The Periodic Table

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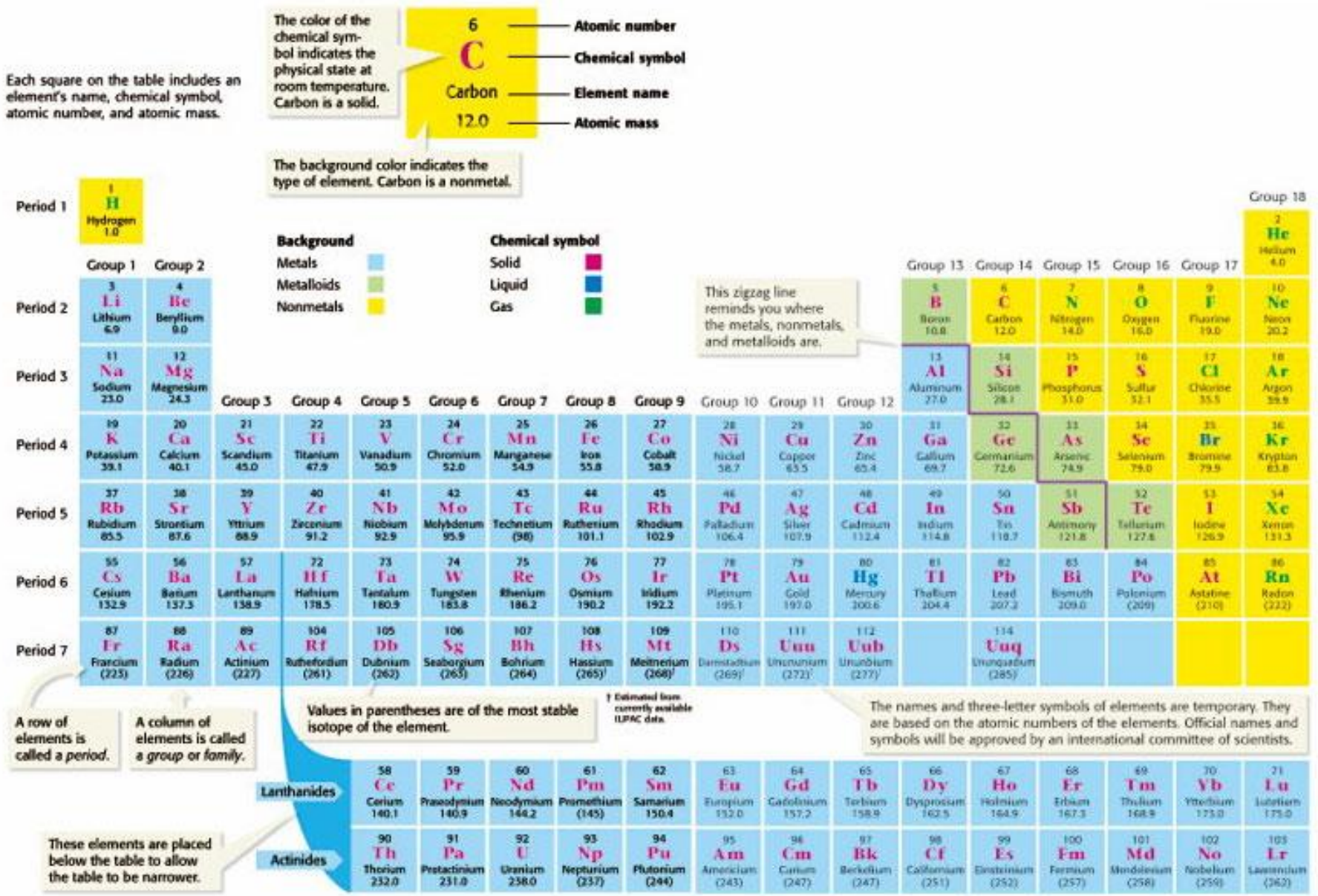
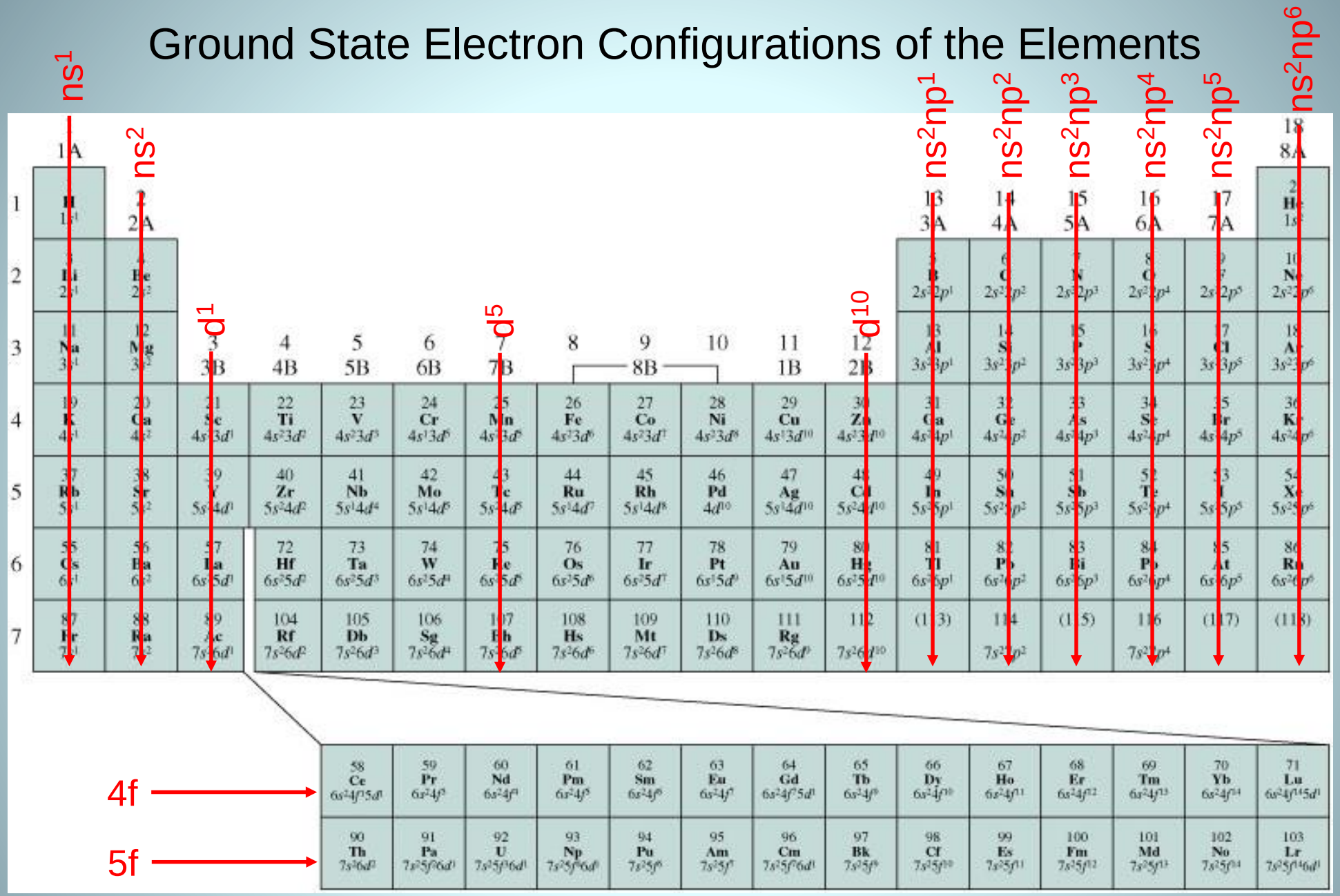
The contents of this presentation is made to provide a brief idea about the topic, details will be discussed in the classes.
Contents have been collected from multiple textbooks and internet.

