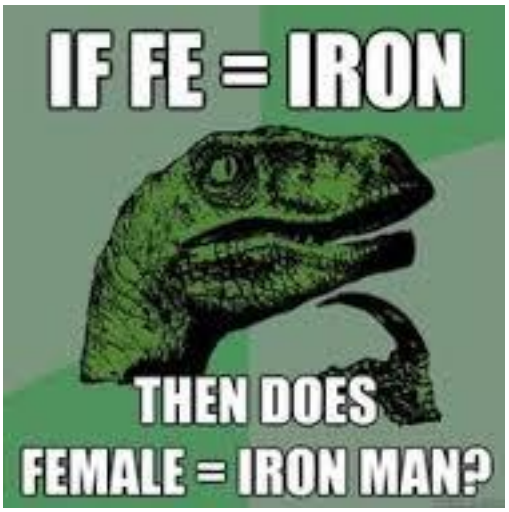
Name:

Regents Chemistry:

Notes: Unit 5: Periodic Table



MIND BLOWN!!!!

Name:

Key Ideas:

- The placement or location of elements on the Periodic Table gives an indication of physical and chemical properties of that element. The elements on the Periodic Table are arranged in order of increasing atomic number. (3.1y)
- Elements can be classified by their properties and located on the Periodic Table as metals, nonmetals, metalloids (B, Si, Ge, As, Sb, Te), and noble gases. (3.1v)
- Elements can be differentiated by their physical properties. Physical properties of substances, such as density, conductivity, malleability, solubility, and hardness, differ among elements. (3.1w)
- Elements can be differentiated by chemical properties. Chemical properties describe how an element behaves during a chemical reaction. (3.1x)
- Some elements exist in two or more forms in the same phase. These forms differ in their molecular or crystal structure, and hence in their properties. (5.2f)
- For Groups 1, 2, and 13-18 on the Periodic Table, elements within the same group have the same number of valence electrons (helium is an exception) and therefore similar chemical properties. (3.1z)
- The succession of elements within the same group demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties. (3.1aa)
- The succession of elements across the same period demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties. (3.1bb)
- When an atom gains one or more electrons, it becomes a negative ion and its radius increases. When an atom loses one or more electrons, it becomes a positive ion and its radius decreases. (5.2c)

SKILLS

- Classify elements as metals, nonmetals, metalloids, or noble gases by their properties (3.1xiii)
- Compare and contrast properties of elements within a group or a period for Groups 1-2, 13-18 on the Periodic Table (3.1xiv)
- Determine the group of an element, given the chemical formula of a compound, e.g., *X*Cl or *X*Cl2 (3.1xv)
- Explain the placement of an unknown element on the Periodic Table based on its properties (3.1xvi)
- Distinguish among metallic substances, given their properties (3.1xix)

Vocabulary:

