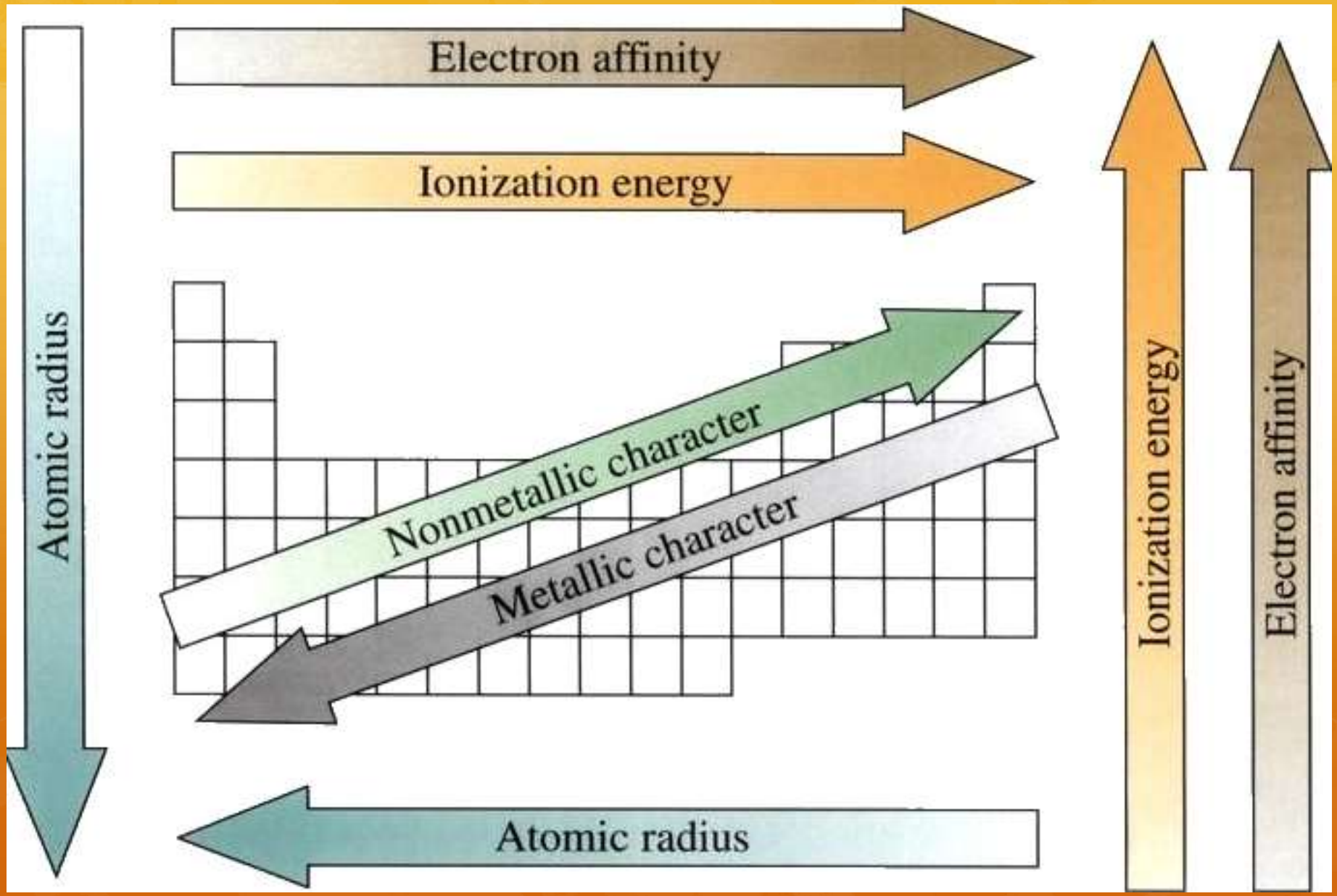
Periodicity- trends across a period

By Akshat Singh


Electron affinity
Ionization energy
Atomic radius
Nonmetallic character
Metallic character
Atomic radius
Ionization energy
Electron affinity

