

Lesson #1: Periodic Law and Trends

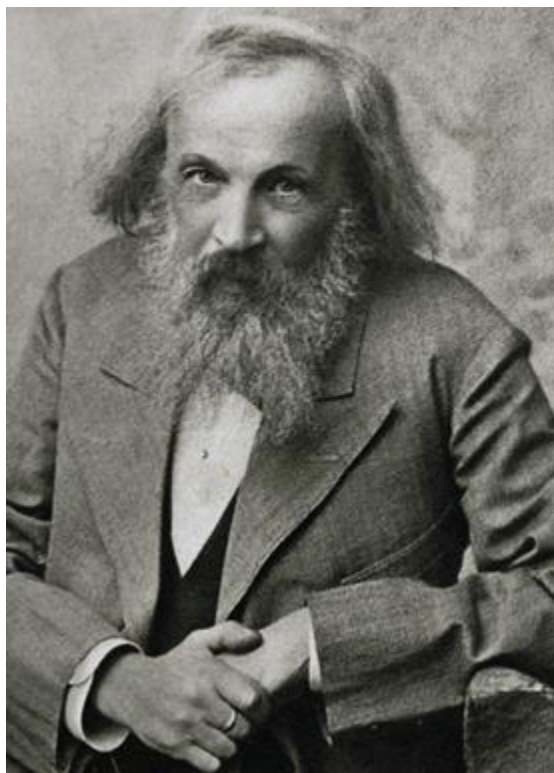
Periodic Law: - When elements are arranged in order of increasing atomic number, a periodic repetition of physical and chemical properties occurs.

Orally: *What does the word periodic mean? Why is the periodic table called the periodic table of elements and not simply the table of elements?*

Answer: *The term periodic makes reference to repetitious patterns that we observe when the elements are arranged as we see them on the table.*

Question: *Why does there appear to be a big chunk of elements missing from the top of the table? Why not just have nice rows with the exact same number of elements in them? Why are the lanthanide and actinide series down here?*

Answer: *All of these questions can be answered by examining several repetitious patterns/trends that occur when the elements are arranged the way we see them in the modern periodic table.*



Dmitri Ivanovich Mendeleev: developed the first version of the periodic table.

Orally: Mendeleev's periodic table was revised several times. His final draft of the periodic table was based on increasing atomic weight instead of atomic number. (See the table below or refer students to pg 159 of Hebden).

Group	I	II	III	IV	V	VI	VII	VIII
Period 1	H=1							
2	Li=7	Be=9.4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27.3	Si=28	P=31	S=32	Cl=35.5	
4	K=39	Ca=40	?=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59 Ni=59
5	Cu=63	Zn=65	?=68	?=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	?=100	Ru=104, Rh=104 Pd=106
7	Ag=108	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140				
9								
10			?Er=178	?La=180	Ta=182	W=184		Os=195, Ir=197 Pt=198
11	Au=199	Hg=200	Tl=204	Pb=207	Bi=208			
12				Th=231		U=240		

Orally: The repetitious patterns that were revealed by his table were so compelling that some elements that had yet to be discovered were predicted by Mendeleev. In addition, he was able to accurately predict the undiscovered element's chemical and physical properties. (See the blank spots above).

Groups (Families): A column of elements in the periodic table that have similar chemical and physical properties.

Period: A horizontal row of elements. Period #1 is the first row, etc.

Orally: Arranging the elements by atomic mass instead of atomic number created some problems. e.g., Look at the modern periodic table of the elements and find argon and potassium. Arrange the elements by mass. The chemical and physical properties of these elements are not consistent with the other elements in the groups. Group #1 elements are very reactive metals while group #18 elements are nonreactive nonmetals. By arranging the elements by atomic number, we resolve these inconsistencies.

Question: what are some of the other trends that we observe with the modern periodic table?

Trends

Trend #1: Metallic vs. nonmetallic properties: Metallic properties increase as one moves right to left through a period and increases down through a group. Therefore Fr is the most metallic element.