	Definition
Alkali metal	An element in Group 1 of the periodic table (excluding Hydrogen). These elements are extremely reactive.
Alkaline earth metal	An element in Group 2 of the periodic table. These elements are very reactive.
Allotrope	1 of 2 or more different forms of an element (nonmetal) in the same phase but with different formulas and different physical/chemical properties.
Anion	A negatively charged ion.
Atomic radius	The size of an atom. Sometimes called "covalent atomic radius".
Brittle	The ability to be crushed into pieces when hammered, a property of nonmetals.
Cation	A positively charged ion.
Chemical Reactivity	The tendency for an atom of a given element to gain or lose electrons when interacting with an atom of another element.
Diatomic molecule	A nonmetal atom that cannot exist alone in nature; forms one or more bonds with another atom of the same element to form a molecule consisting of the two atoms when there is no other element to bond with. Elements that do this are Br, I, N, H, Cl, H, O and F.
Ductile	The ability to be stretched into a wire, a property of metals.
Dull	The lack of ability to reflect light efficiently, a property of nonmetals.
Electronegativity	A measure of the relative tendency of an atom of an element to attract or gain electrons in a chemical bond.
Group	Columns down the periodic table that denote elements with the same number of valence electrons and similar chemical properties.
Halogen	An element in Group 17 of the periodic table. These elements are extremely reactive.
Ionic Radius	The size of an ion compared to the original atom. Metal atoms lose electrons and form + charged ions that are smaller than the original atom, nonmetal atoms form – charged ions that are larger than the original atom.
Ionization Energy	The energy required to remove one electron from an atom of an element.
Luster	The ability to reflect light, a property of metals.
Malleable	The ability to be hammered or rolled into thin sheets, a property of metals.
Metal	Elements that have low electronegativity and ionization energy and large radius that tend to lose electrons to form chemical bonds.
Metalloid	Elements that exhibit properties of both metals and nonmetals (two of the four properties/characteristics of metals); located along the "staircase" (excluding Aluminum)
Monatomic molecule	An atom of noble gas, which is considered to be a molecule because there are no unpaired valence electrons.
Noble gas	An element in Group 18 of the periodic table. These elements are nonreactive.
Nonmetal	Elements that have high electronegativity and ionization energy and small radius that tend to gain or share electrons to form chemical bonds; have none or one property of a metal.
Nonreactive	Not capable of readily undergoing a chemical change.
Period	Rows across the periodic table that denote elements with the same number of principal energy levels.
Periodic Law	The properties of elements are periodic functions of their atomic numbers.
Reactive	Capable of readily undergoing a chemical change.
Semiconductor	An element that can act as either a conductor or insulator, depending on the situation. Used to manufacture microscopic on-off switches called transistors in computer chips.
Stable Octet	An electron configuration that is reached when atoms gain, lose or share electrons in an attempt to get a noble gas electron configuration of eight valence electrons. Hydrogen is an exception to this "Rule of Eight".
Stock system	A method for naming ions of elements that can form more than one possible positive charge by using a Roman numeral after the ion name to denote the ion's charge.
Transition metal	An element in Groups 3-12 of the periodic table. Many of these elements have colored ions.

The Elements – written by Tom Lehrer, 1959:

Antimony (Sb)	Indium (In)	Hafnium (Hf)	Cadmium (Cd)
Arsenic (As)	Gallium (Ga)	Erbium (Er)	Calcium (Ca)
Aluminum (Al)	Iodine (I)	Phosphorous (P)	Chromium (Cr)
Selenium (Se)	Thorium (Th)	Francium (Fr)	Curium (Cm)
Hydrogen (H)	Thulium (Tm)	Fluorine (F)	Sulfur (S)
Oxygen (O)	Thallium (Tl)	Terbium (Tb)	Californium (Cf)
Nitrogen (N)	Yttrium (Y)	Manganese (Mn)	Fermium (Fm)
Rhenium (Re)	Ytterbium (Yb)	Mercury (Hg)	Berkelium (Bk)
Nickel (Ni)	Actinium (Ac)	Molybdenum (Mo)	Mendelevium (Md)
Neodymium (Nd)	Rubidium (Rb)	Magnesium (Mg)	Einsteinium (Es)
Neptunium (Np)	Boron (B)	Dysprosium (Dy)	Nobelium (No)
Germanium (Ge)	Gadolinium (Gd)	Scandium Sc)	Argon (Ar)
Iron (Fe)	Niobium (Nb)	Cerium (Ce)	Krypton (Kr)
Americium (Am)	Iridium (Ir)	Cesium (Cs)	Neon (Ne)
Ruthenium (Ru)	Strontium (Sr)	Lead (Pb)	Radon (Rn)
Uranium (U)	Silicon (Si)	Praeseodymium (Pr)	Xenon (Xe)
Europium (Eu)	Silver (Ag)	Platinum (Pt)	Zinc (Zn)
Zirconium (Zr)	Samarium (Sm)	Plutonium (Pu)	Rhodium (Rh)
Lutetium (Lu)	Bismuth (Bi)	Palladium (Pd)	Chlorine (Cl)
Vanadium (V)	Bromine (Br)	Promethium (Pm)	Carbon (C)
Lanthanum (La)	Lithium (Li)	Potassium (K)	Cobalt (Co)
Osmium (Os)	Beryllium (Be)	Polonium (Po)	Copper (Cu)
Astatine (At)	Barium (Ba)	Tantalum (Ta)	Tungsten (W)
Radium (Ra)	Holmium (Ho)	Technetium (Tc)	Tin (Sn)
Gold (Au)	Helium (He)	Titanium (Ti)	Sodium (Na)
Protactinium (Pa)		Tellurium (Te)	

* as of this date, add Lawrencium (Lr), Rutherfordium (Rf), Dubnium (Db), Seaborgium (Sg), Bohrium, (Bh), Hassium (Hs), Meitnerium (Mt), Darmstadtium (Ds), Copernicum (Cn), Roentgenium (Rg) , Flerovium (Fl) (Uuq on your table), Livermorium (Lv) (Uuh), and a couple of others as of yet unnamed elements.

