

# Science-X

## I.C.S.E.



# 1 Periodic Table, Periodic Properties & Variations of Properties



# Topics

1.1 INTRODUCTION

1.2 SALIENT FEATURES OF MODERN PERIODIC TABLE

1.3 PERIODICITY

1.4 SHELLS (ORBITS) & VALENCY

1.5 PERIODIC PROPERTIES

1.5.1 ATOMIC SIZE (ATOMIC RADIUS)

1.5.2 METALLIC CHARACTER

1.5.3 NON-METALLIC CHARACTER

1.5.4 IONIZATION POTENTIAL OR IONIZATION ENERGY OR IONIZATION ENTHALPY (I.E.)

1.5.5 ELECTRON AFFINITY (E.A.) OR ELECTRON GAIN ENTHALPY

1.5.6 ELECTRONEGATIVITY (E.N.)

1.6 COMPARISON OF ALKALI METALS & HALOGENS



# 1.1 INTRODUCTION

- Elements are the pure substances made up of one type of atoms
- All matter is made up of atoms
- Right now there are 118 elements: 94 natural and 24 synthetic produced in nuclear reactions (IUPAC)
- Classification of elements:
  - Dobereiner Triads: Similar triads  $_{20}\text{Ca}^{40}$  ,  $_{38}\text{Sr}^{88}$  ,  $_{56}\text{Ba}^{137}$  and  $_{17}\text{Cl}^{35}$  ,  $_{35}\text{Br}^{80}$  ,  $_{53}\text{I}^{127}$
  - Newlands Octaves: starting from any element, every 8<sup>th</sup> element is similar to the 1<sup>st</sup> one like Sa, Re, Ga, Ma, Pa, Da, Ni, again start from Pa, Da,.....
  - Mendeleev's Periodic Table: based on the law that  
“ *The properties of elements are the periodic functions of their **atomic masses**.*”
  - Moseley's Modern Periodic Table: based on the law that  
“ *The properties of elements are the periodic functions of their **atomic number**.*”
  - Neils Bohr: Long form of Modern Periodic Table



**ATOMIC NUMBER: (pure number)**

*The Number Of ELECTRONS or PROTONS in an atom*

**ATOMIC MASS: (Unit: a.m.u.)**

*Approx. equivalent to the sum of number of PROTONS and NEUTRONS in the nucleus of an atom*