The Periodic Table of the Elements



Ground State Electron Configurations of the Elements



Metals

- Most elements on the periodic table are metals.
- Conduct electricity and heat.
- Ductile
  - Can be drawn into a wire.
- Malleable
  - Can be hammered or rolled into sheets.
- Usually lustrous
  - Look shiny.
  - Dull in air or oxygen.
- Solids at room temperature (except Hg).

Nonmetals

- Opposite characteristics from metals:
  - Do not conduct electricity and heat well.
  - Not very ductile.
  - Are not lustrous.
  - Can be solids, liquids, or gases at room temperature.

Transition Metals

- **Groups 3-12.**
  - ***d* block elements.**
- **Can lose a different number of valence electrons (therefore has variable oxidation numbers).**
- **Less reactive than other metals.**

Rare Earth Metals

- f block- 2 rows at the bottom of the table
- Lanthanide & Actinide series
  - Lanthanides = 4f
    - Reactive
  - Actinides = 5f
    - All of them are radioactive.
    - Nuclei are unstable and break down.

Group 1: ALKALI METALS

3
Li
Lithium

11
Na
Sodium

19
K
Potassium

37
Rb
Rubidium

55
Cs
Cesium

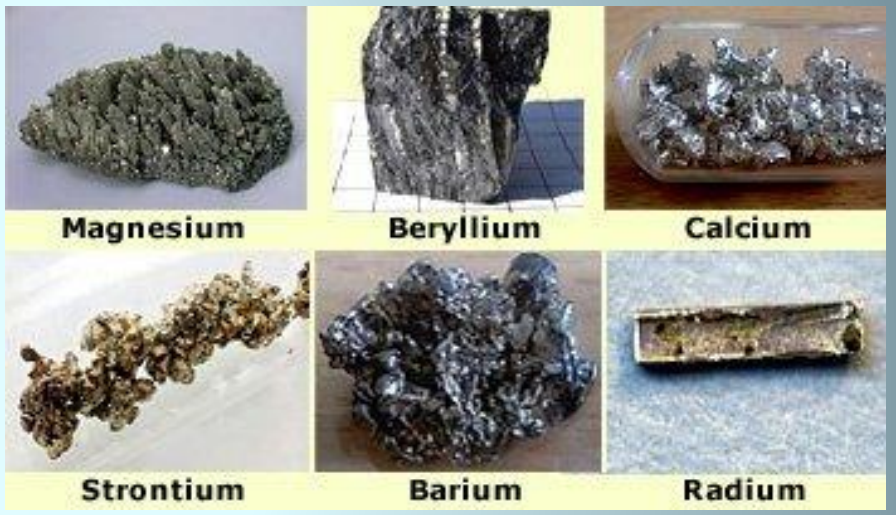
87
Fr
Francium

- Hydrogen is *not* a member, it is a non-metal
- 1 electron in the outer shell, good conductor of electricity and heat
- Soft and silvery metals
- *Very* reactive, esp. with water.
- Stored in oil to keep them from reacting with air and water
- Not found pure in nature, but combined with other elements (as compounds)
- Soft – can be cut with a knife
- Usually lustrous but will dull in contact with air (Form an oxide layer)

Group 2: ALKALINE EARTH METALS

4	Be Beryllium
12	Mg Magnesium
20	Ca Calcium
38	Sr Strontium
56	Ba Barium
88	Ra Radium

- 2 electrons in the outer shell
- White and malleable
- Reactive, but less than Alkali metals
- Conduct electricity
- Higher densities than alkali metals
- Several of these elements are important mineral nutrients (such as Mg and Ca)
- Also found as compounds, rather than pure substances
- Harder and higher melting points than group 1
- Often found as minerals and ores in the Earth's crust



Group 13: Boron Group

5 **B** Boron
13 **Al** Aluminum
31 **Ga** Gallium
49 **In** Indium
81 **Tl** Thallium

- **Group contains one metalloid and four metals**
- **3 electrons in the outer level**
- **Reactive**
- **Solids at room temperature**
- **Aluminum is the most common element from Group 13, which was once rare and expensive, not a “disposable metal”**

Group 14: Carbon Group

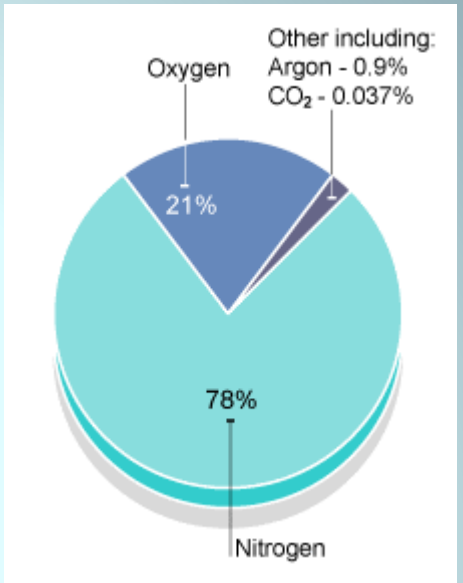
6	**C**	Carbon
14	**Si**	Silicon
32	**Ge**	Germanium
50	**Sn**	Tin
82	**Pb**	Lead
114	**Uuq**	Ununquadium

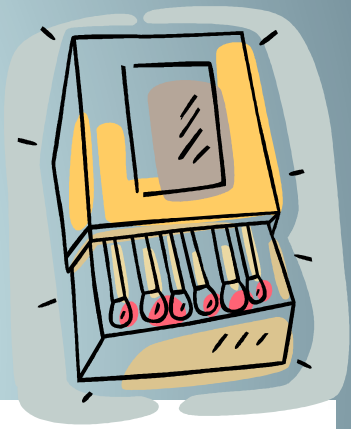
- **Group contains one nonmetal, two metalloids, and two metals**
- **4 electrons in the outer level**
- **Reactivity varies among the elements**
- **Solids at room temperature**
- **Contains elements important to life and computers**
- **Carbon is the basis for an entire branch of chemistry**
- **Silicon and Germanium are important semiconductors**

Group 15: Nitrogen Group

7 N Nitrogen
15 P Phosphorus
33 As Arsenic
51 Sb Antimony
83 Bi Bismuth

- Group contains two nonmetals, two metalloids, and one metal
- 5 electrons in the outer level
- Reactivity varies among the elements
- Solids at room temperature (except for nitrogen, which is a gas)
- Nitrogen makes up over ¾ of the atmosphere
- Nitrogen and phosphorus are both important in living things
- The red stuff on the tip of matches is phosphorus






Nitrogen


Phosphorous


Arsenic


Antimony


Bismuth

Group 16: Oxygen Group

- Group contains three nonmetals, one metalloids, and one metal
- 6 electrons in the outer level
- Reactive
- Solids at room temperature (except for oxygen, which is a gas)
- Oxygen is necessary for respiration
- Many things that stink, contain sulphur (rotten eggs, garlic, skunks etc.)