Lesson 1: Development of the Periodic Table

Objective:

- ***Explain how the periodic table was developed***
- ***Identify the differences between periods and groups***

MENDELEEV (1869):

Ordered the elements based upon ATOMIC MASS
Observed the periodicity based on properties

Was able to predict existence and properties of elements not yet discovered!

MOSELEY (1913):

- Developed the Modern Day Table
- Organized elements by # of **PROTONS (Atomic _____)**

PERIODIC LAW:

The properties of elements are periodic functions of their atomic numbers.

Organization of the Periodic Table

PERIODS: (horizontal _____)

- Equal to the # of energy levels (shells)

GROUPS: (vertical _____)

Elements have the **SAME # of VALENCE ELECTRONS** (electrons in _____ shell) therefore, **similar chemical properties**

EXAMPLE: Which element is in Group 2 and has 4 energy levels?

EXAMPLE: Which element has 3 energy levels and 7 valence electrons?

Reactivity of Elements

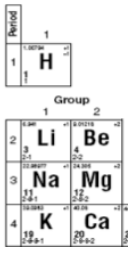
- Determined by the # of valence electrons.
- All atoms (except Hydrogen**) want **8 valence electrons** to become **STABLE** (full valence shell)
- Called a **STABLE OCTET**
- The closer to a stable octet the _____ the element is.

****Period 1** elements only need **2 electrons** to have a full valence shell **instead of 8.**

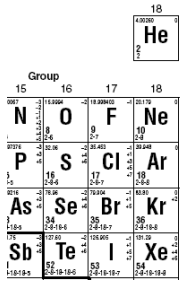
Most Reactive Groups:

Non-reactive Group (already full valence shell):

EXAMPLE: Which two elements have similar chemical properties and why? Li, Na, Be



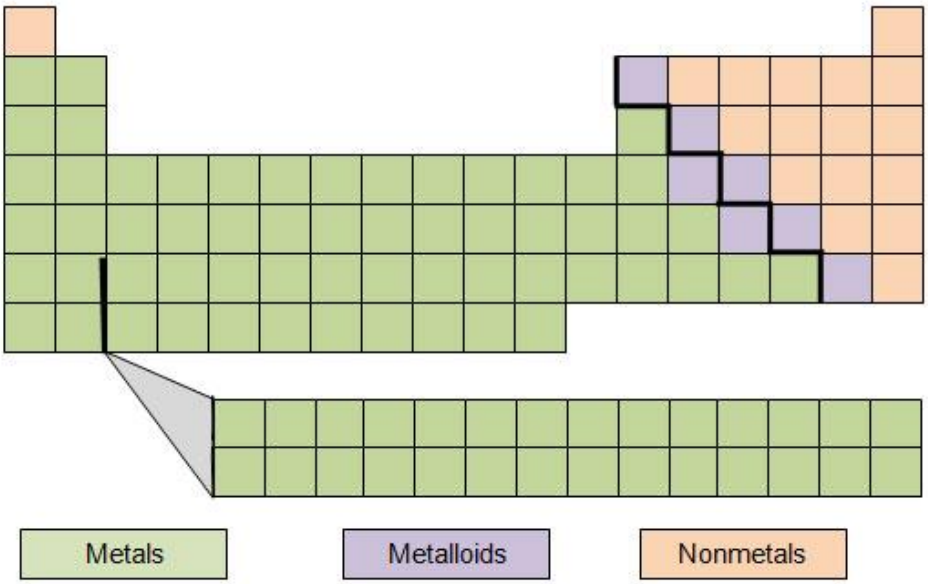
EXAMPLE: Which element would be more reactive, Sulfur or Chlorine? And why?



Objective:

- ***Differentiate between the different groups of elements***
- ***Identify the properties specific to each group of element***
- ***Differentiate between metals, nonmetals, metalloids, or noble gases by their properties***

METALS, NONMETALS, METALLOIDS, and NOBLE GASES

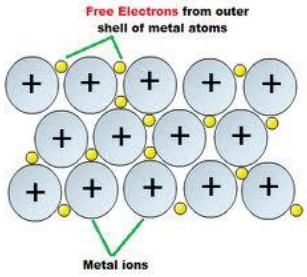


PROPERTIES OF ELEMENTS

A. PROPERTIES OF METALS:

To be a metal, must have _____ properties!!