**MASS NUMBER: (pure number)**

*the sum of number of PROTONS and NEUTRONS in the nucleus of an atom*



## ***PERIODIC TABLE:***

***The tabular arrangement of elements in  
PERIODS (horizontal row) and  
GROUPS (vertical columns)***



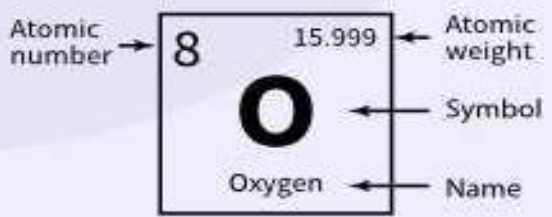


# LONG FORM MODERN PERIODIC TABLE

Group ↓

Period ↓

1	2											13	14	15	16	17	18		
1 1.008 <b>H</b> Hydrogen														5 10.806 <b>B</b> Boron	6 12.011 <b>C</b> Carbon	7 14.006 <b>N</b> Nitrogen	8 15.999 <b>O</b> Oxygen	9 18.998 <b>F</b> Fluorine	10 20.179 <b>Ne</b> Neon
2 6.938 <b>Li</b> Lithium	4 9.012 <b>Be</b> Beryllium																		
3 22.989 <b>Na</b> Sodium	12 24.304 <b>Mg</b> Magnesium													13 26.981 <b>Al</b> Aluminium	14 28.086 <b>Si</b> Silicon	15 30.974 <b>P</b> Phosphorus	16 32.059 <b>S</b> Sulfur	17 35.446 <b>Cl</b> Chlorine	18 39.948 <b>Ar</b> Argon
4 39.098 <b>K</b> Potassium	20 40.078 <b>Ca</b> Calcium	21 44.956 <b>Sc</b> Scandium	22 47.867 <b>Ti</b> Titanium	23 50.942 <b>V</b> Vanadium	24 51.996 <b>Cr</b> Chromium	25 54.938 <b>Mn</b> Manganese	26 55.845 <b>Fe</b> Iron	27 58.933 <b>Co</b> Cobalt	28 58.933 <b>Ni</b> Nickel	29 63.546 <b>Cu</b> Copper	30 65.38 <b>Zn</b> Zinc	31 69.723 <b>Ga</b> Gallium	32 72.630 <b>Ge</b> Germanium	33 74.922 <b>As</b> Arsenic	34 78.971 <b>Se</b> Selenium	35 79.904 <b>Br</b> Bromine	36 83.798 <b>Kr</b> Krypton		
5 85.468 <b>Rb</b> Rubidium	38 87.62 <b>Sr</b> Strontium	39 88.906 <b>Y</b> Yttrium	40 91.224 <b>Zr</b> Zirconium	41 92.906 <b>Nb</b> Niobium	42 95.95 <b>Mo</b> Molybdenum	43 (98) <b>Tc</b> Technetium	44 101.07 <b>Ru</b> Ruthenium	45 101.07 <b>Rh</b> Rhodium	46 106.42 <b>Pd</b> Palladium	47 107.868 <b>Ag</b> Silver	48 112.414 <b>Cd</b> Cadmium	49 114.818 <b>In</b> Indium	50 118.710 <b>Sn</b> Tin	51 121.760 <b>Sb</b> Antimony	52 127.60 <b>Te</b> Tellurium	53 126.904 <b>I</b> Iodine	54 131.29 <b>Xe</b> Xenon		
6 132.905 <b>Cs</b> Caesium	56 137.327 <b>Ba</b> Barium	57-71 Lanthanoids*	72 178.49 <b>Hf</b> Hafnium	73 180.948 <b>Ta</b> Tantalum	74 183.84 <b>W</b> Tungsten	75 186.207 <b>Re</b> Rhenium	76 186.207 <b>Os</b> Osmium	77 192.225 <b>Ir</b> Iridium	78 195.084 <b>Pt</b> Platinum	79 196.967 <b>Au</b> Gold	80 200.592 <b>Hg</b> Mercury	81 204.382 <b>Tl</b> Thallium	82 207.2 <b>Pb</b> Lead	83 208.980 <b>Bi</b> Bismuth	84 (209) <b>Po</b> Polonium	85 (210) <b>At</b> Astatine	86 (222) <b>Rn</b> Radon		
7 223 <b>Fr</b> Francium	88 (226) <b>Ra</b> Radium	89-103 Actinoids**	104 (261) <b>Rf</b> Rutherfordium	105 (268) <b>Db</b> Dubnium	106 (269) <b>Sg</b> Seaborgium	107 (270) <b>Bh</b> Bohrium	108 (277) <b>Hs</b> Hassium	109 (278) <b>Mt</b> Meitnerium	110 (281) <b>Ds</b> Darmstadtium	111 (282) <b>Rg</b> Roentgenium	112 (285) <b>Cn</b> Copernicium	113 (286) <b>Nh</b> Nihonium	114 (289) <b>Fl</b> Flerovium	115 (290) <b>Mc</b> Moscovium	116 (293) <b>Lv</b> Livermorium	117 (294) <b>Ts</b> Tennessine	118 (294) <b>Og</b> Oganesson		