1																										
2																	B									
3																	Si									
4																	Ge	As								
5																		Sb	Te							
6																			Po							
7																										

Metals
 Metalloids
 Non-metals

Properties of metals:

1. Shiny (luster)
2. Malleable - Capable of bending (i.e., deformed) without breaking. **Orally:** Gold is the most malleable metal.
3. Ductile – Capable of being stretched into a wire. e.g., Copper.
4. Good conductors of heat and electricity (electrical conductivity decreases with increased temperature).
5. Very reactive
6. Vary in hardness (They are usually solid). e.g., Iron is very hard while sodium is soft.

Orally:

Question: Why is Hydrogen on the left side of the periodic table?

Answer: Hydrogen is often referred to as a family of one and is not actually part of the group #1 elements. Hydrogen does share some characteristics with the group one elements in that it has one valence electron and often forms a +1 ion when it reacts. Under extreme pressure, Hydrogen solid forms a conductor of electricity that has almost no resistance. (i.e., a superconductor). That said, it is a gas at room temperature and so some periodic tables show hydrogen on both sides of the periodic table. Hydrogen in this case is not attached to group #18 because group #18 elements are nonreactive because their electron valence shells are full. Hydrogen is, however, capable of gaining an electron like a nonmetal to form the -1 hydride ion.

Properties of nonmetals:

1. Lack luster, yet colourful.
2. Not malleable or ductile (i.e., brittle) or are gases/liquids.
3. Poor conductors of heat and electricity.

Demo: Place a piece of ice on a metal surface and on a plastic surface. Measure the volume of water produced after 10 min. The volume of water produced by the metal surface should be higher because it conducts heat much better than the plastic surface.

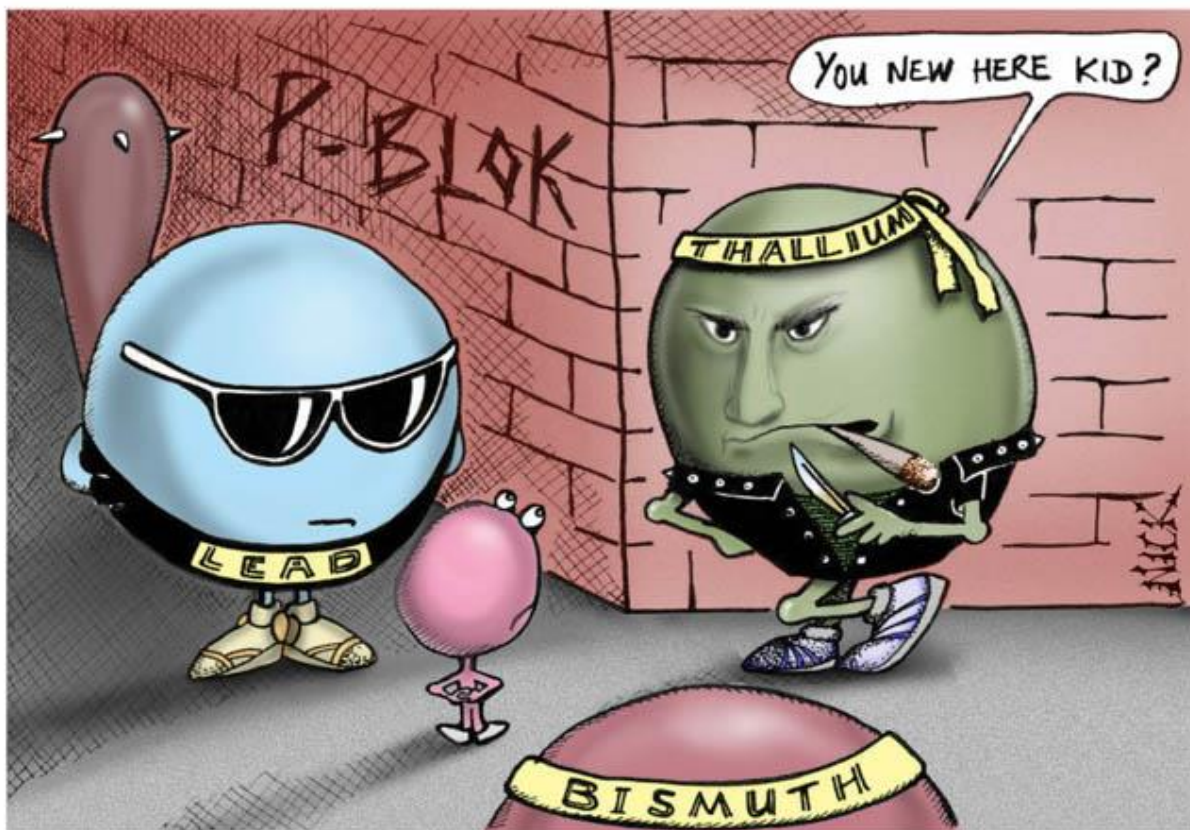
Properties of Semiconductors (also called semimetals or the old term = metalloids):