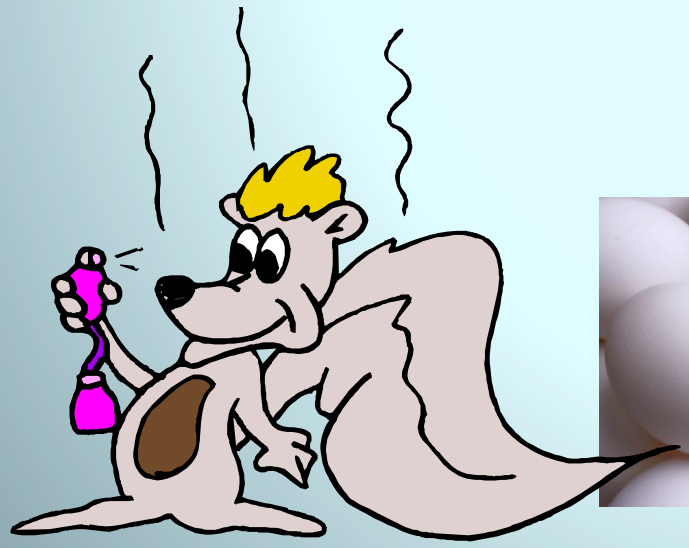
8 O Oxygen

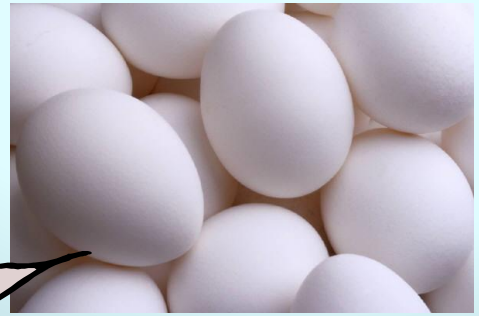
16 S Sulfur

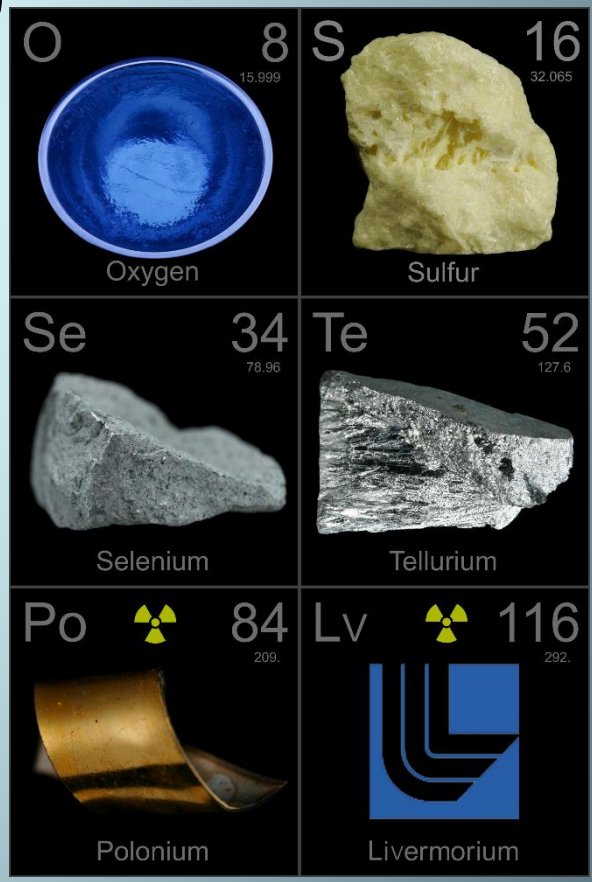
34 Se Selenium

52 Te Tellurium

84 Po Polonium







Group 17: Halogens

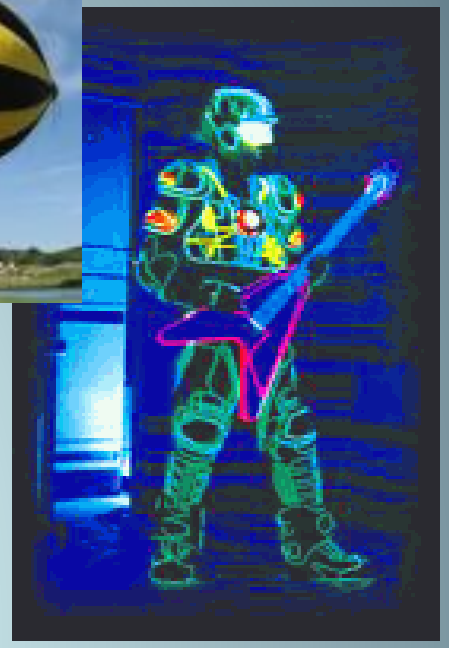
9	F Fluorine
17	Cl Chlorine
35	Br Bromine
53	I Iodine
85	At Astatine

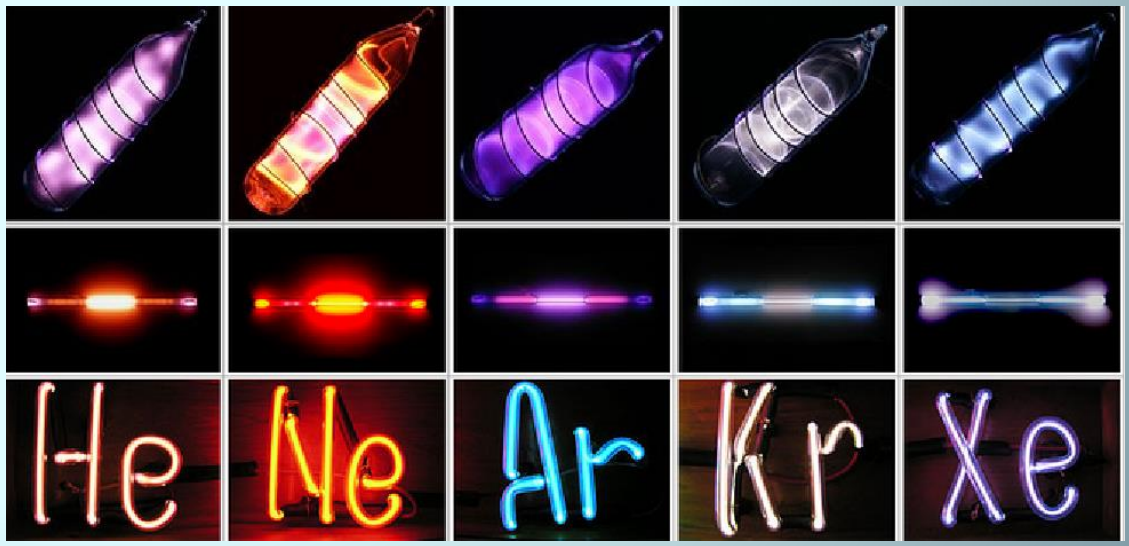
- All are non-metals
- 7 electrons in the outer level (Only need to gain one more electron to have a full valence shell and be stable)
- Very reactive, volatile, diatomic, nonmetals
- Used as disinfectants and to strengthen teeth
- Frequently react with alkali metals (Ex: NaCl, KF, LiBr etc.)
- Compounds formed from halogens typically are called salts