\*Lanthanoids

57 138.905 <b>La</b> Lanthanum	58 140.116 <b>Ce</b> Cerium	59 140.908 <b>Pr</b> Praseodymium	60 144.242 <b>Nd</b> Neodymium	61 (145) <b>Pm</b> Promethium	62 150.36 <b>Sm</b> Samarium	63 151.964 <b>Eu</b> Europium	64 157.25 <b>Gd</b> Gadolinium	65 158.925 <b>Tb</b> Terbium	66 162.500 <b>Dy</b> Dysprosium	67 164.930 <b>Ho</b> Holmium	68 167.259 <b>Er</b> Erbium	69 168.934 <b>Tm</b> Thulium	70 173.048 <b>Yb</b> Ytterbium	71 174.967 <b>Lu</b> Lutetium
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\*\*Actinoids

89 (227) <b>Ac</b> Actinium	90 232.037 <b>Th</b> Thorium	91 231.036 <b>Pa</b> Protactinium	92 238.029 <b>U</b> Uranium	93 (237) <b>Np</b> Neptunium	94 (244) <b>Pu</b> Plutonium	95 (243) <b>Am</b> Americium	96 (247) <b>Cm</b> Curium	97 (247) <b>Bk</b> Berkelium	98 (251) <b>Cf</b> Californium	99 (252) <b>Es</b> Einsteinium	100 (257) <b>Fm</b> Fermium	101 (258) <b>Md</b> Mendelevium	102 (259) <b>No</b> Nobelium	103 (266) <b>Lr</b> Lawrencium
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Alkali Metals	Alkaline Earth Metals	Lanthanide	Actinide	Transition Metals
Post-Transition Metals	Metalloid	Other non-metals	Halogens	
	Noble gas	Unknown Chemical Properties		

## 1.2 SALIENT FEATURES OF MODERN PERIODIC TABLE

***Total Number of Periods (rows) : 7***

***Total Number of Columns (groups) : 18***





## 1.3 PERIODICITY

The properties of elements that appear at regular intervals are known as **Periodic properties** and the phenomenon is known as **Periodicity**

### Cause of periodicity

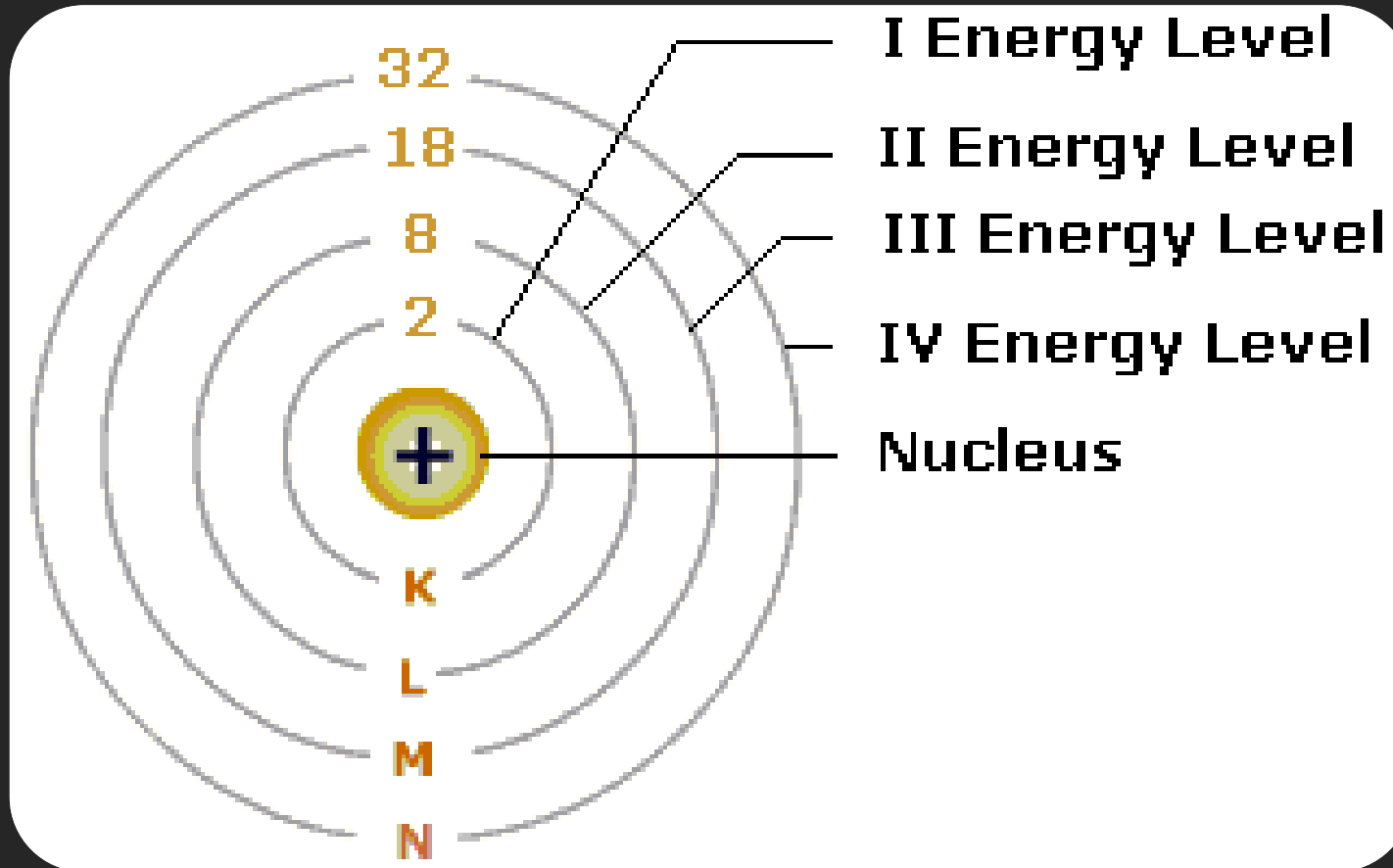
The cause of periodicity is the re-occurrence of similar electronic configuration after certain intervals