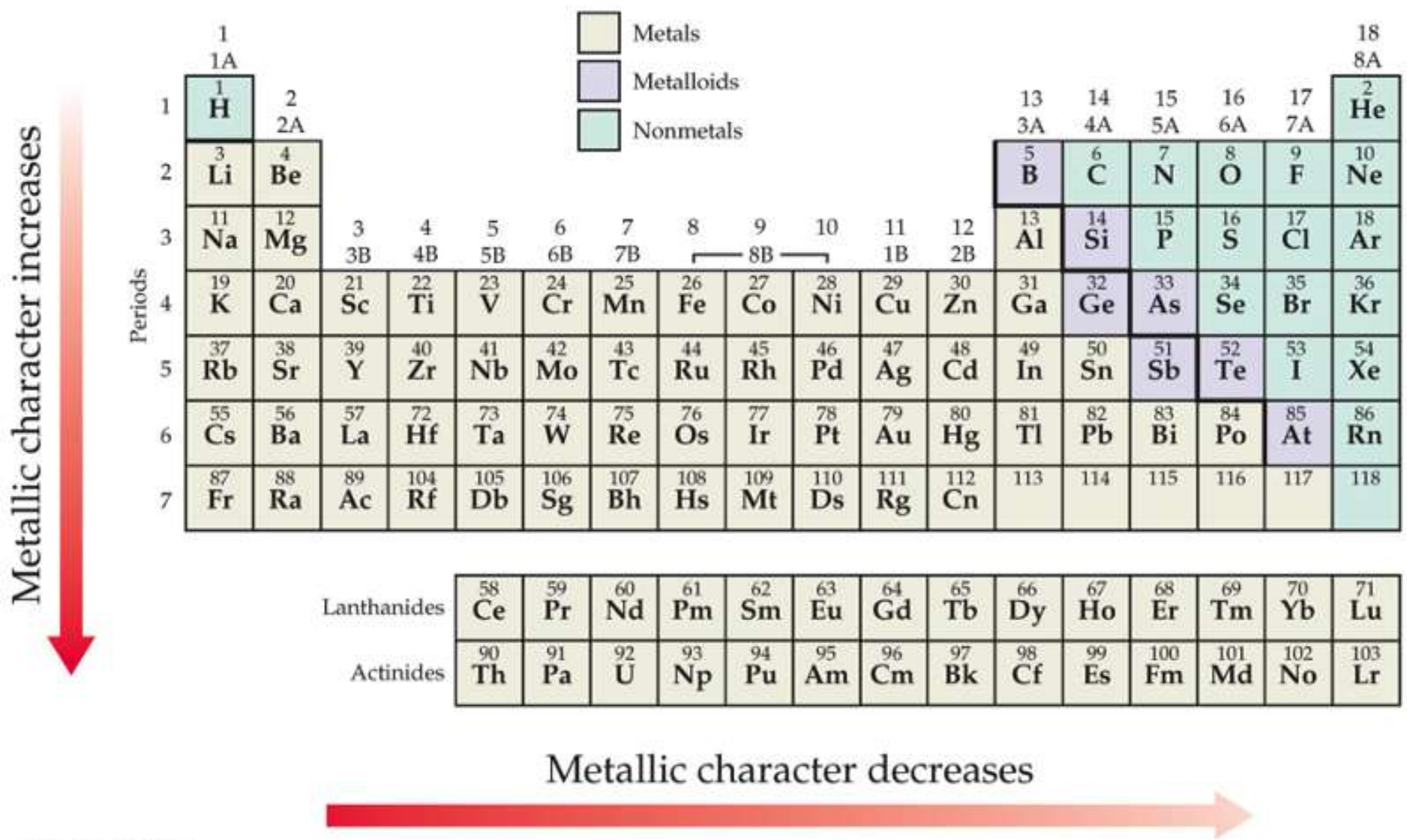
Metallic/Non Metallic character

- On moving from left to right across a period the properties of elements change from metallic to non-metallic.
- This is because ionization energy and electronegativity both increase and nuclear pull increases and atomic size decreases
- Elements in s-,d- and f- block are all metals while in the p- block the elements in the bottom left are metals and those in the top right are non-metals with metalloids in between.
- In between them are a few elements such as Si, Ge, As and Sb. These are the metalloids.

