nonmetal on the left side of the table.

Periodic Trends

Horizontal & vertical trends can be seen in the elements for:

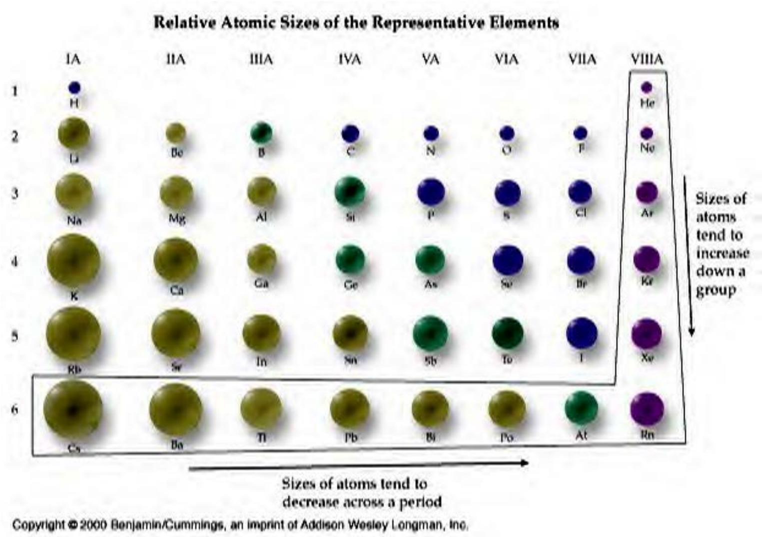
- atomic radius
- ionization energy
- electron affinity
- electronegativity

ATOMIC RADIUS

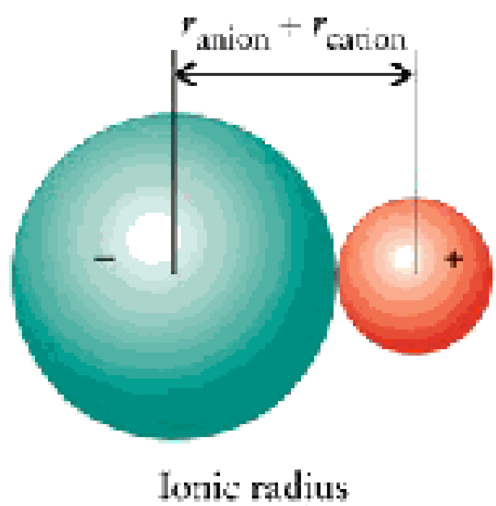
To find atomic radius, atoms are assumed to be spheres. The electron cloud size determines the atomic radius for an atom. The radius values are only estimates. These values are measured by finding the distance between 2 nuclei and dividing the distance by 2.

GROUP TREND: Atomic radius increases as you move from **top to bottom** in a family. This is because major energy levels (1-7) are being filled with more & more electrons. The electrons get farther & farther from the nucleus.

PERIOD TREND: Atomic radius generally decreases from **left to right** as atomic number increases. This is because extra electrons are entering the same level while the nucleus gets larger & more positive. This draws the electron cloud in towards the nucleus.



[Atomic Size of Elements]



[Atomic Size of Ions]

ATOMIC RADIUS OF IONS: When an atom loses an electron it has a positive charge. The radius of the atom decreases because there's a smaller electron cloud. When an atom gains an electron it has a negative charge. The radius of the atom increases because the electron cloud is larger.

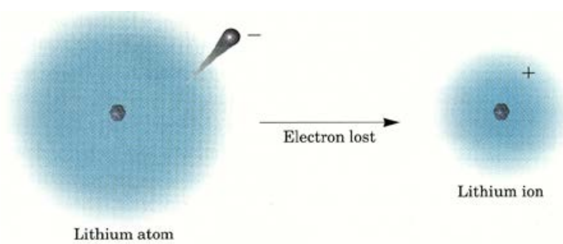
IONIZATION ENERGY

Ionization energy is the energy needed to remove an electron from an atom.

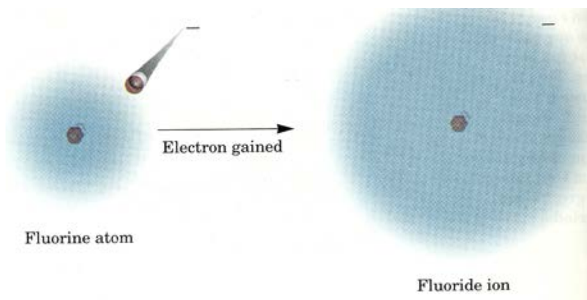
GROUP TREND: In vertical groups, ionization energy decreases from **top to bottom**. This is because electrons are farther from the nucleus & filled levels cause a shielding effect.

SHIELDING EFFECT: Inner electrons shield outer electrons from the positive nucleus. This means outer electrons are not held as tightly.

PERIOD TREND: Ionization energy tends to increase as you move from **left to right** toward the noble gases. This is because metals tend to lose electrons & nonmetals tend to gain electrons. All of them want to as stable as the noble gases.



[Diagram of Ionization Energy]



[Diagram of Electron Affinity]

ELECTRON AFFINITY

Electron affinity is the ability of an atom to attract and hold an extra electron.

GROUP TREND: Electron affinity decreases from **top to bottom** of a group. This is because it's easier for small atoms with the nucleus closer to the outer electrons to gain another electron.

PERIOD TREND: Electron affinity in a horizontal period increases from **left to right**. This is because the desire to gain an electron increases the closer you get to fill the energy level. What do you think the electron affinity of the noble gases is? Zero, they are happy like they are.

ELECTRONEGATIVITY

Electronegativity is the measured tendency to attract an electron in a chemical bond.

GROUP TREND: Electronegativity decreases from the **top to bottom**. Smaller atoms have a shorter distance to the nucleus & less shielding effect.

PERIOD TREND: Electronegativity values increase as you go from **left to right**. Metals want to empty their sublevels so they lose electrons. Nonmetals want to gain electrons so they can be like the noble gases.

NOBLE GASES AND TRENDS

They have the highest ionization energy because they don't want to lose electrons. This is because their filled electron shells are extremely stable. The electron affinity of noble gases compared to other elements is zero. Noble gases have the highest ionization energy, and they have zero electron affinity and electronegativity.