*\* In a particular group the elements have similar properties due to similar electronic configuration*



## 1.4 SHELLS (ORBITS) & VALENCY

Orbits: The certain definite circular paths in which electrons revolve around the nucleus of an atom are known as Orbits or Shells



## ***Number of shells = period***

According to Bohr's model of an atom, the maximum number of electrons that can be in an orbit or shell is calculated using the formula  $2n^2$  where  $n$  is the orbit number.

## ***Number of electrons in an orbit = $2n^2$***

*Where  $n$  = number of the orbit*

*Examples,*

<b>Orbit Number</b>	<b>Total Electrons (<math>2n^2</math>)</b>
<b>1</b>	<b>2</b>
<b>2</b>	<b>8</b>
<b>3</b>	<b>18</b>
<b>4</b>	<b>32</b>



## VALENCY

Valency is the combining capacity of an atom. It is the number of electrons that an atom can share, donate or accept

*Valency of elements of a particular group remains the same due to their similar electronic configuration*



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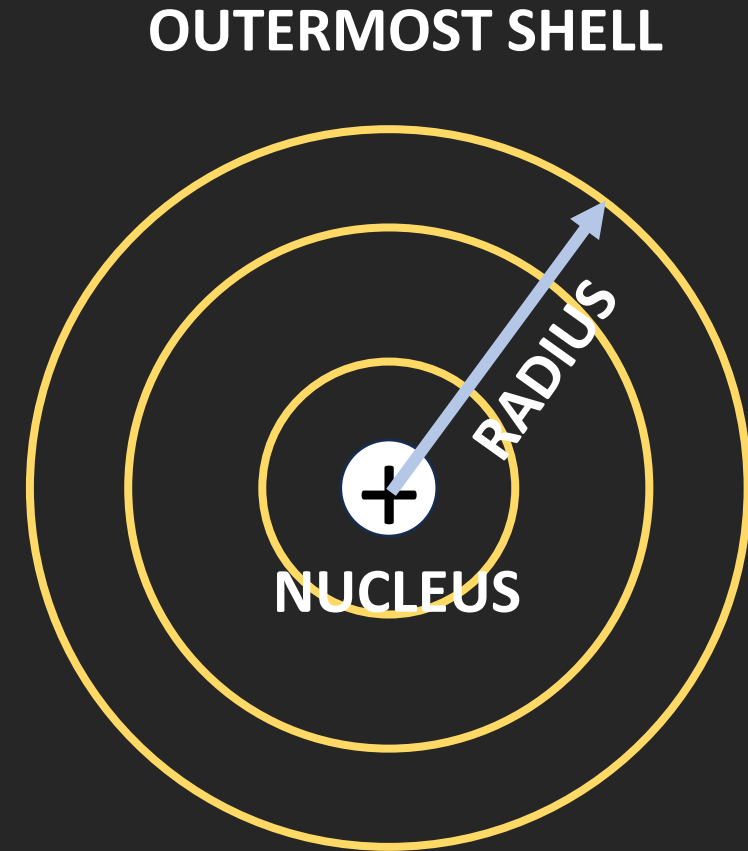
# 1.5 PERIODIC PROPERTIES