Group 18: Noble Gases

2 He Helium
10 Ne Neon
18 Ar Argon
36 Kr Krypton
54 Xe Xenon
86 Rn Radon

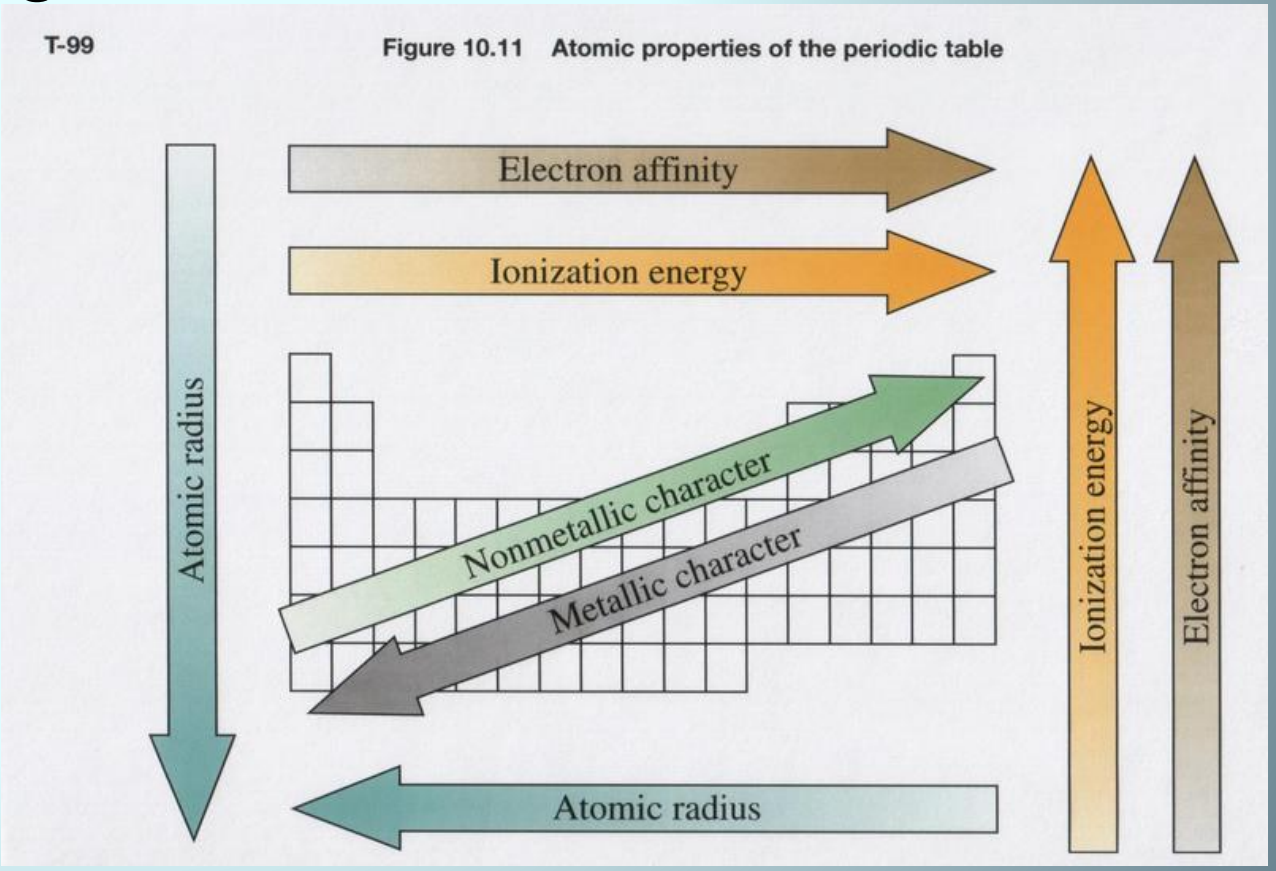
- All are nonmetals
- 8 electrons in the outer level (except helium, which has 2)
- VERY unreactive, monatomic gases
- Colorless, odorless gases at room temperature
- Used in lighted “neon” signs
- Have a full valence shell





Trends in the Periodic Table

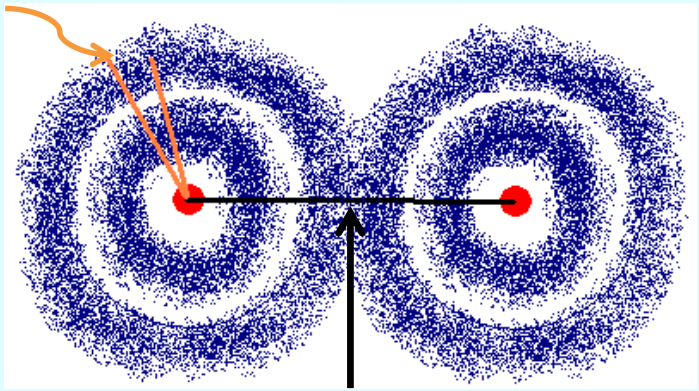
- **Periodic trends exist since properties of elements repeat in the table.**
- **We will look at the following trends:**
  - **atomic radius**
  - **ionic radius**
  - **ionization energy (IE)**
  - **electron affinity**
  - **electronegativity**



Atomic Radius (size)

- **<u>Atomic Radius</u>: Half the distance between two bonded atoms' nuclei.**
- **Hard to measure with only one atom due to e^- cloud.**
- **Bond distance is easier to measure- then cut in half.**

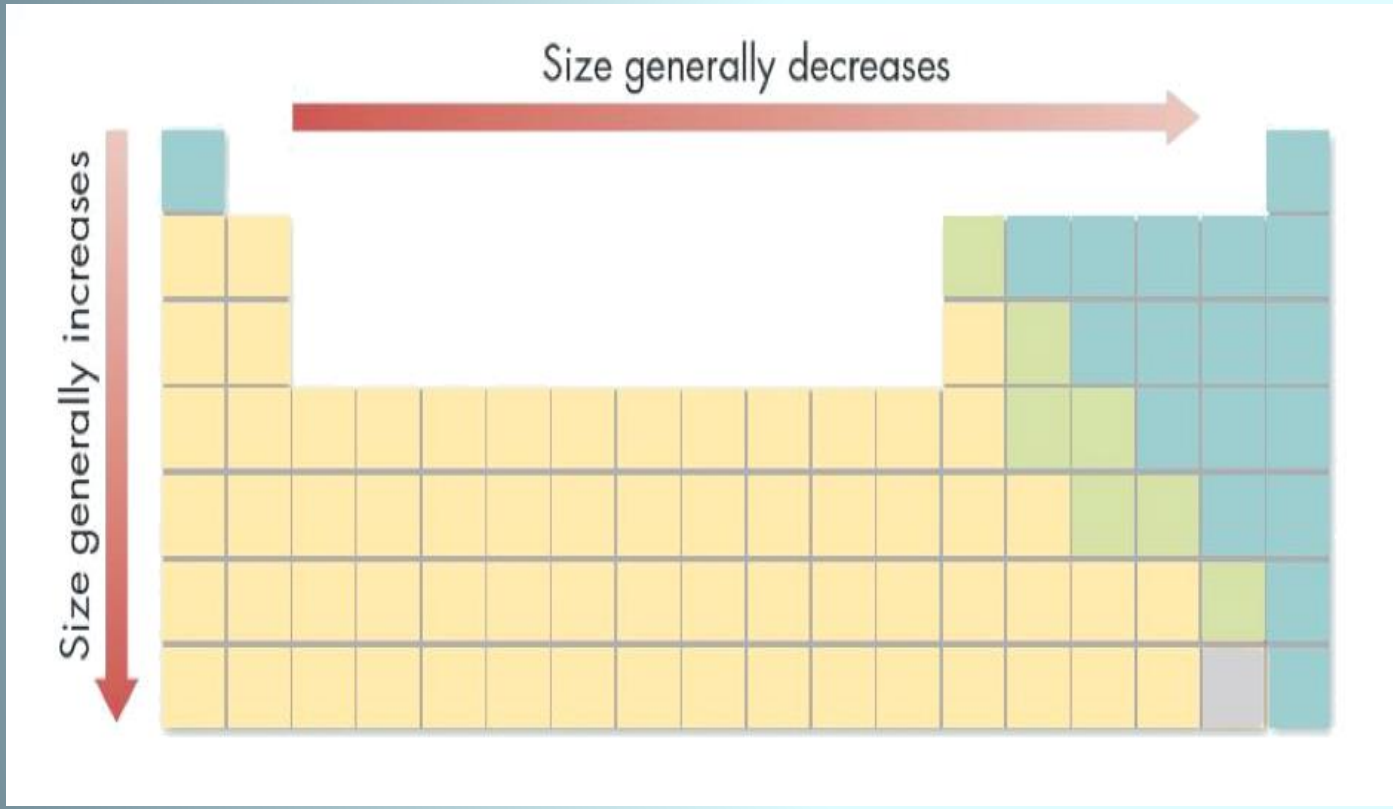
Where should we consider the outside of the atom to be?