Properties of metals

- They have low ionization energies and electronegativities.
- They form compounds by ionic/electrovalent bonding by losing electrons to form positive ions.
- They are solids at stp (except Mercury and Gallium and have high boiling points and melting points.
- They are malleable and ductile and good conductors of both heat and electricity in solid state

Metallic character trends



Properties of non-metals

- They have high ionisation energies and electronegativities.
- They form compounds with metals by gaining electrons to form negative ions but they also form covalent bonds with other non-metals by sharing electrons.
- The physical properties of elements depend on how the covalent bonds join atoms of the element.
- If the covalent bonds give rise to molecules, they are gases, liquids or soft solids with low melting points.
- If the covalent bond produces a three dimensional network the elements are hard solids with high melting points.
- All non- metals except Graphite do not conduct electricity.

Nature of Oxides

- Going across a period of the periodic table, the nature of oxides the elements form changes.
- For example Sodium and Magnesium Oxides are highly basic in nature and they neutralize acids, dissolving to form salt and water.
- Amphoteric Oxides like Aluminum react and dissolve in both alkalis and acid.
- Oxides of elements like Silicon have little acid-base activity but they show some acidic nature by slowly dissolving conc. Alkalis to form silicates.
- At the extreme right of the periodic table the oxides of elements, besides noble gases dissolve in water to form acidic solutions.
- Hence, the overall trend of oxides across a period is basic to acidic.

Reactions of oxides

- $O^{2-} + H_2O$ gives $2OH^-$
- $Na_2O + H_2O$ gives $2Na^+ + 2OH^-$
- $MgO + 2HCl$ gives $MgCl_2 + H_2O$
- $MgO + 2H^+$ gives $Mg^{2+} + H_2O$
- $Al_2O_3 + 6H^-$ gives $2Al^{3+} + 3H_2O$
- $Al_2O_3 + 2OH^- + 3H_2O$ gives $2Al(OH)_4$
- $SiO_2 + 2OH^-$ gives $SIO_3^{2-} + H_2O$
- $P_4O_{10} + 6H_2O$ gives $4H^+ + 4H_2PO_4$-

Oxides	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_6 P_4O_{10}	SO_2 SO_3
Structure	giant ionic lattice			giant molecular	simple molecular	
Bonding	strong electrostatic forces of attraction between ions			covalent bonds between atoms	weak Van der Waals' forces of attraction between molecules	
Melting point / °C	1280	2900	2040	1610	24 580	-75 17
Acid / base nature	basic		amphoteric	acidic		
Reaction with water	alkaline solution (pH ≈ 13)	weakly alkaline solution (pH ≈ 9)	Insoluble (pH = 7)		acidic solution (pH < 2)	acidic solution (pH < 2) acidic solution (pH = 1)

Acid Rain

- The oxides of both sulfur and Nitrogen are released into the air by several processes some natural and some by humans
- These deposit back to the earth in particular when they dissolve in rain waterto form what is called acid rain
- $SO_2 + H_2O$ gives $H^+ + HSO_3^-$
- $SO_3 + H_2O$ gives $H^+ + HSO_4^-$
- $2NO_2 + H_2O$ gives $H^+ + NO_3^- + HNO_2$

Acid Rain (continued)