to be continued...



## 1.5.1 ATOMIC SIZE (ATOMIC RADIUS)

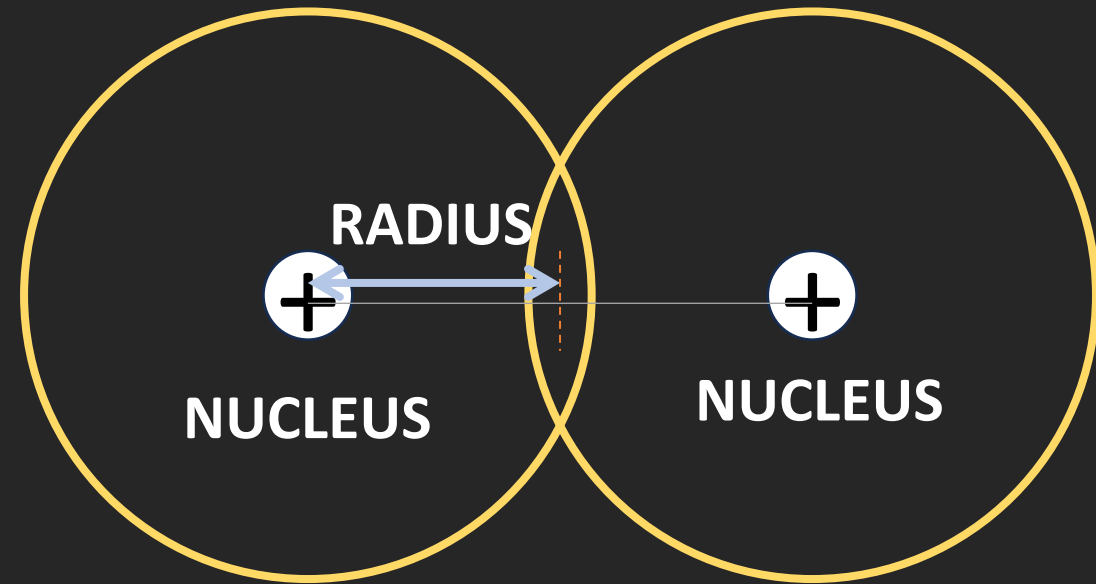
The distance between the centre of the nucleus and the outermost shell is known as Atomic size or Atomic radius.