- a nonmetal that increases in electrical conductivity as temperature increases.
- have properties that are intermediate relative to metals and nonmetals.

(Observe the semimetal line in the periodic table above or pg. 163 from Hebden. Note, however, that Hebden does not list Po as a semimetal and he did list Se as a semimetal while some consider it a nonmetal. Selenium can be mixed with arsenic and tellurium to form amorphous semiconductors.)

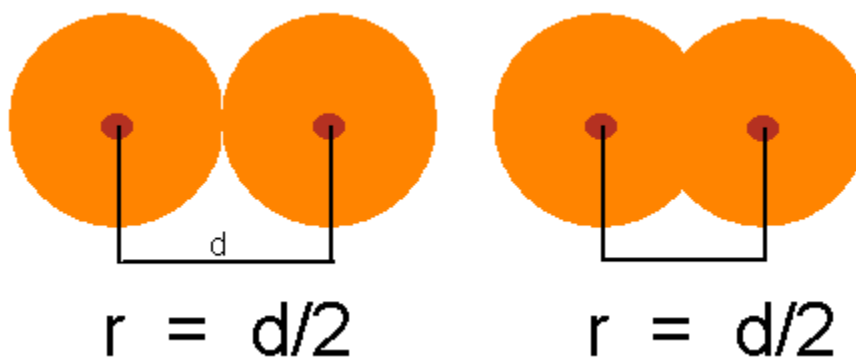
Trend #2: Electronic configurations:

1. Elements in the same group have the same number of valence electrons.
2. As one move down a group, the principal quantum number increases.
3. Blocks of the periodic table contain common subshells (i.e., orbitals)



Unwittingly, and against his mother's advice, Vince the first-row transition metal had been lured far away from home, and now found himself surrounded by heavier elements of the P-block.

Trend #3: Atomic Radii – measurement that expresses the distance between the nucleus of an atom to the outermost electron(s). **Orally:** Radii can vary depending on the bonding relationship between atoms due to the way that atomic radii are measured.