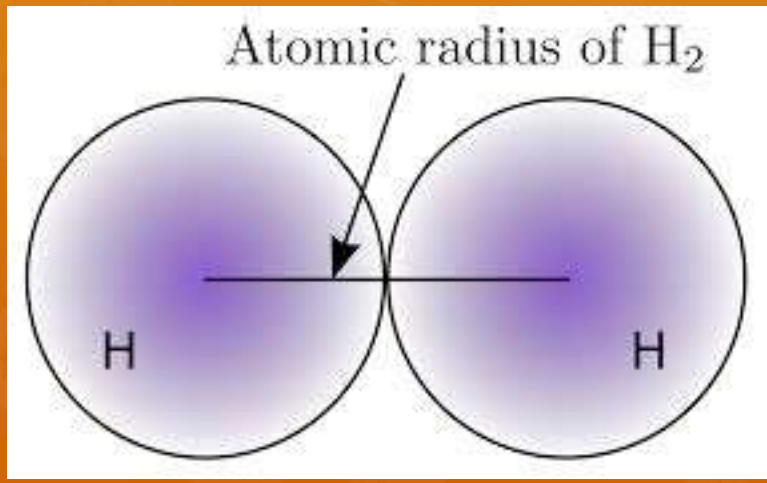
- Acid rain has many negative effects on the environment.
- It makes the water in freshwater bodies too acidic hence, killing aquatic life.
- It damages leaves and roots of plants and cause leaching of metal ions from soil especially Mg^{2+} which is important to produce chlorophyll.
- This leaching of metal ions can enter the water supply and then reach us and cause harmful effects. For example, high (Al^{3+}) can increase risk of Alzheimer's.

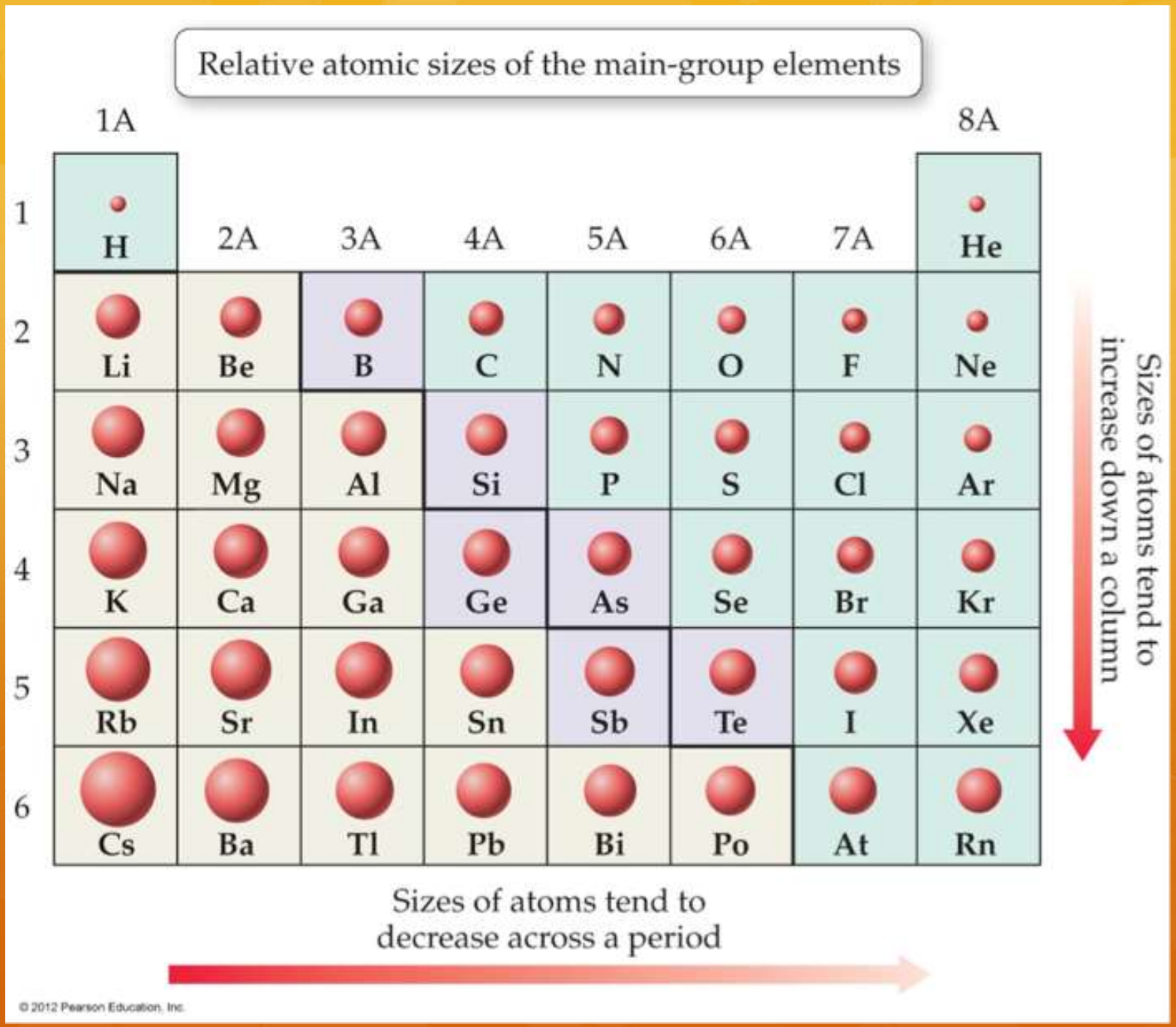
Acid Rain (continued)