## OUTERMOST SHELL

**Atomic radius can also be defined as the half of the internuclear distance between two bonded atoms in a molecule**



- The size of the atom **increases** as the number of shells increase
- The size of the atom **decreases** as the nucleus charge increases



# Trends in Atomic Size

**Down a group:** atomic size increases as the number of shells increases

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<b>Fl</b>	<b>64pm</b>
<b>Cl</b>	<b>99pm</b>
<b>Br</b>	<b>114pm</b>
<b>I</b>	<b>133pm</b>
<b>At</b>	<b>140pm</b>

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**Across a period:** atomic size decreases from L to R in a period

Example:

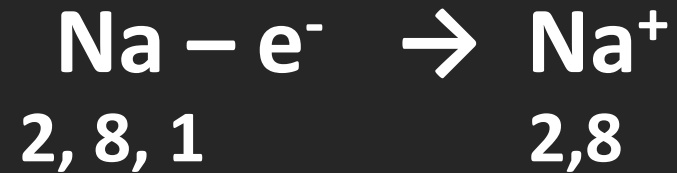
Li	Be	B	C	N	O	Fl	Ne
3	4	5	6	7	8	9	10
152pm	112pm	88pm	77pm	70pm	66pm	64pm	112pm

**Exception:** Atomic size of Noble gases is bigger than the halogens of the same period.

**Reason:** The outmost shell is complete in the atoms of the Noble gases. Due to the crowding of the electrons in the outermost shell, a repulsive force between the electrons increases the size of the atom and also the nuclear charge has less effect on the outmost electrons due to the shielding effect. The size of the atoms of Noble gases is not more than the Alkali metals in the same period.



- Cation is always **smaller** than the parent atom



*As the number of electrons decreases and the effective nuclear charge increases resulting into smaller size of cation*

- Anion is always **bigger** than the parent atom



*As the number of electrons increases and the effective nuclear charge (pull) decreases resulting into bigger size of anion*



- **Size of Iso-electronic ions: size **decreases** as the nuclear charge increases as the resultant pull on the electrons increases,**

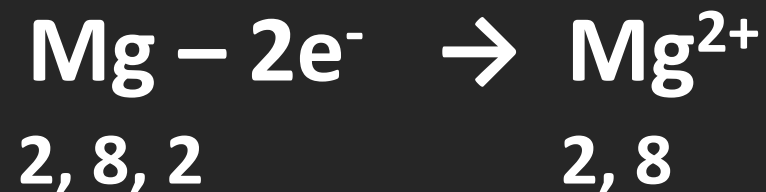
Iso-electronic ion	$\text{Mg}^{2+}$	$\text{Na}^+$	$\text{F}^-$	$\text{O}^{2-}$
No. of electrons	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>
No. of Protons	<b>12</b>	<b>11</b>	<b>9</b>	<b>8</b>
Size in Å	<b>0.65</b>	<b>0.95</b>	<b>1.26</b>	<b>1.42</b>



## 1.5.2 METALLIC CHARACTER

*The elements whose atoms have a tendency to lose electrons and make a positive ion (cation) are known as Metals.*

*Examples,*



**Exception: H forms H<sup>+</sup> ion but it is a non-metal**



# Trends in Metallic character

**Down a group:** metallic character increases as we go down a group

**Across a period:** metallic character decreases as we move across a period.



### 1.5.3 NON-METALLIC CHARACTER

*The elements whose atoms have a tendency to gain electrons and to complete their octet to get stabilized and make a negative ion are known as Non-metals*

*The Non-metallic character depends on two factors as follows,*

- (i) Atomic size: smaller the size more is the non-metallic character*
- (ii) Nuclear charge: more the nuclear charge more is the non-metallic character*



# Trends in Non-metallic character

**Down a group:** non-metallic character decreases as we go down a group

**Across a period:** metallic character increases as we move across a period.



# Chemical Reactivity

**The chemical reactivity depends on the tendency to lose or gain electrons by an atom**

***Therefore, greater the tendency to lose or gain electrons, greater is the reactivity***



# Trends in Chemical Reactivity

**Across a period:** on moving from L to R in a period, the chemical reactivity first decreases then increases

**Example: 3<sup>rd</sup> period:**

Na	Mg	Al	Si	P	S	Cl
Most reactive Metal			Least reactive			Most reactive Non-metal

**Down a group:** The chemical reactivity of metals increases down a group because the tendency to lose electrons increases down a group. The most reactive metal is at the bottom of group 1



# Trends in Chemical Reactivity

## Down a group:

**Metals:** The chemical reactivity of metals increases down a group because the tendency to lose electrons increases down a group. The most reactive metal is at the bottom of group 1 i.e. Francium (Fr)

**Non-metals:** The chemical reactivity of non-metals decreases down a group because the tendency to gain electrons decreases down a group. The most reactive non-metal is at the top of group 17 i.e. Fluorine (F).