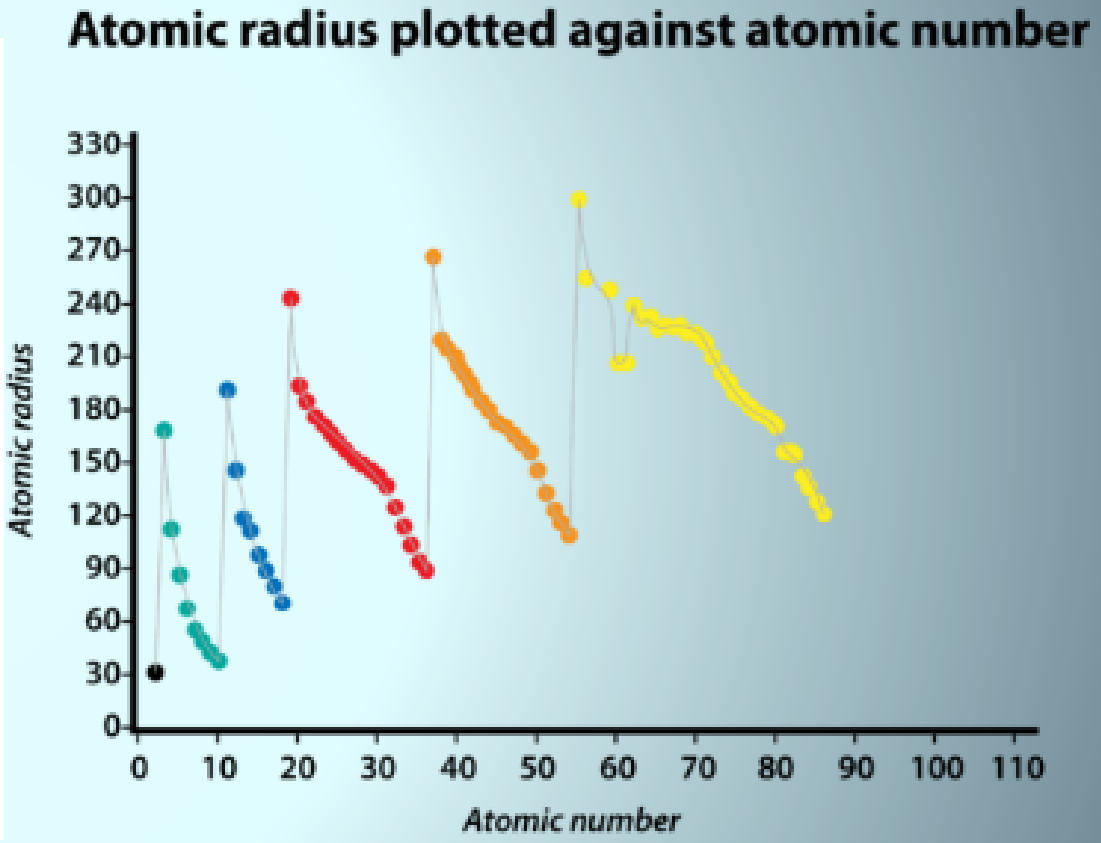


$$\frac{\text{distance between two bonded atoms' nuclei}}{2}$$

Measured in picometers (pm) or Angstroms (Å).

Atomic Radius (size)





- **Which atom in each pair has the larger atomic radius?**

a) **Li or K**

b) **Ca or Ni**

c) **Ga or B**

d) **O or C**

e) **Cl or Br**

f) **Be or Ba**

- **Which atom in each pair has the larger atomic radius?**

a) Li or K

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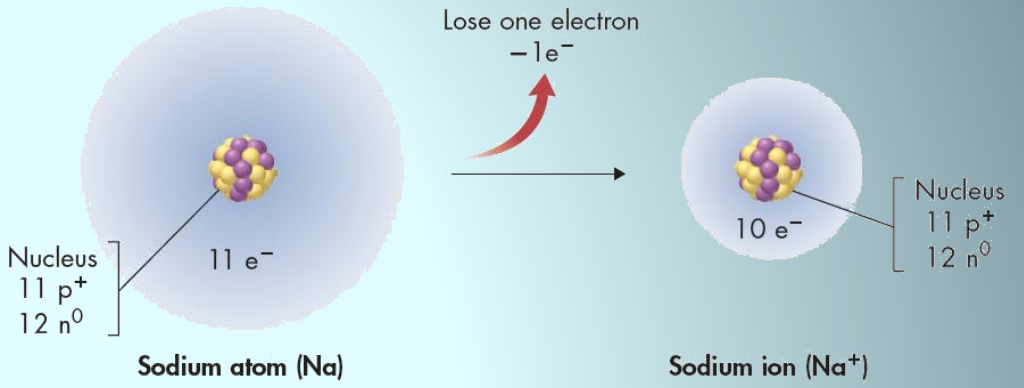
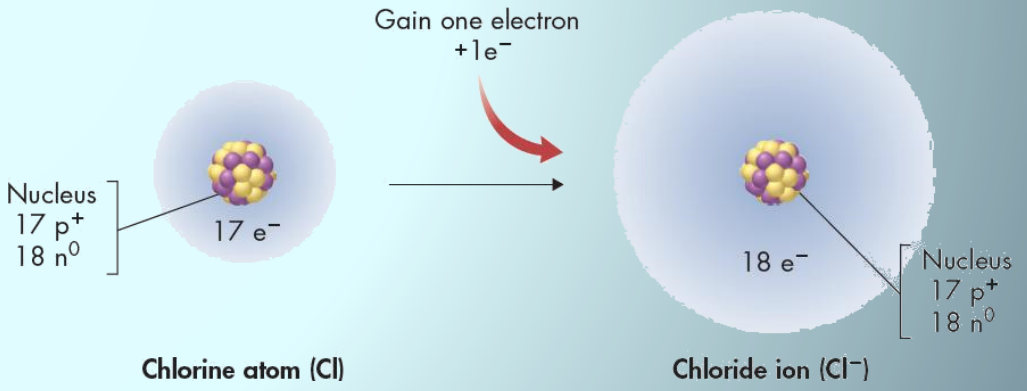
f) Be or Ba

Ionic Radii

- **Cation** – ion with a positive charge
  - Metals tend to form cations.