- **Malleable** (can be hammered or rolled into thin sheets)
- **Ductile** (can be drawn into a wire)
- **Excellent conductors** of heat and electricity
- **Luster** (shiny)
- Lose electrons to form **cations** (_____ property)
- Solid @ STP (except Hg)



All properties are a result of the structure of metals with

"Sea of _____ valence _____"

PROPERTIES OF NONMETALS

To be a non-metal, must have _____ properties!!

…opposite those of metals

- **Poor conductors** of heat and electricity
- **Brittle** (shatter when struck)
- **Dull**
- Tend to gain electrons to form **anions**

PROPERTIES OF METALLOIDS

To be a metalloid, must have _____ properties!!

- **Semiconductors** (Good/moderate conductor)
- **Luster** (like metals) and **Brittle** (like nommetals)
- Used for making computer microchips

METALLIC CHARACTER: How much like a metal an element is

- Franicium_ is most metallic
- Closer to Fr more metallic…further from Fr least metallic
- Fluorine (opposite end of table) is most active non-metal

SUMMARY OF CATEGORIES OF ELEMENTS

	Metals	Metalloids	Nonmetals
Phys. prop.	• malleable • ductile • shiny • excellent conductors (heat, electricity… MOBILE e-'s)	in-between	• brittle • dull • poor conductors (heat, electricity)
Chem. prop.	• lose e-'s • form + ions • low E.N. • low I.E.	B, Si, Ge, As, Sb, Te	• gain e-'s • form - ions • high E.N. • high I.E.
	All four Properties	2-3 properties	0-1 properties

IN CLASS NOTES:

ELEMENT GROUPS

Starting from the Right….The NON-METALS

Group 18: The _____

This is the only group that has only gases.
Non-reactive elements. Rarely combined with other elements.

1. Have a _____ valence shell of electrons.
2. All have _____ electrons except He with only _____ electrons.
3. Krypton and Xenon can react with _____ & _____
4. Elements in this group are always found by themselves; they are _____
5. Examples _____

Group 17: The _____

This is the only group that has all three phases of matter at room temperature and/or STP.

7 valence electrons; Tends to gain one electron to form _____ ions.

Very reactive elements. Never found uncombined in nature; always in compounds. Elements can be obtained by *electrolysis* (decomposition of the compound)

1. Gas._____ Liquid_____ Solid _____
2. Elements in this group are always found in pairs; they are called _____
3. Examples _____
4. Most reactive non-metal: _____

Group 16

1. Which element is diatomic? _____
2. Describe the test for oxygen? _____
3. What are the allotropes of oxygen?_____
4. Describe the appearance of the two allotropes of sulfur_____ _____
5. Examples_____

Group 15

1. Which element is diatomic? _____
2. What makes nitrogen very stable? _____
3. What is an allotrope?_____
4. Which element in group 15 forms allotropes?_____
5. Examples_____

Staircase elements: The METALLOIDS

Elements touching staircase have properties of both metals and nonmetals except for Al and At. They are called _____.

Examples: _____

Groups 14-17

As you go down each of these groups from top to bottom, the elements change from _____ to _____ to _____.

TO THE LEFT: THE METALS

Groups 3-11: The _____

1. Least reactive metals
2. Color or Salt _____
3. Color of Solution _____
4. Examples: _____

Key property for transition metals is color. Electron shells are not filled in order. More than one oxidation state.

Group 2: The _____

2 valence electrons. Tends to lose the two electrons to form _____ ions.

Very reactive elements. Never found uncombined in nature, always in compounds. Can be obtained by electrolysis.

1. Color or Salt _____
2. Color of Solution _____
3. Observations
    a. Calcium metal in water _____
    b. Burning of magnesium_____
4. Examples:_____

Group 1: The _____

1 Valence electron. Tends to lose the one electron to form _____ ions.

Very reactive elements. Never found uncombined in nature, always in compounds. Can be obtained by electrolysis.

1. Color or Salt _____
2. Color of Solution _____
3. Observations
    a. Sodium metal in water _____
    b. Potassium metal in water _____
    c. Which is more reactive? _____
    d. How element is stored _____
4. Which are more reactive, group 1 or group 2?_____
5. Examples: _____
6. Most reactive metal: _____

Hydrogen:

Not in a group

A non-metal; _____ element.