- Other effects are increase corrosion of limestone ($CaCO_3$) structures which dissolve in acid
- $CaCO_3 + 2H^+$ gives $Ca^{2+} + CO_2 + H_2O$
- A decrease in pH also increases the rate at which unprotected iron and steel rust.

Atomic Size

- Across a period the number of valence shells remains the same but nuclear charge increases.
- Therefore, the nuclear force of attraction on the valence electrons increases
- Hence, across a period the atomic size decreases




Relative atomic sizes of the main-group elements
1A
8A
1
2
3
4
5
6
H
2A
3A
4A
5A
6A
7A
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Al
Si
P
S
Cl
Ar
K
Ca
Ga
Ge
As
Se
Br
Kr
Rb
Sr
In
Sn
Sb
Te
I
Xe
Cs
Ba
Tl
Pb
Bi
Po
At
Rn
Sizes of atoms tend to increase down a column
Sizes of atoms tend to decrease across a period
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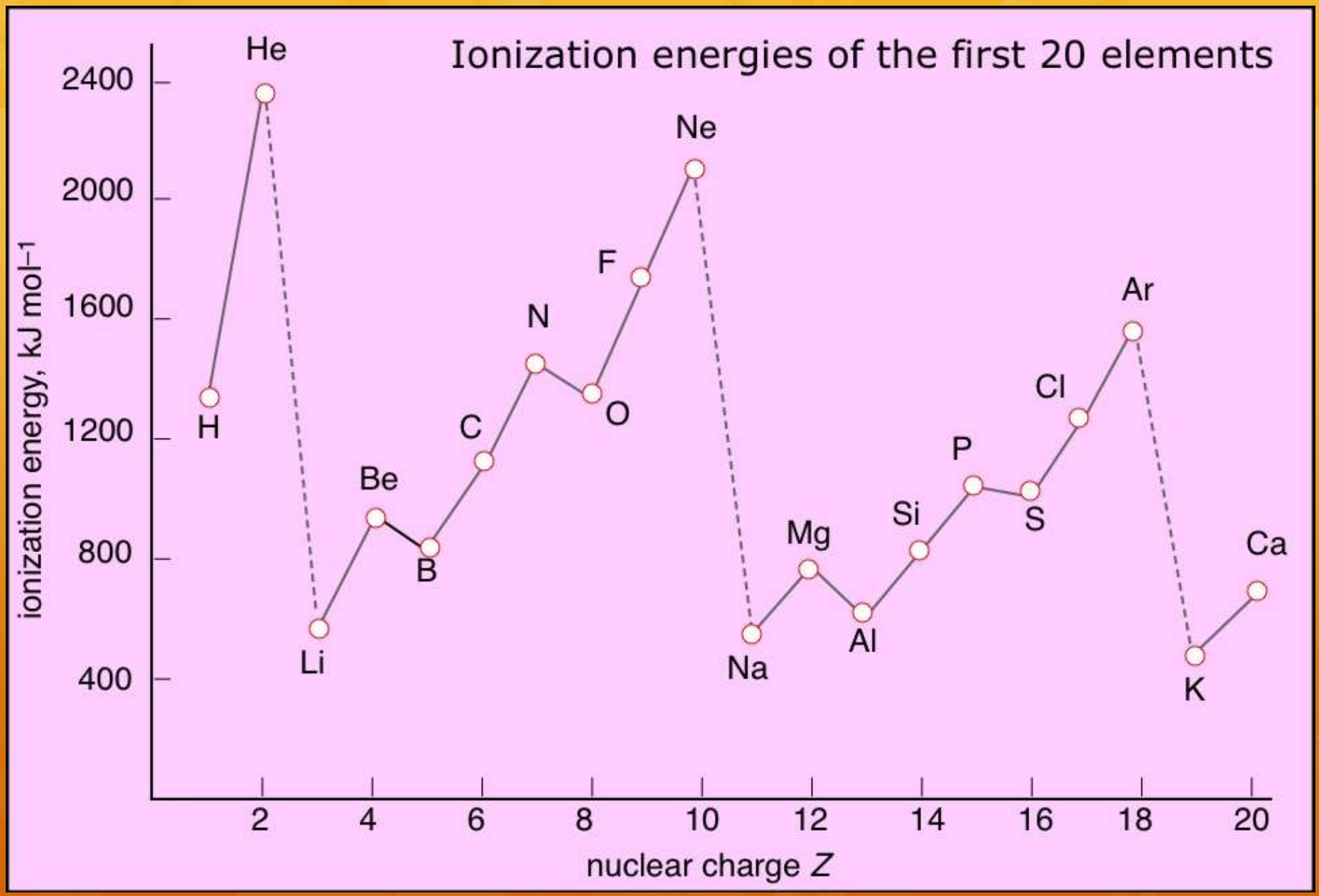
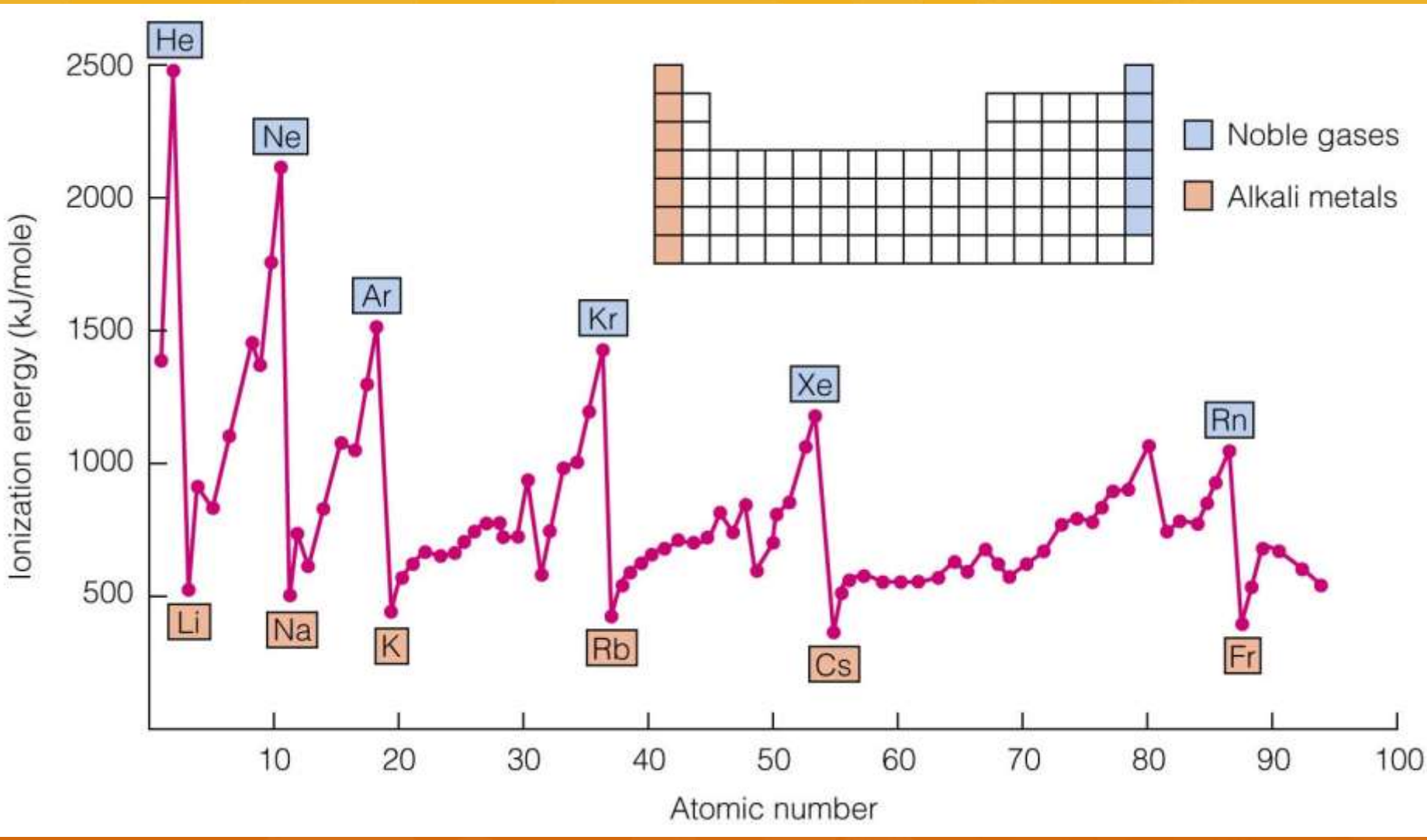
Ionization Potential