Van der Waals Radii

Covalent Radii

1. Atoms increase in atomic radius as one moves down through a group.

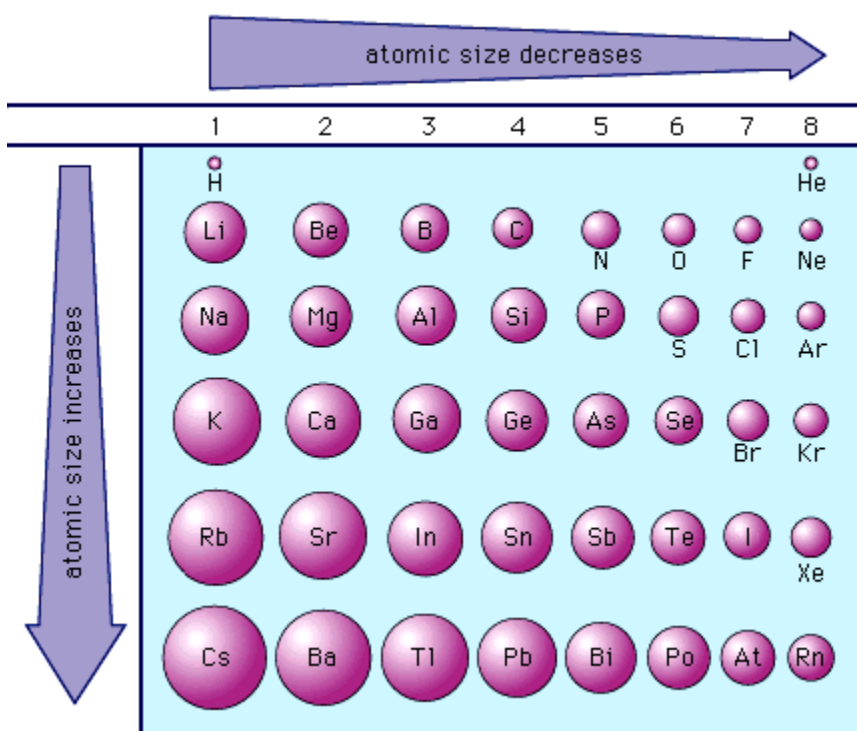
Question: Why?

Answer: The greater the period number, the larger the energy shell that electrons will occupy. i.e., larger energy shell = larger atomic radii.

2. Atoms decrease in atomic radius as one moves from left to right through a period.

Question: Why?

Answer: As one moves across a period we increase both the number of electrons and protons (i.e., nuclear charge), however the electrons do not occupy a higher energy shell so the electrons get sucked in a little.



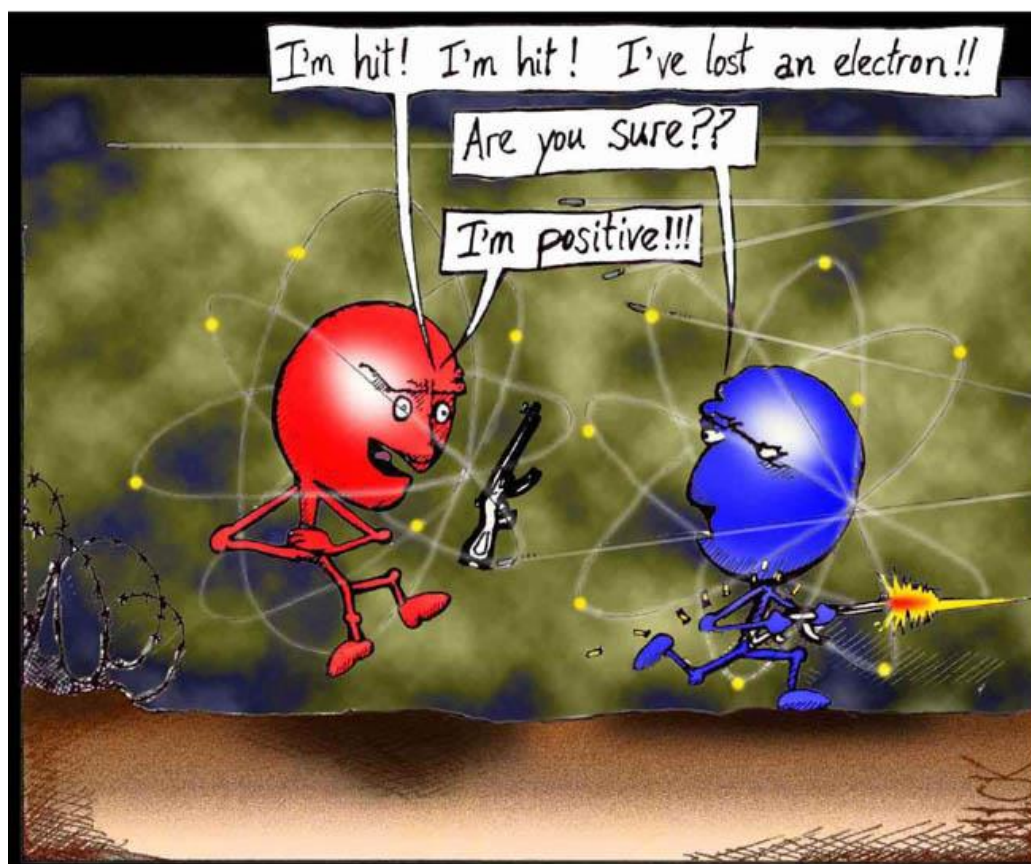
<http://www.youtube.com/watch?v=ba2yN2HtPTA>