_____ phase at STP.

Describe the test for Hydrogen _____

Objective:

- ***Describe the trend in atomic radius***
- ***Explain why the trend in atomic radius exists***

ATOMIC RADIUS:

- The SIZE of the atom
- located on Table S.

TREND IN ATOMIC RADIUS

Across a PERIOD	Down a GROUP
Trend: DECREASES	**Trend:** INCREASES
Why: Nuclei have greater **NUCLEAR PULL** (larger positive charges) which PULL electrons CLOSER	**Why:** GREATER number of ENERGY SHELLS (indicated by the PERIOD #)

Using Table S to determine the trend:

- Pick a Period (row) or Group (column) and note the values of the elements

EXAMPLE: Going across *a period* what is the trend in atomic radius?

Pick an element on the left side of the periodic table and pick another element on the right side of the same period. The trend is : _____.

RECALL……

ION SIZE: METALS
Ion radius SMALLER than atomic radius
Why?
Metal ions LOSE electrons to form Cations

ION SIZE: NONMETALS
Ion radius LARGER than atomic radius
Why?
Nonmetal ions GAIN electrons to for anion

Objective:

- ***Describe the trend in ionization energy and electronegativity***
- ***Explain why these trends exists***

IONIZATION ENERGY:

- Energy required to **REMOVE** the most loosely bound **ELECTRON**.
- Located on Table S

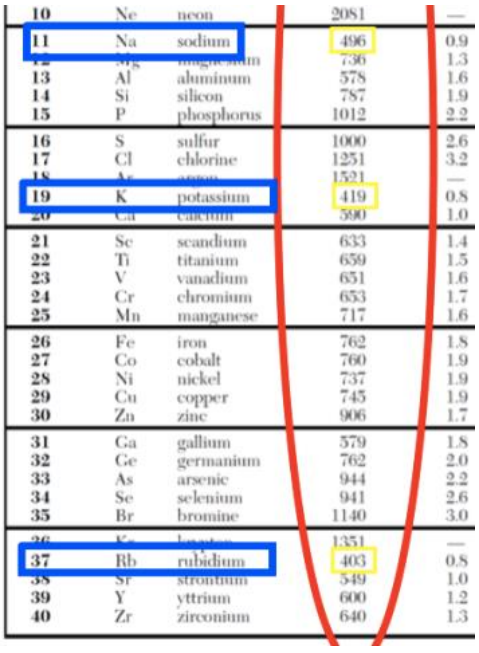
TREND IN IONIZATION ENERGY

Across a PERIOD	Down a GROUP
Trend: INCREASES across a period	**Trend:** DECREASES down a group
Why: STRONGER **NUCLEAR PULL** makes it more difficult to remove electrons	**Why:** More **ELECTRON SHIELDING** (inner electron shells) reduce the NUCLEAR PULL on outermost electrons

EXAMPLE: (use table S to determine the trend)

What is the trend in ionization energy going down a group?

Why does this trend occur?



10	Ne	neon	2081	—
11	Na	sodium	496	0.9
12	Mg	magnesium	736	1.3
13	Al	aluminum	578	1.6
14	Si	silicon	787	1.9
15	P	phosphorus	1012	2.2
16	S	sulfur	1000	2.6
17	Cl	chlorine	1251	3.2
18	Ar	argon	1521	—
19	K	potassium	419	0.8
20	Ca	calcium	590	1.0
21	Sc	scandium	633	1.4
22	Ti	titanium	659	1.5
23	V	vanadium	651	1.6
24	Cr	chromium	653	1.7
25	Mn	manganese	717	1.6
26	Fe	iron	762	1.8
27	Co	cobalt	760	1.9
28	Ni	nickel	737	1.9
29	Cu	copper	745	1.9
30	Zn	zinc	906	1.7
31	Ga	gallium	579	1.8
32	Ge	germanium	762	2.0
33	As	arsenic	944	2.2
34	Se	selenium	941	2.6
35	Br	bromine	1140	3.0
36	Kr	krypton	1351	—
37	Rb	rubidium	403	0.8
38	Sr	strontium	549	1.0
39	Y	yttrium	600	1.2
40	Zr	zirconium	640	1.3