# Gradation in Physical Properties

## Down a group:

**Metals:** The M.P and B.P of metals decrease down a group

Metals	M.P. (°C)	B.P. (°C)
Li	180.5	1347
Na	94.5	883
K	63.5	774

**Non-metals:** The M.P and B.P of non-metals increase down a group

Non-metals	M.P. (°C)	B.P. (°C)	Physical state
F	-219.6	-187	Gas
Cl	-101	-34.6	Gas
Br	-7.2	+58.8	Liquid
I	+113.6	+183	Solid

**Density :** increases down a group





## **Across a period:**

**The M.P and B.P. increase from L to R in a particular period upto group-14 and then decrease.**

**Density: increase from L to R in a particular period and then slight decrease**



## 1.5.4 IONIZATION POTENTIAL OR IONIZATION ENERGY OR IONIZATION ENTHALPY (I.E.)

The energy required to remove an electron from a gaseous isolated atom to make a positive ion is known as Ionization Energy or Ionization Enthalpy (I.E.)



Units of I.E. : electron volts per atom (eV/atom)

I.E. depends on

- (i) Atomic size: IE is inversely proportional to atomic size
- (ii) Nuclear Charge : IE is directly proportional to nuclear charge

## Trends in IONIZATION ENERGY

**Across a Period: increase due to increased nuclear charge**

**Down a group: decrease due to increase in the atomic size**



## 1.5.5 ELECTRON AFFINITY (E.A.) OR ELECTRON GAIN ENTHALPY

The energy released while making a negative ion from a gaseous isolated atom by adding an electron



Units of I.E. : electron volts per atom (e/V/atom)

E.A. depends on

- (i) Atomic size: EA is inversely proportional to atomic size
- (ii) Nuclear Charge :EA is directly proportional to nuclear charge



## Trends in ELECTRON AFFINITY

**Across a Period: increase due to increased nuclear charge**

**Down a group: decrease due to increase in the atomic size**



## 1.5.6 ELECTRONEGATIVITY (E.N.)

The tendency of an atom in a molecule to attract the shared pair of electrons towards itself is known as Electronegativity



Units of E.N. : E.N. is a dimensionless quantity because it is just a tendency  
But there are many scales to measure EN. The most widely used scale of EN was given by Linus Pauling (1932)

E.N. depends on

- (i) Atomic size: EN is inversely proportional to atomic size
- (ii) Nuclear Charge :EN is directly proportional to nuclear charge

## Trends in ELECTRONEGATIVITY (E.N.)

**Across a Period: increase due to increased nuclear charge**

**Down a group: decrease due to increase in the atomic size**





## 1.6 COMPARISON OF ALKALI METALS & HALOGENS



	Alkali Metals (Group-1)	Halogens (Group-17)
Occurrence	Combined state	Combined state
Physical state	Shining, Soft, Li is hardest	Non-metals, gaseous, poisonous, diatomic molecules
Valence electron, Conduction nature	1 Valence shell electron	7 Valence shell electron
M.P. & B.P.	Decrease down a group	Increase down a group
Atomic Size	Largest size in a period	Smallest size in a period
I.E.	Lowest	Highest
E.A.	Lowest	Highest
E.N.	Lowest	Highest
Reactivity	Reactive metals	Reactive non-metals
Rxn with Water & Acids	Vigorous rxn producing H, reactivity increases down a group	No rxn with dilute acids and water
Reducing/Oxidizing agents formation	Strong Reducing agents	Strong Oxidizing agents



# QUIZ

## Tomorrow