(atomic radii trend of periodic table.)

Question: what happens to the atomic radius of elements when atoms form ions?

Answer: It depends.

1. Metals tend to donate electrons during a reaction to form stable cations (i.e., positive ions). By removing electrons the overall atomic radius decreases.



Another casualty in the War of the Atoms.

2. Nonmetals tend to accept electrons to form stable anions (i.e., negative ions). By adding electrons, the overall atomic radius increases.

<http://www.youtube.com/watch?v=dHZIMbBZ0UA> (ion formation video)

Orally:

Question: How many electrons does sodium need to remove to become a stable cation?

Answer: One electron. The electron removed eliminates the 3rd energy shell thereby making the ion significantly smaller.

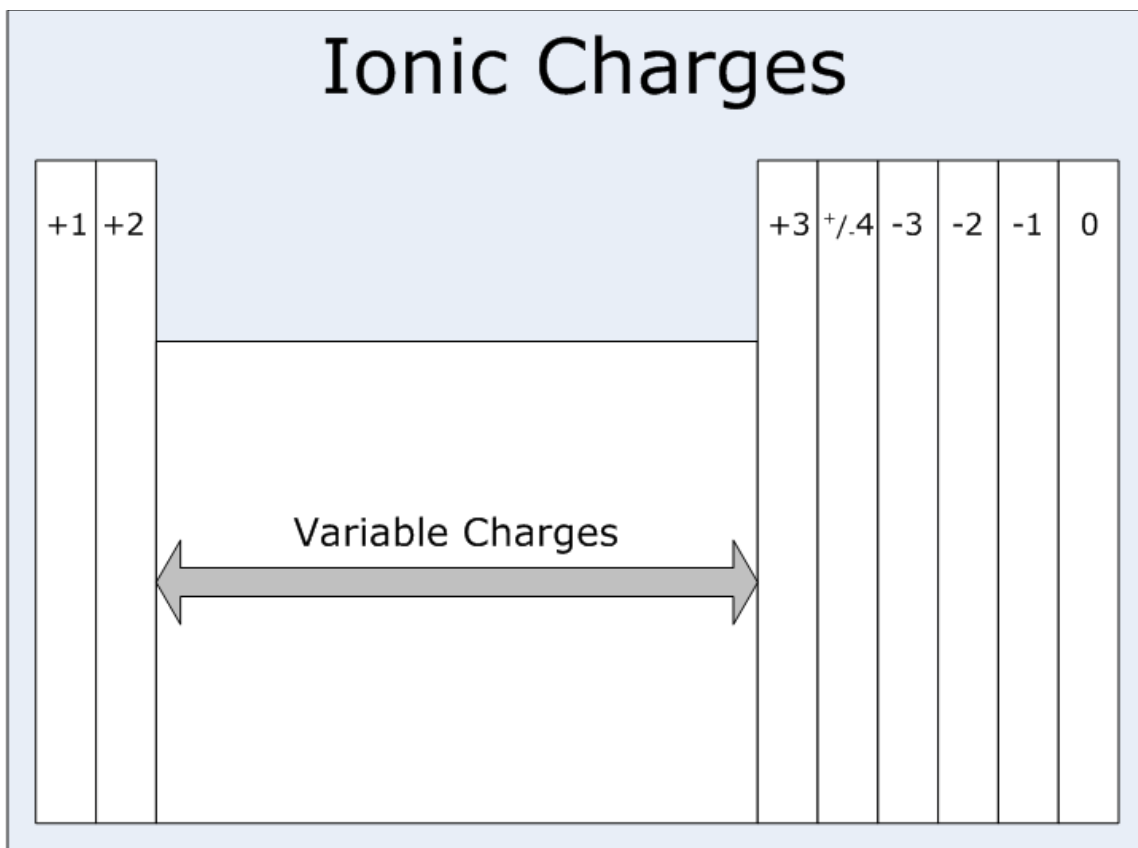
Question: How many electrons does Oxygen need to add to become a stable anion?