- As the atomic radius decreases across a period, the nuclear attraction on the electrons increases.
- Hence, more energy is required to remove an electron from the outermost shell
- Hence, Ionization Potential increases across a period
- It is maximum for Inert Gases


Ionization energies of the first 20 elements
ionization energy, kJ mol⁻¹
2400
2000
1600
1200
800
400
2
4
6
8
10
12
14
16
18
20
nuclear charge Z
H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Al
Si
P
S
Cl
Ar
K
Ca

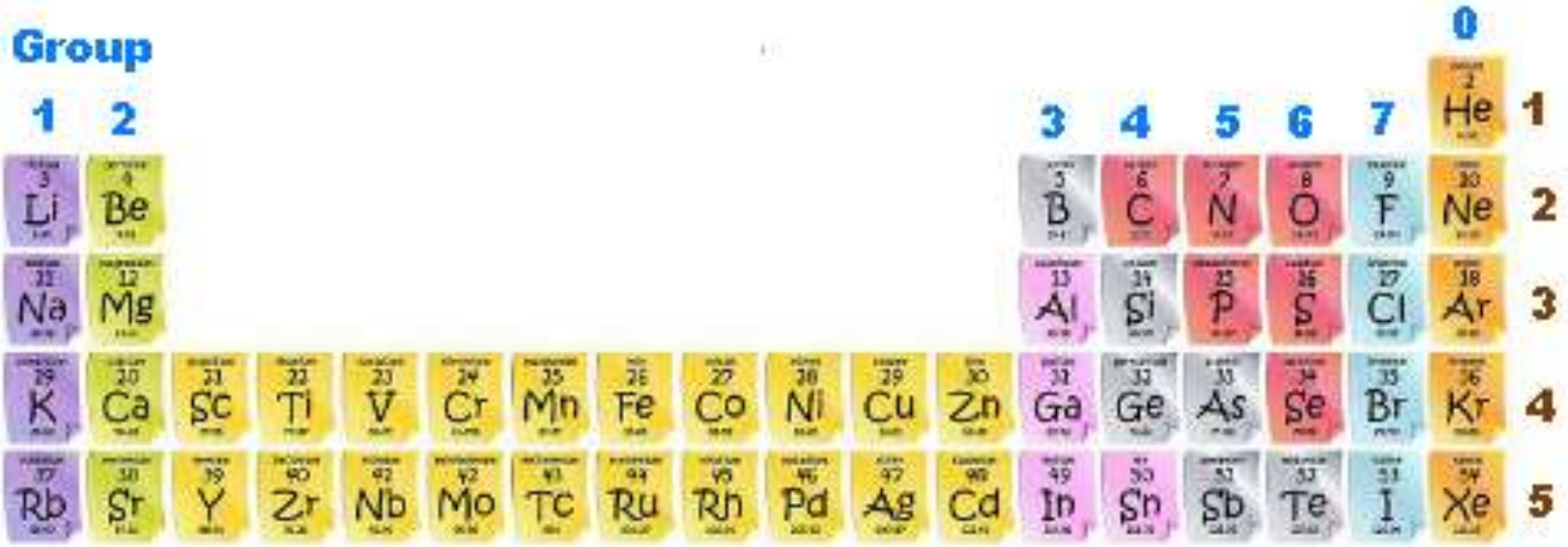
Electron Affinity and Electronegativity

- Since, across a period, Atomic Size decreases and a small atom takes up electrons more readily than a large atom, the nucleus has a greater attraction on the electron
- Hence, Electron Affinity and Electronegativity increases across a period.
- It is highest for halogens, least for alkali metals and 0 for inert gases.
- Non metals are more likely to accept electrons than metals. V11As like to accept electrons the most.


He
Ne
Ar
Kr
Xe
Rn
Li
Na
K
Rb
Cs
Fr
2500
2000
1500
1000
500
Ionization energy (kJ/mole)
10
20
30
40
50
60
70
80
90
100
Atomic number
Noble gases
Alkali metals

Chemical Reactivity