ELECTRONEGATIVITY: Measure of the **ATTRACTION** for electrons

- Located on Table S
- **FLUORINE** most electronegative (4.0)
- The closer an atom is to Fluorine the **GREATER** the electronegativity
- Scale of 0 - 4

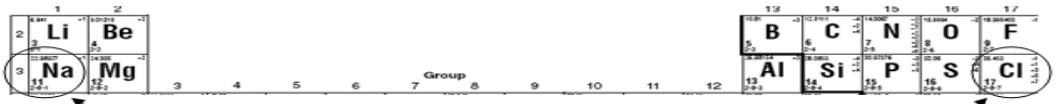
TREND IN ELECTRONEGATIVITY

Across a PERIOD	Down a GROUP
Trend: **INCREASES** across a period	**Trend:** **DECREASES** down a group
Why: Greater nuclear charge (pull) to attract electrons	More **ELECTRON SHIELDING** (inner electron shells) reduce the NUCLEAR PULL on outermost electrons

EXAMPLE:

a. What is the trend in electronegativity across a period?

b. Why does this trend occur?



Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
1	H	hydrogen	1312	2.2	14	20.	0.0000S2	32
2	He	helium	2372	—	—	4	0.000164	37
3	Li	lithium	520.	1.0	454	1615	0.534	130.
4	Be	beryllium	900.	1.6	1560.	2744	1.85	99
5	B	boron	801	2.0	2348	4273	2.34	84
6	C	carbon	1086	2.6	—	—	—	75
7	N	nitrogen	1402	3.0	63	77	0.001145	71
8	O	oxygen	1314	3.4	54	90.	0.001308	64
9	F	fluorine	1681	4.0	53	85	0.001553	60.
10	Ne	neon	2081	—	24	27	0.000825	62
11	Na	sodium	496	0.9	371	1156	0.97	160.
12	Mg	magnesium	738	1.3	923	1363	1.74	140.
13	Al	aluminum	578	1.6	933	2792	2.70	124
14	Si	silicon	787	1.9	1687	3538	2.3296	114
15	P	phosphorus (white)	1012	2.2	317	554	1.823	109
16	S	sulfur (monoclinic)	1000.	2.6	388	718	2.00	104
17	Cl	chlorine	1251	3.2	172	239	0.002898	100.

METALLIC CHARACTER

- Decreases across period
- Increases down group
- ***Reason***: The less energy required to remove an electron (**Ionization energy**) due to lesser **Nuclear Charge** and/or greater **Electron Shielding**

NONMETALS

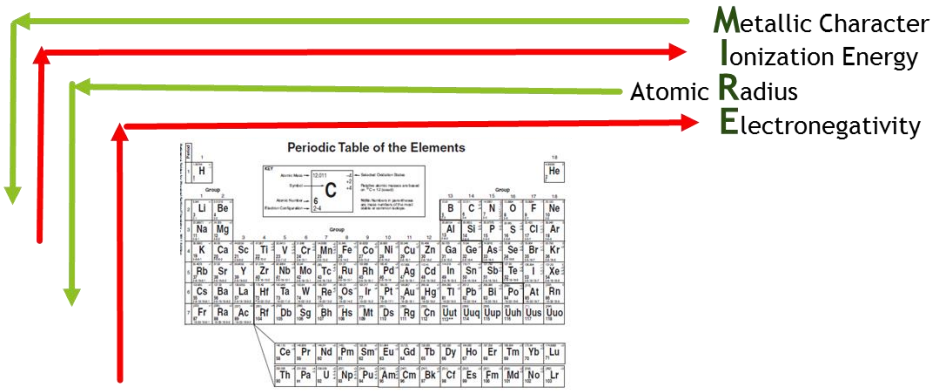
- Increases across period
- Decreases down group
- ***Reason:*** The greater the attraction for electrons (**Electronegativity**), due to the greater **nuclear charge** and fewer electron shells/**Electron Shielding**

METALS HAVE _____ Ionization Energy & Electronegativity

NON METALS HAVE _____ Ionization Energy & Electronegativity

Summary

Periodic Property	Variation across a Period	Variation down a Group
Metallic Character	Decreases	Increases
Atomic Radius	Decreases	Increases
Ionization Energy	Increases	Decreases
Electronegativity	Increases	Decreases


Metallic Character
Ionization Energy
Atomic Radius
Electronegativity
Periodic Table of the Elements