Answer: Two electrons. The +8 nuclear charge now has to pull on 10e⁻ instead of 8e⁻. The nuclear charge is divided more ways among the electrons, and the added electrons increase repulsive forces within the electron cloud which makes the atomic radius bigger.

Trend #4: Ionic Charges

Question: What trend exists between ionic charges and the periodic table?

Answer: See the periodic table below.



Orally:

Question: Why do we see variable charges from group #3 – 12?

Answer: Because the transition elements are able to support multiple charges due to the addition of the *d* – orbitals. (The section is the *d*-block!). Look at your ion sheet in your periodic table booklet. Find all the ions with more than one charge. Now look where they are located on the periodic table.

Trend #5: Electronegativity – The tendency of an atom to attract electrons from another atom.

(Have students look at their periodic table booklets for the electronegativity page.)

Electronegativity																		—													
2.1																	He														
H																															
1.0	1.5															2.0	2.5	3.0	3.5	4.0	—										
Li	Be															B	C	N	O	F	Ne										
0.9	1.2															1.5	1.8	2.1	2.5	3.0	—										
Na	Mg															Al	Si	P	S	Cl	Ar										
0.8	1.0	1.3	1.5	1.6	1.6	1.5	1.8	1.8	1.8	1.9	1.6	1.6	1.8	2.0	2.4	2.8	—														
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr														
0.8	1.0	1.2	1.4	1.8	1.8	1.9	2.2	2.2	2.2	1.9	1.7	1.7	1.8	1.9	2.1	2.5	—														
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe														
0.7	0.9	1.1	1.3	1.7	1.7	1.9	2.2	2.2	2.2	2.4	1.9	1.8	1.8	1.9	2.0	2.2	—														
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn														
0.7	0.9	1.1	—	—	—	—	—	—																							
Fr	Ra	Ac	Unq	Unp	Unh	Uns	Uno	Une																							
																		* 1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.3	
																		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
																		** 1.3	1.5	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	—
																		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

1. Electronegativity increases up a group.
2. Electronegativity increases across a period from left to right.

Recall that metals tend to give electrons and nonmetals tend to gain. Electronegativity increases as nonmetallic properties increase.

Orally:

Question: Which element is the most nonmetallic (omit the noble gases).

Answer: Fluorine. Therefore, Fluorine is the most electronegative.

(Read Fluorine the slut).

http://www.youtube.com/watch?v=93G_FqpGFGY&feature=related

electronegativity trend of periodic table.

Trend #6: Ionization energy – the energy that is required to remove the outermost electron.

One electron removed = 1st ionization energy, the second e- removed = 2nd ionization energy.

The more e- that one attempts to remove from an atom, the more energy one will require.

Question: Why?

Answer: The nuclear charge remains the same, so each e- “feels” a stronger pull to the nucleus.

Rule: Ionization energy increases as nonmetallic properties increase.

<http://www.youtube.com/watch?v=8F9nA4Fg3Rw>

ionization energy trend of periodic table.



[illegible]

Assignment: Hebden Workbook.

1. Metals vs non pg. 162 #34, 35, 36, 38.
2. Atomic radius pg. 165 #40, 48a, 49a, 58a, 59a.
3. Electronegativity pg. 173 #48b, 49b-c, 58b-e, 59b-c, 60, 61.
4. Ionization energy pg.165 #48c, 49d, 50, 51.