- On moving from left to right in a period, the chemical reactivity of elements first decreases and then increases.
- The group 1 elements can lose electrons easily as compared to group 2. Group 2 elements can lose electrons easily in comparison to group 14 and not at all in comparison to group 1.
- As the tendency to lose electrons decreaes, reactivity also decreaes. Silicon is the least reactive element in the 3rd period.
- From P to Cl, the tendency to gain electrons increases, hence reactivity increases. Cl is the most reactive non-metal



Period 3

Sodium Magnesium Aluminium Silicon Phosphorus Sulphur Chlorine Argon

Na Mg Al Si P S Cl Ar

Metals Metalloid Non-Metals

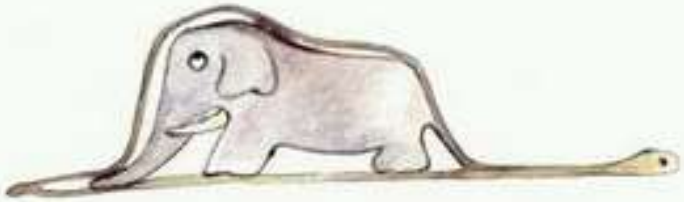
High Reactivity → Low Reactivity → High Reactivity → Unreactivity

Resources

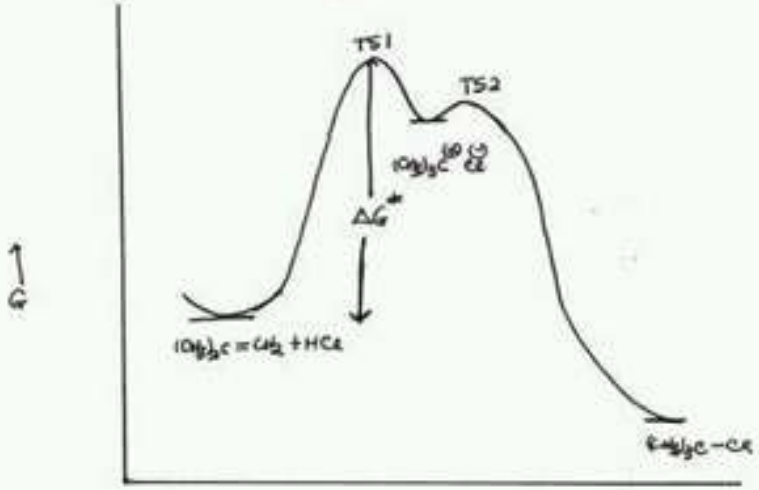
- ICSE chemistry notes
- Chemistry 4th edition by Sadru Damji and John Green
- Concise Chemistry by S.P. Singh

What does this look like to you?

If it looks like a plain hat, you're an adult



If it looks like an elephant being eaten by a boa constrictor, you're still a child at heart



If it looks like a free-energy reaction diagram, you're in organic chemistry and your life is over.

Le Petit Prince