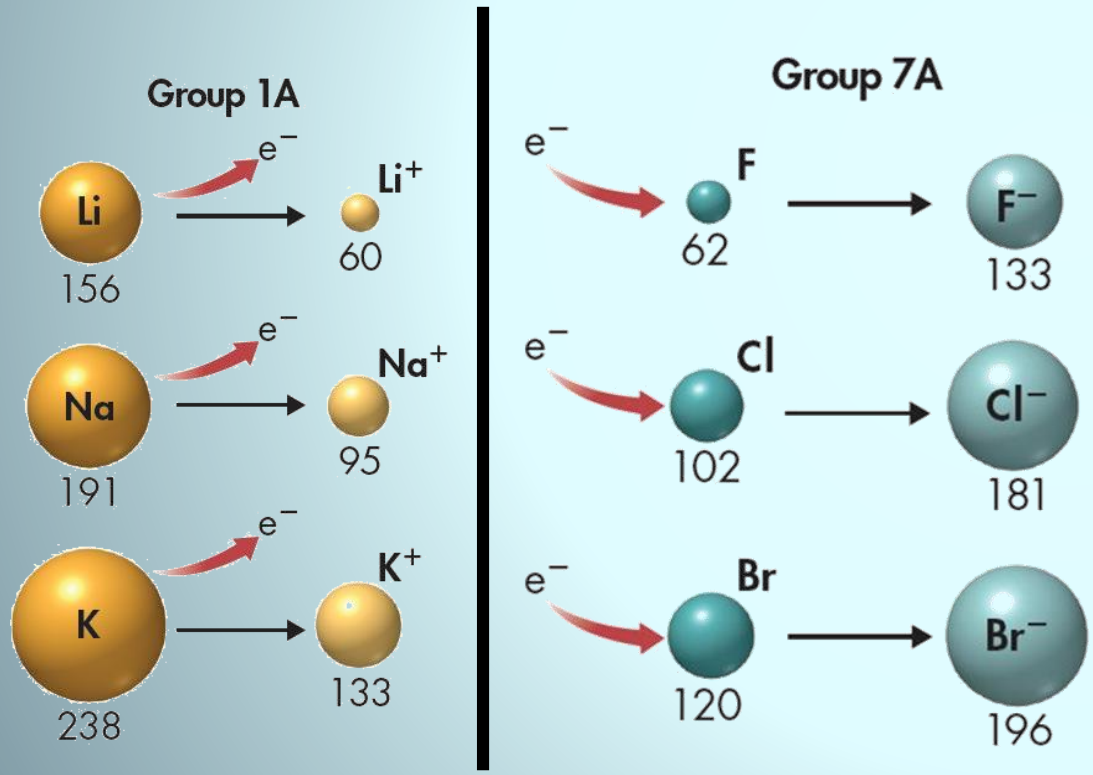


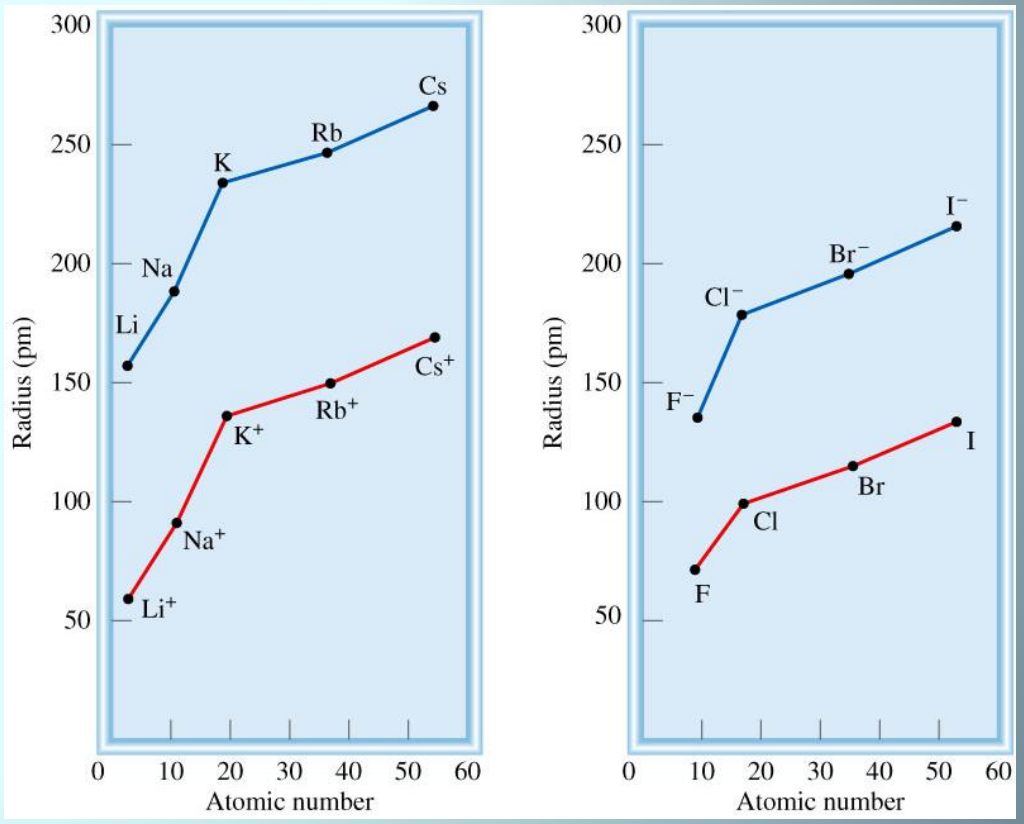
- **Anion** – ion with a negative charge
  - Nonmetals tend to form anions.



Ionic Radii

Cation is always **smaller** than atom from which it is formed.
Anion is always **larger** than atom from which it is formed.





- **Which particle has the larger radius in each atom/ion pair?**

a) **Na, Na^{+}**

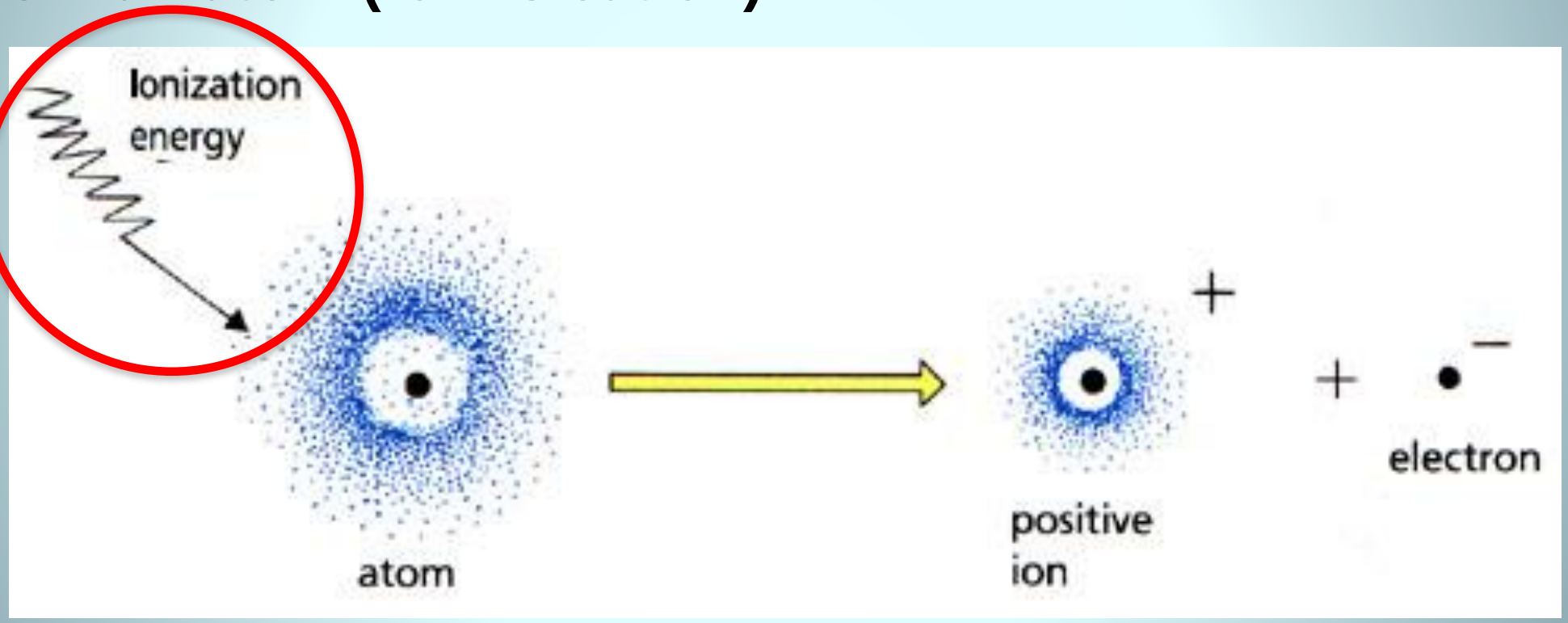
b) **S, S^{2-}**

c) **I, I^{-}**

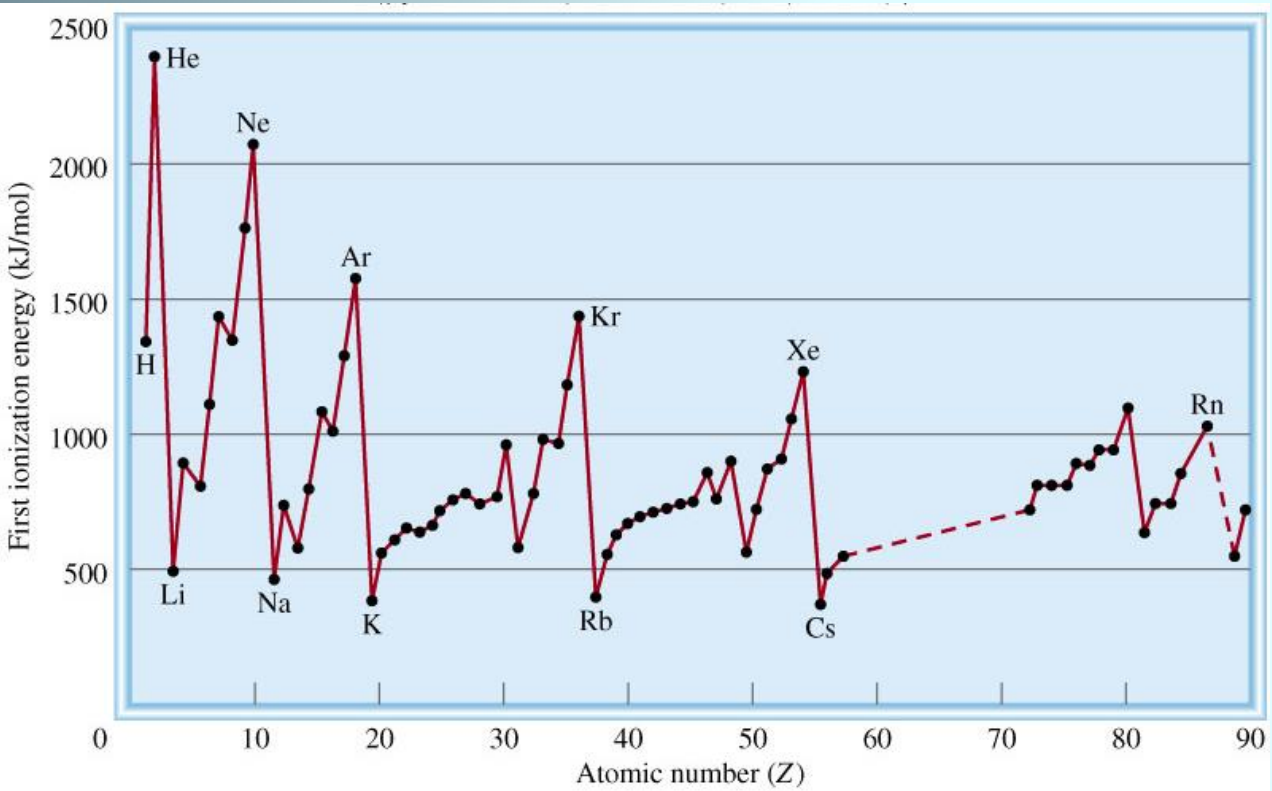
d) **Al, Al^{3+}**

Ionization Energy (IE)

- **<u>Ionization energy</u>: energy needed to remove an electron from an atom (forms cation).**



Variation of the First Ionization Energy with Atomic Number



Example of Exceptions:

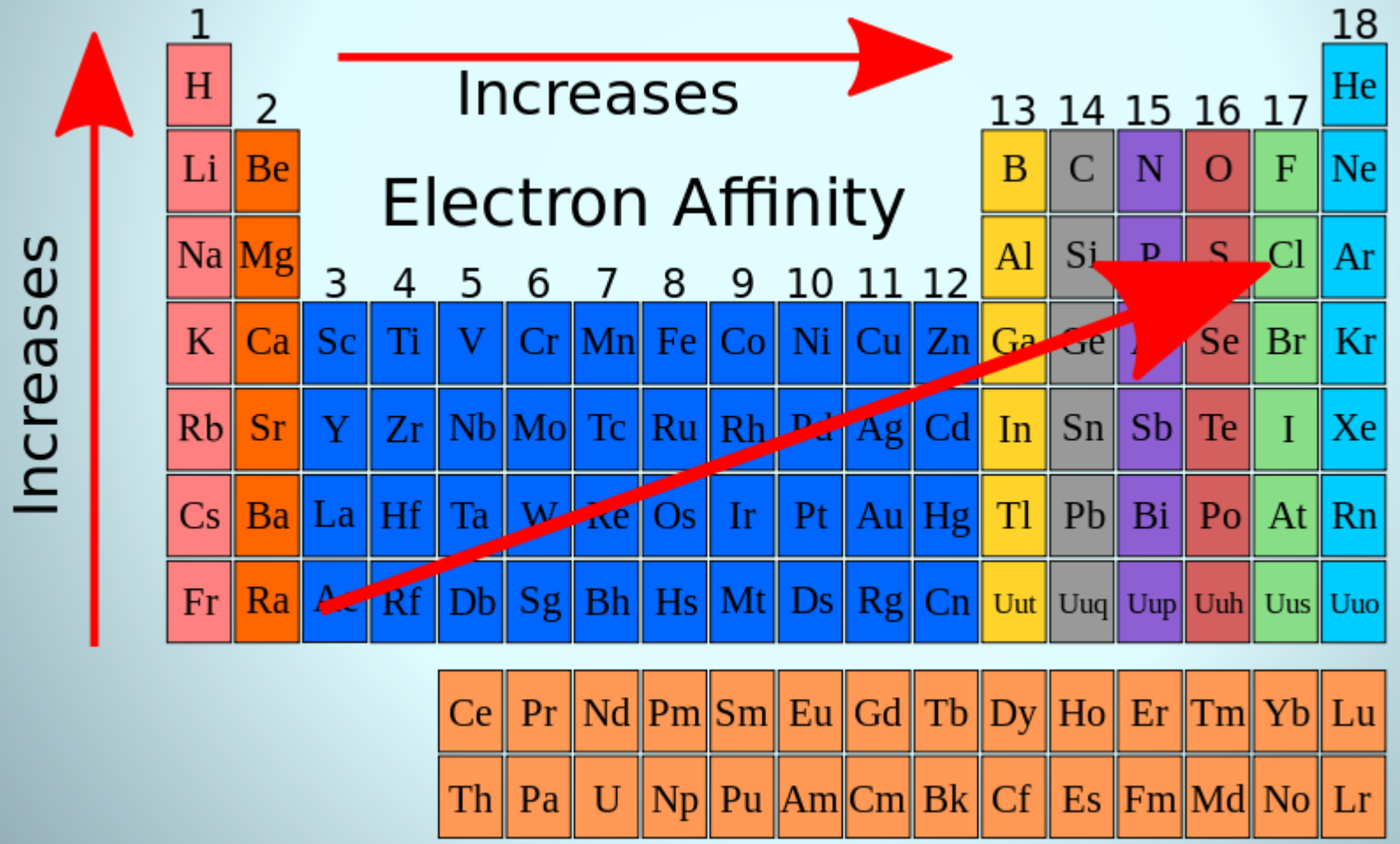
Ionization energy of Be is higher than B. Because, Be has fully filled s orbital, but B has an unpaired electron in *p* orbital.

Be(4) = $1s^2\ 2s^2$ IE = 899.50 $kJmol^{-1}$
B(5) = $1s^2\ 2s^2\ 2p^1$ IE = 800.64 $kJmol^{-1}$

Similarly, Ionization energy of N is higher than O, due to the half-filled *p* orbital in N.

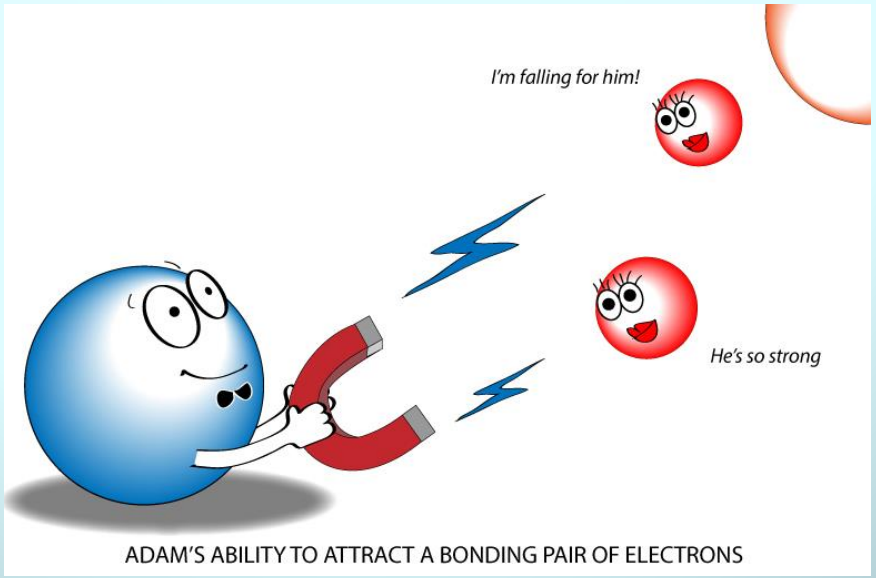
Electron Affinity

amount of energy *released* when an electron is attached to a neutral atom or molecule in the gaseous state to form a negative ion.

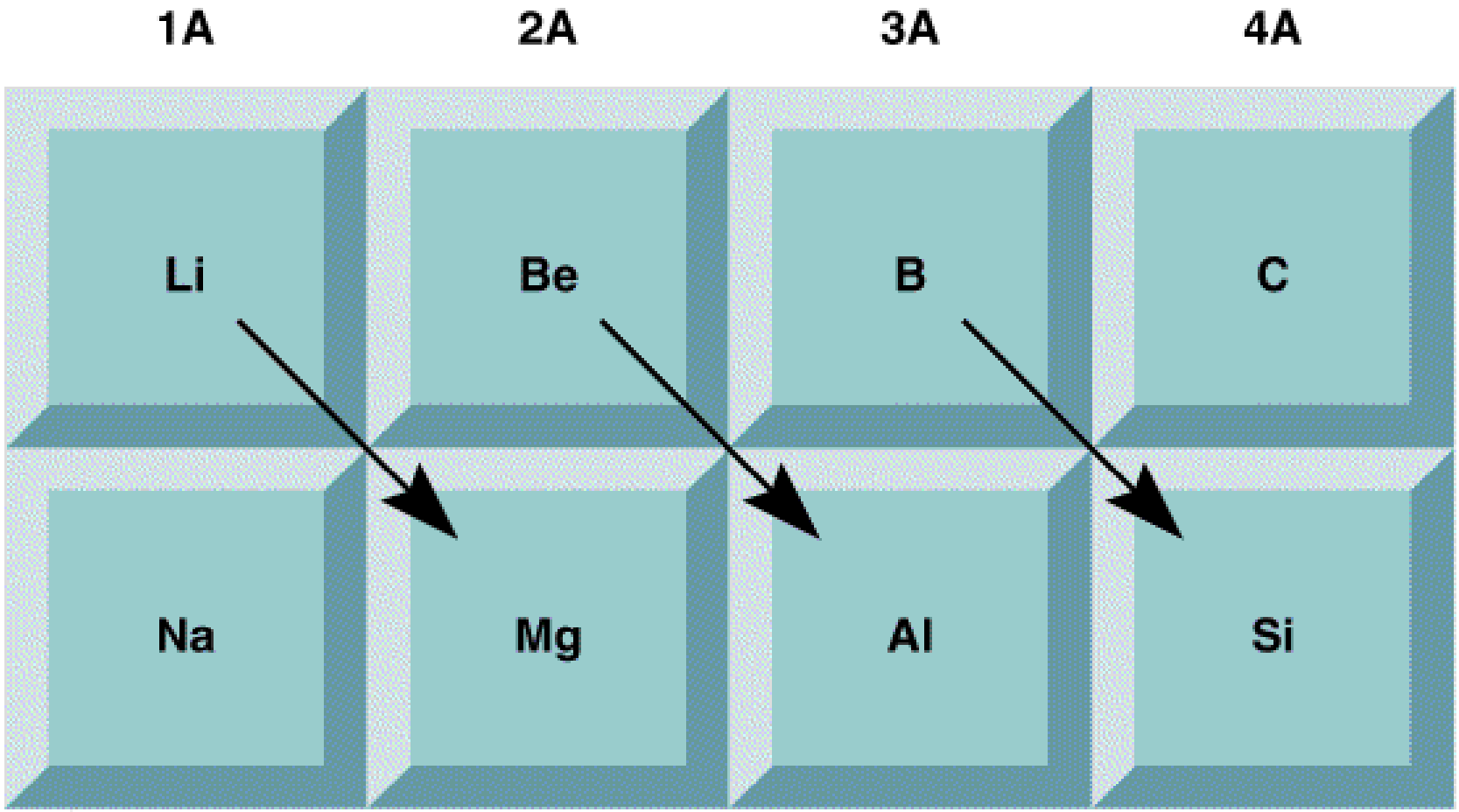


Electronegativity

- **Ability of an atom to attract electrons in a bond.**
  - **Electrons from each atom are involved when atoms bond.**
  - **Each atom's ability to attract e^- is different.**
    - **Ranges from 0 – 4.0.**
      - **F assigned 4.0 (highest value- has the greatest ability to attract e^- when bonded).**
      - **Noble gases don't have a value (don't need to form bonds- they are stable).**



Diagonal Relationships in the Periodic Table



Thank you